ESCOLA DE DOUTORAMENTO
INTERNACIONAL CAMPUS TERRA
DA USC

Ruth Rodríguez
Bermúdez

Tese de Doutoramento

Valoración racial e autenticación do sistema de produción ecolóxica de leite no norte de España

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TESE DE DOUTORAMENTO

VALORACIÓN RACIAL E AUTENTICACIÓN DO SISTEMA DE PRODUCIÓN ECOLÓXICA DE LEITE NO NORTE DE ESPAÑA

Ruth Rodríguez Bermúdez

ESCOLA DE DOUTORAMENTO INTERNACIONAL

PROGRAMA DE DOUTORAMENTO EN MEDICINA E SANIDADE VETERINARIA

LUGO

2018

DECLARACIÓN DO AUTOR/A DA TESE

Valoración racial e autenticación do sistema de produción ecolóxica de leite no Norte de España

D./Dna. Ruth Rodríguez Bermúdez

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Valoración racial e autenticación do sistema de produción ecolóxica

de leite no Norte de España

M. Marta López Alonso, Profesora Titular do Departamento de Patoloxía Animal da Universidade de Santiago de Compostela e Marta I. Miranda Castañón, Profesora Titular do Departamento de Anatomía, Produción Animal e Ciencias Clínicas Veterinarias da Universidade de Santiago de Compostela

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Que a presente tese, correspóndese co traballo realizado por D/Dna. ***Ruth Rodríguez Bermúdez****, baixo a miña dirección, e autorizo a súa presentación, considerando que reúne os requisitos esixidos no Regulamento de Estudos de Doutoramento da USC, e que como director desta non incorre nas causas de abstención establecidas na Lei40/2015.*

De acordo co artigo 41 do Regulamento de Estudos de Doutoramento, declara tamén que a presente tese de doutoramento é idónea para ser defendida en base á modalidade de COMPENDIO DE PUBLICACIÓNS, nos que a participación da doutoranda foi decisiva para a súa elaboración.

A utilización destes artigos nesta memoria, está en coñecemento dos coautores, tanto doutores como non doutores. Ademais, estes últimos teñen coñecemento de que ningún dos traballos aquí reunidos poderá ser presentado en ningunha outra tese de doutoramento.

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A presente Tese de Doutoramento foi realizada dentro do Proxecto de Investigación titulado: "SITUACIÓN NUTRICIONAL DO GANADO VACÚN LEITEIRO EN PRODUCIÓN ECOLÓXICA DO NORTE DE ESPAÑA. COMPARACIÓN COS SISTEMAS CONVENCIONAIS" (AGL2010-21026), financiado polo Ministerio de Ciencia e Innovación e desenvolvido en colaboración co Centro Tecnolóxico Agroalimentario de Lugo (CETAL) na Facultade de Veterinaria de Lugo, Universidade de Santiago de Compostela.

Durante o período de Tese de Doutoramento, Ruth Rodríguez Bermúdez foi beneficiaria das seguintes bolsas de investigación:

- Contrato predoutoral Xunta de Galicia (Ref. PRE/2013/183) dentro do marco das axudas de apoio á etapa predoutoral do Plan galego de investigación, innovación e crecemento 2011-2015 (Plan I2C), convocatoria do ano 2013.
- Contrato predoutoral FPU (Formación do Profesorado Universitario) (Ref. FPU14/01476) do Ministerio de Educación, Cultura e Deporte, convocatoria do ano 2014.
- Bolsa predoutoral para estadías de investigación no estranxeiro da Fundación Barrié de la Maza, convocatoria do ano 2013.

A vaca é o símbolo da paz.
Val máis o que siñifica unha vaca que o que simboliza un león rampante. Xa o dixo un dos nosos economistas "O albre xenealóxico dunha vaca de leite é máis útil que o albre xenealóxico dun aristócrata".
A vaca esqueceuse dos cornos e dános o seu traballo, o seu leite, a súa carne, o seu coiro e a carne e o coiro dos seus fillos. Non nos pode dar máis.
[...]
O día que seipamos o que val unha vaca, Galiza quedará redimida.

Castelao, Sempre en Galiza

Alfonso Daniel Rodríguez Castelao. Sempre en Galiza. Editorial Galaxia 2014. 1ª edición 3ª impresión Biblioteca Castelao páx164-165 ISBN: 978-84-8288-729-6

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RESUMO

Na actualidade a gandería ecolóxica é un sistema de produción en crecemento porén aínda presenta deficiencias en certos aspectos que cómpre estudar en profundidade. Os gandeiros do noroeste de España continúan a usar os animais herdados de convencional (Holstein), aínda que manifestan non estar satisfeitos coa súa produción. Nos estudos relacionados co comportamento racial viuse que as vacas Holstein producen máis leite pero menos sólidos, sendo os cruces os que mostran unha mellor produción normalizada de sólidos debido á combinación das maiores porcentaxes de sólidos cunha produción intermedia de leite. Por outro lado, a nivel reprodutivo son máis eficientes os cruces e en lonxevidade as Holstein. Dado que as Holstein non teñen problemas graves de adaptación ao sistema deberíase facer un esforzo en conseguir unha liña rústica adaptada a ecolóxico, así como elaborar un índice de mérito xenético para este sistema. Coñecer a opinión dos consumidores é fundamental para establecer estratexias de mercado por iso se elaborou unha enquisa sobre percepción do consumidor, atopando que unha grande maioría das persoas confunde os produtos ecolóxicos cos locais e amigables co medio ambiente, que o prezo continúa a ser unha barreira para a compra de produtos ecolóxicos, e que a desconfianza tamén ten importancia á hora de consumilos. Cabe destacar que os consumidores teñen interese na protección das razas locais nos sistemas de ecoturismo polo que pode constituír unha boa opción para a protección das razas menos produtivas con censos reducidos.

Dado que os consumidores desconfían da orixe ecolóxica dos produtos considerouse de interese deseñar un método que permita diferenciar tanto os produtos como o sistema de produción en ecolóxico de cara a certificar a súa orixe. A diferenciación realizouse a partir de mostras de leite e sangue (soro) utilizando técnicas quimiométricas para distinguir a orixe das mostras en función da súa composición mineral. O modelo de clasificación desenvolvido para as mostras de leite conseguiu clasificar ben as mostras dentro do tipo de produción cun erro do 5%, as mostras erroneamente clasificadas correspóndense con mostras de leite convencional procedentes de granxas de baixos insumos, xa que teñen unha nutrición moi semellante ás granxas ecolóxicas. Para autenticar o sistema ecolóxico utilizouse sangue (soro) determinando a súa orixe a través da quimiometría en base á súa composición mineral. O patrón de recoñecemento amosou un ratio preditivo próximo ao 90% para ambos sistemas (ecolóxico e convencional). Estes resultados poden axudar aos produtores, consumidores e organismos reguladores a verificar que se están a cumprir os estándares de ecolóxico.

Palabras clave: razas, produción, reprodución, características funcionais, consumidores, quimiometría, minerais

RESUMEN

En la actualidad la ganadería ecológica es un sistema de producción en crecimiento, sin embargo presenta deficiencias en ciertos aspectos que conviene estudiar en profundidad. Los ganaderos del noroeste de España continúan usando los animales heredados de convencional (Holstein), aunque manifiestan no estar satisfechos con su producción. En los estudios relacionados con el comportamiento racial se vio que las vacas Holstein producen más leche pero con menos sólidos, siendo los cruces los que muestran mejor producción normalizada de sólidos debido a la combinación de mayores porcentajes de sólidos con una producción intermedia de leche. Por otro lado, a nivel reproductivo son más eficientes los cruces y en longevidad las Holstein. Dado que las Holstein no tienen problemas graves de adaptación al sistema se debería hacer un esfuerzo en conseguir una línea rústica adaptada a ecológico, así como elaborar un índice de mérito genético para este sistema. Conocer la opinión de los consumidores es fundamental para establecer estrategias de mercado por eso se elaboró una encuesta sobre percepción del consumidor, encontrando que una gran mayoría de las personas confunde los productos ecológicos con los locales y amigables con el medio ambiente, que el precio continua siendo una barrera para la compra de productos ecológicos, y que la desconfianza también tiene interés en la protección de las razas locales en los sistemas de ecoturismo por lo que puede constituir una buena opción para la protección de las razas menos productivas con censos reducidos.

Dado que los consumidores desconfían del origen ecológico de los productos se consideró interesante diseñar un método que permita diferenciar tanto los productos como el sistema de producción en ecológico de cara a certificar su procedencia. La diferenciación se realizó a partir de muestras de leche y sangre (suero) utilizando técnicas quimiométricas para distinguir el origen de las muestras en función de su composición mineral. El modelo de clasificación desarrollado para las muestras de leche consiguió clasificar bien las muestras dentro de su tipo de producción con un error del 5%, las muestras erróneamente clasificadas se corresponden con muestras de leche convencional procedentes de granjas de bajos insumos, ya que tienen una nutrición muy similar a las granjas ecológicas. Para autentificar el sistema ecológico se utilizó sangre (suero) determinando su procedencia a través de la quimiometría en base a su composición mineral. El patrón de reconocimiento demostró un ratio predictivo próximo al 90% para ambos sistemas (ecológico y convencional). Estos resultados pueden ayudar a los productores, consumidores y organismos reguladores a verificar que se están cumpliendo los estándares de ecológico.

Palabras clave: razas, producción, reproducción, características funcionales, consumidores, quimiometría, minerales

SUMMARY

Organic agriculture is a production system that is growing in the present even that some aspects continue to be not solved so they should be deeper studied. Organic farmers in Northern Spain continue to use the same animals they had in conventional systems (Holstein), even they say they are not satisfied with their production. In studies to analyze breed influence it was observed that Holstein produce more milk yield but lower solid composition, while crosses have better standardized solid production due to higher solid percentages and intermediate milk production. Moreover, crosses are more efficient in reproduction and Holstein in longevity. Holsteins have not serious problems for adaptation to organic systems so an effort should be made to find a rustic strain adapted to those systems, and also to elaborate a genetic merit index for organic systems. Knowing consumers opinion is very important to establish marketing strategies so an inquiry was performed, findings show that the majority of people think that local and environmental friendly products are organic, price continues to be a barrier for organic consumption and mistrust has also some relevance. Is should be considered that consumers have interest in local breed protection in ecotourism so it could be a good option for the protection of least productive breeds in reduced census.

Knowing that consumers distrust organic origin of products it was considered interesting to develop a method to differentiate organic system and products to certificate their origin. Differentiation was performed using milk and blood (serum) samples. Chemometric analysis was used to distinguish product samples origin based on mineral composition. The classification model applied to milk samples was able to classify correctly samples in production system with a 5% error, samples incorrectly classified were those ones from low-input conventional systems, because of similar nutrition to organic farms. For the authentication of organic system blood (serum) was used applying a chemometric analysis based on mineral composition. The recognition pattern yielded a predictive hit rate close up to 90% for both systems (organic and conventional). These results could help producers, consumers and regulatory bodies to verify that organic standards have been followed.

Key words: breeds, production, reproduction, functional traits, consumers, chemometric, minerals

INTRODUCIÓN

INTRODUCIÓN

1. O CONCEPTO E PRINCIPIOS DA GANDERÍA ECOLÓXICA

A gandería ecolóxica é un sistema agrícola que ten como obxectivo proporcionar ao consumidor alimentos frescos e saborosos respectando en todo momento o ciclo natural de produción. Para iso débese respectar a normativa vixente que limita ou prohibe o uso de pesticidas e fertilizantes químicos sintéticos, antibióticos, aditivos alimentarios e outros insumos; prohíbese absolutamente o uso de organismos modificados xeneticamente; e favorécese o uso de recursos locais, rotación de pastos, escolla de animais e plantas adaptados ao medio, a gandería en pastoreo e as prácticas de manexo adecuadas a cada especie (EC, 2018). Ademais, dentro da gandería ecolóxica farase especial énfase na mellora da saúde e do benestar animal (Diepen et al., 2007; Rozzi et al., 2007; Ahlman et al., 2011; Horn et al., 2012; Rozzi, 2012).

A International Federation of Organic Agriculture Movements (IFOAM) estableceu na Asemblea Xeral de 2005 unha definición que recolle os catro Principios da Agricultura Ecolóxica: "A agricultura ecolóxica é un sistema produtivo que promove a saúde dos solos, ecosistemas e persoas. Ten como base os procesos ecolóxicos, a biodiversidade e os ciclos adaptados ás condicións locais en alternativa ao uso de insumos con efectos adversos. A agricultura ecolóxica combina a tradición, innovación e ciencia para beneficio do medio ambiente e promoción das relacións xustas e a calidade de vida para todos os organismos involucrados" (IFOAM, 2005a).

Os principios da Agricultura Ecolóxica aplícanse no seu sentido máis amplo e inclúen a forma na que as persoas coidan o solo, a auga, as plantas e os animais para producir, preparar e distribuír alimentos e outros bens. Estes principios teñen como obxectivo servir de inspiración ao movemento ecolóxico en toda a súa diversidade, orientar o desenvolvemento de posicións políticas, programas e normas de IFOAM(IFOAM, 2005b).

- Principio de Saúde: " *A agricultura ecolóxica debe soster e promover a saúde do solo, das plantas, dos animais, das persoas e do planeta como unha única e indivisible*". Sostendo polo tanto que a saúde dos individuos e comunidades non pode ser separada da saúde dos ecosistemas. Debe polo tanto verse a saúde non só como a ausencia de enfermidade senón como o mantemento do benestar físico, mental, social e ecolóxico. Polo tanto o rol da agricultura ecolóxica vai ser manter e mellorar a saúde dos ecosistemas e organismos, desde o máis pequeno ata os seres humanos, tendo como finalidade producir alimentos nutritivos de alta calidade que promovan o coidado da saúde e do benestar. Por iso se debe evitar o uso dos fertilizantes, praguicidas, produtos veterinarios e aditivos que podan ocasionar efectos negativos na saúde.

- Principio de Ecoloxía: "*A agricultura ecolóxica debe estar baseada en sistemas e ciclos ecolóxicos vivos, traballar con eles, emulalos e axudar a sostelos*". Establece polo tanto que a produción debe estar baseada en procesos ecolóxicos e na reciclaxe. A nutrición e o benestar lógranse a través da ecoloxía do ambiente específico de produción; así, por exemplo, no caso dos cultivos este é o solo vivo, nos animais é o ecosistema da granxa e nos peixes e organismos mariños é o ambiente acuático. Os ecosistemas de agricultura ecolóxica, pastoreo e aproveitamento de produtos silvestres deben axustarse aos ciclos e equilibrios ecolóxicos da natureza, sendo estes universais pero o seu funcionamento é específico ao lugar. O manexo ecolóxico debe adaptarse ás condicións locais, ecoloxía, cultura e escala. Os insumos deben diminuír mediante a reutilización, reciclaxe e manexo eficiente dos materiais e enerxía para así manter e mellorar a calidade ambiental e a conservación dos recursos. Polo tanto o obxectivo da agricultura ecolóxica é lograr o equilibrio ecolóxico a través do deseño de sistemas agrarios, o establecemento de hábitats e o mantemento da diversidade xenética e agrícola. Os que producen, transforman, comercializan ou consomen produtos ecolóxicos deben protexer e beneficiar o ambiente común que inclúe paisaxes, hábitat, biodiversidade, aire e auga.
- Principio de Equidade: *"A agricultura ecolóxica debe basearse en relacións que aseguren a equidade con respecto ao ambiente común e ás oportunidades de vida".* A equidade está caracterizada pola igualdade, o respecto, a xustiza e a xestión responsable do mundo compartido; todos aqueles involucrados na agricultura ecolóxica deben conducir as relacións humanas de tal maneira que aseguren a xustiza a todos os niveis e a todas as partes (produtores, traballadores agrícolas, transformadores, distribuidores, comercializadores e consumidores). A finalidade da agricultura ecolóxica é proporcionar unha boa calidade de vida a todos os involucrados e contribuír á soberanía alimentaria e á redución da pobreza, producindo alimentos de calidade e outros produtos en cantidade suficiente. Dentro deste principio tamén se engloba outorgar aos animais as condicións de vida acordes coa súa fisioloxía, comportamento natural e benestar. Os recursos naturais e ambientais deben manterse como legado para futuras xeracións.
- Principio de Precaución: *"A agricultura ecolóxica debe ser xestionada dunha maneira responsable e con precaución para protexer a saúde e o benestar das xeracións presentes e futuras".* Os que practican este tipo de agricultura poden incrementar a eficiencia e a produtividade sempre que non comprometan a saúde e o benestar. Isto fai que as novas tecnoloxías teñan que ser avaliadas e os métodos existentes revisados. Por este motivo a ciencia é necesaria para asegurar que sexa saudable, segura e ecoloxicamente responsable.

A normativa ecolóxica tamén nos proporciona información sobre o termo agricultura ecolóxica e os seus principios (EC, 2007) facendo referencia a que a agricultura ecolóxica é un sistema produtivo que combina as boas prácticas ambientais, cun alto nivel de biodiversidade, a preservación dos recursos naturais, a aplicación dun alto nivel de benestar animal e un método produtivo que concorda coa preferencia dun certo sector de consumidores. Nesta normativa faise referencia entre outros aspectos á necesidade de usar recursos dispoñibles a nivel local e así como minimizar o uso de recursos non renovables. Finalmente establece como *obxectivos* da produción ecolóxica os seguintes:

- Establecer un sistema de manexo sostible que respecte os sistemas naturais e sosteña e mellore a saúde do solo, auga, plantas e animais e o equilibrio entre eles, contribúa a unha alta diversidade biolóxica, faga un uso responsable da enerxía e os recursos naturais como a auga, o solo, a materia orgánica e o aire, presente un alto nivel de benestar e en particular acade as necesidades específicas de comportamento animal.
- Ter como obxectivo elaborar produtos de alta calidade.
- Ter como obxectivo producir unha ampla variedade de alimentos e outros produtos agrícolas que satisfagan as demandas dos consumidores en canto a bens producidos usando procesos que non danen o ambiente, a saúde das persoas e das plantas nin tampouco a saúde e benestar dos animais.

2. EVOLUCIÓN HISTÓRICA DA AGRICULTURA E GANDERÍA ECOLÓXICA

A agricultura e gandería ecolóxica aparece no século XX como unha reacción global e unha vontade de cambiar o sector. A produción ecolóxica é un sistema deseñado para optimizar a produtividade e o estilo de vida da comunidade, incluído o manexo de múltiples recursos como o solo, os cultivos, o gando e a xente (OMAFRA, 2009). A creación en 1972 da IFOAM foi un piar básico para o desenvolvemento da agricultura ecolóxica actual. Tanto IFOAM como outras institucións e colectivos interesados en todo o mundo traballaron no desenvolvemento das guías para o manexo dos sistemas desde o punto de vista ecolóxico, social e económico. Os principios da produción de gando ecolóxico inclúen a preservación da biodiversidade, o desenvolvemento de prácticas adaptadas ao comportamento natural dos animais e do desenvolvemento dun manexo sostible das explotacións (IFOAM, 2005c).

A pesar da difusión e aceptación destes principios da agricultura ecolóxica no principio dos anos 60 en Europa, o grande crecemento da mesma non se aprecia ata o final dos 90, con máis de 120.000 granxas ecolóxicas en 1999 (Padel, 2000; Padel et al., 2004). O número de animais criados en ecolóxico aumentou expoñencialmente desde aquel momento con determinados países liderando o cambio desde os sistemas intensivos cara os ecolóxicos, entre eles destacan Austria, Francia, Reino Unido, Suecia, Italia e España (EC, 2013). De feito, a produción ecolóxica está medrando nun rango de 10 a 20% por ano en Europa, mentres que os sistemas convencionais están decrecendo debido á crise económica global (Díez et al., 2012). O número de vacas de leite en granxas ecolóxicas alcanzou os 0,7 millóns de animais, representando aproximadamente o 3% do censo de vacas de leite rexistradas en Europa en 2011 (EC, 2013).

A pesar deste crecemento, as granxas ecolóxicas seguen a ter un número limitado de animais e polo tanto un tamaño pequeno cando as comparamos coas convencionais. De feito, arredor do 85% das granxas ecolóxicas pertencen a un só propietario ou a unha soa familia (Organic Farming Research Foundation, 2003). Ademais, as granxas ecolóxicas en Europa invisten menos en tecnoloxía do que as convencionais, en estudos recentes móstrase que as granxas ecolóxicas de leite son un 4,5% menos eficientes tecnicamente do que as intensivas (Sipilainen and Oude-Lansink, 2005). De usar os avances tecnolóxicos deseñados para as granxas intensivas a produtividade das granxas ecolóxicas mellorarìa nun 5,3% (Kumbhakar et al., 2009). Porén, os investimentos na produción ecolóxica parecen estar condicionados á filosofía produtiva do gandeiro, máis enfocada ao benestar animal e á produción que aos aspectos económicos (Escalante et al., 2013). A diversificación da produción nas granxas ecolóxicas, incluída a produción de queixo (Nauta et al., 2006a), iogur (Van Loo et al., 2013) ou a atracción de turistas á granxa (Villarino Pérez et al., 2009), poden aumentar os beneficios destas granxas pequenas e pouco tecnolóxicas (San Segundo-Barahona, 2008; Pouliquen, 2014).

O sector ecolóxico espertou recentemente a atención da comunidade científica, como demostran os estudos sobre prácticas de manexo en sistemas ecolóxicos (Organic Research, 2015) e a creación de Network for Animal Health and Welfare in Organic Agriculture (NAHWOA), que é un proxecto da Comisión Europea que ten como finalidade formar unha plataforma conxunta de organizacións dedicadas á investigación e institucións involucradas na gandería ecolóxica (NAHWOA, 2001). Actualmente, a investigación no campo da agricultura ecolóxica céntrase na avaliación da saúde animal e na maximización do uso dos recursos dispoñibles. Porén, a información dispoñible sobre as razas e o perfil xenético das vacas que pode ser máis eficiente en produción ecolóxica é aínda escaso (Ahlman, 2010).

3. NORMATIVA ECOLÓXICA

A agricultura ecolóxica encóntrase regulada en España desde o ano 1989, no que se aprobou o Regulamento da denominación Xenérica "Agricultura Ecolóxica", que foi de aplicación ata a entrada en vigor do Regulamento Europeo (CEE) 2092/91 sobre a produción agrícola ecolóxica e a súa indicación nos produtos agrarios e alimenticios. O Consello Regulador de Agricultura Ecolóxica era o organismo encargado de controlar a produción ecolóxica en todo o territorio estatal. A partir de 1993, establécese un novo regulamento de agricultura ecolóxica (Real Decreto 1852/1993) elaborado a partir do anterior, é neste momento cando as Comunidades Autónomas comezan a asumir as competencias no control deste sistema de produción.

A pesar do cambio nas normativas o Regulamento Europeo (CEE) 2092/91 e as súas posteriores modificacións estivo vixente ata o ano 2007, momento no que se publicou o Regulamento (CEE) 834/2007 do Consello sobre a produción e etiquetado dos produtos ecolóxicos e o Regulamento (CE) 889/2008 polo que se establecen as disposicións do anterior Regulamento no que se refire a importacións de produtos ecolóxicos procedentes de terceiros países.

A regulamentación da agricultura e gandería ecolóxica garante que os produtores inscritos baixo o selo de produción ecolóxica cumpran uns determinados requisitos e que estean dados de alta no organismo de control competente en cada país (Blanco-Penedo, 2008). En España, os Consellos ou Comités de Agricultura Ecolóxica territoriais son os que se encargan do control e certificación da produción agraria ecolóxica, son organismos dependentes das Consellerías ou Departamentos de Agricultura ou Medio Rural das Comunidades Autónomas ou das direccións xerais adscritas ás mesmas. En Galiza, o CRAEGA (Consello Regulador de Agricultura Ecolóxica de Galicia) é o organismo que controla e certifica as producións ecolóxicas da comunidade (CRAEGA, 2014).

No que respecta á inclusión das razas na gandería ecolóxica o Regulamento (CE) 1804/1999 que modifica o Regulamento (CEE) 2092/91 establece que se debe preservar a variabilidade ecolóxica e que para a escolla da raza se debe ter en conta a súa capacidade para se adaptar ás condicións locais, así como a súa vitalidade, resistencia a enfermidades ou problemas de saúde (sendo unha medida de prevención dos mesmos). Polo tanto a escolla das razas ou liñas produtivas ha de facerse tentando evitar os problemas de saúde ou enfermidades asociadas a determinadas razas propias da produción intensiva. Fai especial fincapé en que se debe dar preferencia ás razas ou liñas autóctonas. O Regulamento (CE) 834/2007 e o Regulamento (CE) 889/2008 volven facer fincapé nos aspectos anteriormente mencionados.

Por outro lado en canto á autenticación dos produtos o Regulamento (CEE) 2092/91 establece que a finalidade do Regulamento é establecer uns principios que permitan establecer inspeccións específicas en canto aos sistemas ecolóxicos. Esta regulamentación harmoniza as normas de produción, etiquetaxe e inspección para as especies máis importantes, facendo fincapé na importancia de proporcionar unha adecuada protección do consumidor. Establece ademais que todo operador que queira producir gando en ecolóxico estará suxeito a inspeccións regulares, o rexistro das entradas e saídas de gando, así como de administración de tratamentos, ten que estar accesible e ter os datos actualizados.

No Regulamento (CE) 834/2007 establecese que as autoridades competentes que deleguen as funcións de control a corpos de inspección deben auditar as súas labores, se desa auditoría resulta que non realizan os procedementos adecuadamente debe suspenderse inmediatamente a delegación de competencias. O Regulamento (CE) 889/2008 establece que os corpos de inspección ou autoridades inspectoras deben realizar como mínimo unha inspección física ao ano a todos os operadores, durante a inspección a autoridade ten que tomar mostras dos produtos non autorizados para produción ecolóxica ou de produtos en xeral para comprobar se se está actuando de conformidade co establecido nas leis de produción ecolóxica. Tamén se tomarán mostras para determinar posibles contaminacións cruzadas con produtos non autorizados para produción ecolóxica. Despois de cada visita a autoridade competente entregará un informe asinado polo operador ou o seu representante. Ademais, as autoridades ou corpos de inspección deben realizar visitas aleatorias de control, preferiblemente acudindo sen aviso previo, baséandose no risco xeral de incumprimento das normas de produción ecolóxica, tendo en conta polo menos os resultados de controis previos, a cantidade de produtos problemáticos e o risco de intercambio de produtos.

4. SITUACIÓN RACIAL DAS VACAS DE LEITE A NIVEL MUNDIAL

Os sistemas de produción de leite de vacún están dominados a nivel mundial pola raza Holstein (Frisoa norteamericana) (Zenger et al., 2007; Oltenacu and Broom, 2010; Felius et al., 2015), presentado poucas excepcións a esta dominancia. A raza Holstein apareceu nos Estados Unidos procedente de animais importados do Norte de Europa nos últimos anos do século XIX; nun primeiro momento a súa expansión limitouse a Norteamérica ata o comezo de 1970 cando comezaron as exportacións (Oltenacu and Broom, 2010). Os factores responsables da expansión da raza Hosltein foron i) o feito de coñecerse a nivel mundial que esta raza producía unha maior cantidade de leite cas outras razas, particularmente en sistemas de produción intensiva, ii) os obxectivos a nivel mundial dos gandeiros de bovino de leite centráronse nos ingresos da venda do leite e iii) o desenvolvemento da tecnoloxía reprodutiva necesaria para importar seme e embrións desde os Estados Unidos a outros países (Brotherstone and Goddard, 2005; Oltenacu and Broom, 2010).

O extraordinario potencial produtivo da Holstein cando se alimenta con dietas de alta calidade levou ao desenvolvemento de explotacións convencionais moi especializadas e cunha alta tecnoloxía, capaces de aportar unha alimentación equilibrada nun ambiente cómodo e controlado. Neste escenario favorable, a xenética da Holstein foi incorporada rapidamente nos rabaños europeos, reemprazando amplamente tanto a Frisoa orixinal coma outras razas locais (Philipsson, 1987; Brotherstone and Goddard, 2005). A expansión deste modelo de gandería de leite con vacas Holstein baixo as condicións de gandería intensiva levou a un aumento importante na produción de leite, deste xeito, en moitos países a produción de leite por vaca aumentou máis do dobre entre 1965 e 2005 (Oltenacu and Algers, 2005; Knaus, 2009).

Aínda que a nutrición e o manexo axudaron a mellorar a produción de leite da Holstein, o aumento drástico da súa produción débese principalmente ao progreso xenético (Brotherstone and Goddard, 2005; Oltenacu and Algers, 2005; Oltenacu and Broom, 2010). Estimouse que a selección xenética responde a un 55% da ganancia produtiva observada a nivel fenotípico (Pryce and Veerkamp, 2001; Shook, 2006). Este tipo de produción apareceu como resultado dunha alta intensidade selectiva e uns estritos obxectivos de cría tendo como finalidade o aumento produtivo e o potencial para aumentar a eficiencia incluíndo características con capacidade para reducir os custos que non foran tidas en conta durante décadas. Estas características son xeralmente as chamadas "características funcionais" (p. ex. saúde, saúde do ubre, lonxevidade e reprodución), que se observou que están correlacionadas negativamente coa produción de leite (Roxström, 2001; Wall et al., 2003; Ahlman, 2010). Seleccionar os animais en función das características funcionais é complicado debido ás dificultades para identificar e definir as características, ademais da baixa heredabilidade das mesmas (Berglund, 2008). Como resultado da selección das vacas

Holstein aumentouse a produción de leite por vaca pero tendo como consecuencia unha redución da resistencia a enfermidades e da fertilidade na poboación global das vacas de leite (Rauw et al., 1998; Haile-Mariam et al., 2004; Oltenacu and Algers, 2005; Jorjani et al., 2009; Bjelland et al., 2011).

Existen poucas excepcións ao uso dominante de vacas da raza Holstein, xeralmente atópanse ligadas a sistemas de pastoreo ou sistemas que se centran no fomento de razas rústicas coma as Frisoas adaptadas a pastoreo, os cruces ou razas locais. O sistema novozelandés é, sen ningunha dúbida, o sistema de pastoreo máis importante exportado a nivel mundial, trátase dun sistema de baixos insumos comparable ao sector ecolóxico desde o punto de vista nutricional (Basset-Mens et al., 2009). Os gandeiros de Nova Zelandia seleccionaron a súa propia liña de vacas Frisoas derivadas de animais importados dos Estados Unidos antes de 1925; a selección desta liña céntrase na capacidade de produción de graxa e proteína mentres que o volume de leite se penaliza (Macdonald et al., 2008). No sistema de pastoreo novozelandés empréganse para producir, a parte do Frisón rústico propio (34,7%), tamén vacas Jersey (10,4%) e cruces de ambas razas (45,6%), así como outras razas rústicas (9,3%).

Nos sistemas convencionais tamén se poden atopar razas autóctonas a pequena escala, dentro de Europa, as razas Fleckvieh e Parda Alpina son as máis comúns nos sistemas leiteiros de Austria e Suíza (ZAR, 2014). No entanto que nos Países Nórdicos coma Suecia é a Vermella Sueca quen se encontra en maior proporción (45,8%) acompañada de outras razas europeas e cruces que representan un 6,4% do total de razas (Ahlman, 2010). Finalmente, en Francia aínda que é a Holstein quen domina os rabaños convencionais (66,2%) existe certa variedade racial, xa que tamén se empregan outras razas como a Montbeliarde (17.5%) e a Normanda (8,3%) (Institute d'Elevage and France Conseil Elevage, 2016).

5. SITUACIÓN RACIAL NA GANDERÍA ECOLÓXICA

A pesar das recomendacións da Comisión Europea en canto ao uso de razas (EC, 2007; EC, 2008) fixéronse poucos esforzos por encontrar unha raza ben adaptada ás condicións ecolóxicas, dando como resultado que os gandeiros manteñen a mesma raza que antes de se adaptaren a ecolóxico. De feito, na maioría dos casos as vacas de leite presentes en ecolóxico seguen a se seleccionar baseándose na información obtida para os sistemas convencionais (Boelling et al., 2003; Nauta, 2010). Estudos recentes recollen que o principal reto para unha gandería ecolóxica sostible é identificar os xenotipos mellor adaptados a un sistema baseado no consumo de forraxes, este reto gaña importancia a medida que as condicións ambientais de ecolóxico e convencional diverxen xa que os obxectivos produtivos tamén se distancian (Thanner et al., 2014; Zollitsch et al., 2014).

Durante a última metade do século XX, a selección xenética das vacas de leite centrouse case exclusivamente na raza Holstein para mellorar a produción de leite. Este proceso dá lugar a unha vaca que pode considerarse un animal de alto rendemento adaptado á produción en sistemas intensivos altamente estandarizados. Porén, os sistemas de produción ecolóxica son moi diferentes dos convencionais, sobre todo en canto a réxime de alimentación e tratamentos veterinarios (Ahlman, 2010). O proceso de selección anteriormente citado deu como resultado unha redución da eficiencia reprodutiva (aumento do intervalo entre partos), aumento dos problemas de saúde, aumento das taxas de eliminación e redución da vida produtiva (González-Recio et al., 2006; Bluhm, 2009), especialmente cando estas vacas altamente seleccionadas se crían fóra do sistema de manexo intensivo e altamente suplementado a nivel nutricional. De feito, as vacas Holstein altamente produtivas mostran unha capacidade limitada de adaptación aos sistemas de baixos insumos propios das granxas ecolóxicas (Nauta et al., 2001; Nauta, 2010; Zollitsch et al., 2014), dando como resultado problemas de lonxevidade (Kolver, 2003) e de eficiencia produtiva (Diepen et al., 2007; Garmo et al., 2009).

Neste contexto, ao mesmo tempo que a gandería ecolóxica foi medrando en Europa os gandeiros déronse conta que as vacas usadas en convencional non estaban ben adaptadas ás necesidades da gandería ecolóxica (Vaarst et al., 2004; Nauta, 2010). En xeral os gandeiros ecolóxicos demandan vacas máis robustas (Ahlman, 2010), entendendo por robusticidade a habilidade de producir adecuadamente nas estritas condicións ecolóxicas (Strandberg and Roxström, 2000). As preferencias dos gandeiros ecolóxicos son diferentes dos que están en convencional polo tanto os obxectivos de produción deberían centrarse na resistencia a enfermidades e na lonxevidade a expensas da produción de leite (Ahlman et al., 2014; van Soest et al., 2015).

A diversidade racial dos sistemas ecolóxicos é similar á descrita para os sistemas convencionais, dominando as vacas de raza Holstein cunha tendencia a aumentar en porcentaxe, como sucede por exemplo en Alemaña (Nauta et al., 2005a, 2006b; Rahmann and Nieberg, 2005), Canadá (Rozzi et al., 2007) e España (Rodríguez-Bermúdez et al., 2016), aínda que algúns países escapan desta tendencia e conseguen manter certas razas locais.

Nos Países Baixos, as granxas ecolóxicas especializadas na produción de leite usan vacas de raza Holstein (29%) e os seus cruces con razas máis robustas (51%) como son a Parda Alpina, Montbeliarde e razas de dobre aptitude como a Maas-Rijn-Ijssel. Porén nas granxas multifuncionais, a Holstein representa só unha pequena fracción (2%) das razas usadas, sendo predominantes os cruces (57%) e as vacas autóctonas holandesas (34%) (como a Maas-Rijn-Ijssel, Groninger White Face e Frisoas holandesas) (Nauta et al., 2009). Nas granxas ecolóxicas suecas a maioría das vacas son de raza Vermella Sueca (54,3%) e a proporción de vacas Holstein (35,5%) é menor que nos rabaños convencionais (46,9%), aumentando a proporción de razas menores como a Jersey (1,5%), Swedish Polled (1,2%) e cruces (7,7%) (Ahlman, 2010). En Austria e Suíza, as razas locais, Parda Alpina (51,7%) e Fleckvieh (34,6%) predominan nos sistemas ecolóxicos como xa o facían nos convencionais (Baumung et al., 2001; Haas and Bapst, 2004).

6. A ADAPTACIÓN DAS VACAS DE LEITE A ECOLÓXICO. CARACTERÍSTICAS QUE SE DEBEN MELLORAR

Como xa se mencionou anteriormente as vacas Holstein seleccionáronse para alta produción láctea en sistemas intensivos. Independentemente do tipo de sistema, o obxectivo dos gandeiros é maximizar os beneficios sen comprometer a saúde, a fertilidade e o benestar animal (Pryce et al., 1999a). Aínda nas condicións de manexo óptimas a selección enfocada cara ao aumento da produción de leite leva a un empeoramento da saúde e da eficiencia reprodutiva nas vacas de leite a nivel mundial, xa que estas características están correlacionadas negativamente (Rauw et al., 1998; Pryce and Veerkamp, 2001; Evans et al., 2002; Brotherstone and Goddard, 2005; Oltenacu and Algers, 2005; Oltenacu and Broom, 2010; Prendiville et al., 2011a).

A eficiencia reprodutiva das vacas de alta produción Holstein decrece de maneira importante cando se mudan a outros ambientes, o que fixo dubidar se estes xenotipos seleccionados en sistemas de altos insumos son adecuados para os sistemas ecolóxicos que se basean no aproveitamento de forraxes (Grétar and Hardarson, 2001; Kristensen and Pedersen, 2001; Nauta et al., 2001, 2006c; Horn et al., 2012), sendo sistemas de baixos insumos que requiren en maior medida alta fertilidade e eficiencia reprodutiva que produción individual de leite (Dillon et al., 2003a; Veerkamp et al., 2003). Tendo en conta que a maioría dos touros se proban en sistemas que aportan altas cantidades de concentrado, é importante determinar se o comportamento produtivo das fillas é diferente en función do sistema no que sexan testados (Pryce et al., 1999a).

As vacas de alta produción empregan unha grande cantidade da enerxía para producir leite (Dillon et al., 2006), pero non son capaces de alcanzar eses niveis sen consumir suplementos de alta calidade. Cando estes animais se alimentan soamente a base de pasto a súa capacidade de inxestión diaria diminúe arredor do 20% (Kolver, 2003), co que non poden expresar o seu potencial xenético. Isto suxire que cando as vacas de alta produción se introducen en sistemas ecolóxicos teñen maior risco de sufrir desordes metabólicas e baixa fertilidade debido ás deficiencias enerxéticas na lactación temperá (Knaus et al., 2001; Kristensen and Pedersen, 2001). Polo tanto é difícil que estas vacas se podan adaptar a sistemas de baixos insumos coma o ecolóxico. Ademais, nos sistemas de pastoreo as vacas de alta produción mostran unha peor fertilidade, menor condición corporal e son eliminadas en maior medida que outras dun mérito xenético medio (Rozzi, 2012). Nos sistemas de pastoreo coma o de Nova Zelandia, as vacas Holstein con alto potencial xenético para a produción de leite tamén mostran baixas taxas de supervivencia, mala fertilidade e mala condición corporal, polo tanto o seu rendemento vese grandemente reducido ao final da súa vida produtiva (Harris and Kolver, 2001).

Coa finalidade de resolver a perda de eficiencia das vacas Holstein nalgúns sistemas produtivos estableceuse o concepto interacción xenotipo-medio ambiente, do inglés Genotype by Environment Interaction (GxE). A interacción GxE pode definirse como un cambio na resposta dos xenotipos a diferentes ambientes ou cambios no mérito xenético relativo en diferentes ambientes (Falconer and Mackay, 1996). As interaccións GxE son especialmente importantes cando os animais se crían nunhas condicións ambientais específicas (como é o caso da produción ecolóxica) debido ao seu potencial para manter a diversidade xenética (Charlesworth and Hughes, 2000). Convén ter en conta que cando os animais están xeneticamente adaptados a unhas condicións específicas son máis produtivos e os custos e produción son menores (Simm et al., 2004).

As interaccións GxE para a produción de leite describíronse ben para os rabaños convencionais; xa que os produtores de leite de varios países mostraron a súa preocupación respecto do descenso da fertilidade das vacas con altas proporcións de xenética Holstein (Weigel et al., 2001; Kearney et al., 2004). Varios estudos indican que existe unha alta correlación xenética negativa entre a produción, a fertilidade e a saúde das vacas de leite modernas criadas en sistemas de produción intensivos (Verkerk et al., 2000; Harris and Kolver, 2001). Isto é indicativo dunha diminución na adaptación asociada a unha selección para o aumento da produción de leite na vaca de leite actual (Oltenacu and Algers, 2005).

Dentro do sistema ecolóxico, as interaccións GxE observáronse no caso das características produtivas nos Países Baixos (Nauta et al., 2006c) e para as características relacionadas coa fertilidade en Suecia (Sundberg et al., 2010). Debido as interaccións GxE, os touros seleccionados para empregar en sistemas convencionais poden non ser adecuados aos sistemas ecolóxicos (Nauta et al., 2006c). Se unha característica coma a produción de leite a controlan diferentes xenes, dependendo do sistema produtivo, é posible que a clasificación de sementais varíe tamén entre os sistemas (Pryce et al., 1999a).

A interacción consanguinidade x medio ambiente é un tipo particular de interacción GxE (Fox and Reed, 2011) que pode ser moi importante nos sistemas de produción de leite, sobre todo cando se seleccionan animais altamente emparentados que logo se empregan en ambientes pouco favorables. A consanguinidade é o resultado da cría de animais procedentes de ancestros emparentados entre si, o que fai que aumente a homocigosidade xenómica tanto no propio individuo resultante como nas poboacións. Deste xeito, a consanguinidade resulta nunha perda da saúde xeral que se coñece como depresión consanguínea. Porén, a expresión e magnitude da depresión consanguínea pode ser moi sensible ás condicións ambientais nas que se mida a consanguinidade porque a expresión xenética varía en función das condicións ambientais (Armbruster and Reed, 2005). Os individuos consanguíneos son con máis frecuencia sensibles ao estrés ambiental, posiblemente porque o estrés aumenta a expresión de alelos deletéreos recesivos ou porque as células defensivas fronte ao estrés se levan a unhas condicións fisiolóxicas límite (Fox and Reed, 2011), polo que reducen o valor de algunhas características funcionais, particularmente aquelas relacionadas coa reprodución (Pryce et al., 2004; Adamec et al., 2006; Bjelland et al., 2013).

De acordo co United States Department of Agriculture Animal Improvement Laboratories (USDA-AIPL, 2012), o coeficiente de consanguinidade para as Holsteins medrou de 0,4% en 1970 a 5,8% en 2012. O exceso de parentesco entre os animais levou a unha rápida perda de variabilidade xenética e a efectos fenotípicos adversos asociados coa consanguinidade (Gurgul et al., 2016). Na actualidade o manexo dos niveis de consanguinidade é un obxectivo importante nos programas de cría das vacas de leite para asegurar que as poboacións bovinas son capaces de se adaptar aos obxectivos de cría mantendo a diversidade xenética e evitando os efectos negativos asociados á depresión consanguínea (Howard et al., 2017).

A busca dunha vaca de leite ideal non só é unha preocupación dos sistemas ecolóxicos, senón que a nivel mundial os produtores de leite recoñecen que o beneficio non responde necesariamente a unha alta produción de leite, sobre todo se os custos de mantemento continúan a medrar (Bluhm, 2009). Os gandeiros que traballan en sistemas de baixos insumos prefiren xeralmente vacas máis robustas que manteñan boas producións de leite pero sen padecer problemas de saúde (Nauta, 2001). Estudos desenvolvidos en Nova Zelandia (Harris and Winkleman, 2000) e Irlanda (Dillon et al., 2003a; b), onde os sistemas produtivos se basean no pastoreo indicaron que as vacas máis beneficiosas para estes ambientes son diferentes das seleccionadas en réximes onde se aportan grandes cantidades de concentrado. Un estudo económico realizado en Nova Zelandia demostrou que existe unha diferenza do 12% nas ganancias económicas por granxa a favor da raza Frisoa de Nova Zelandia con respecto ás Holstein de xenética norteamericana (LIC, 1999).

A produción de leite non é a única característica que debe ser considerada. Aínda que a información é escasa, os gandeiros en sistemas ecolóxicos manifestan que dentro das características que se deberían priorizar están a lonxevidade, a capacidade de inxestión de forraxe e a resistencia a enfermidades (especialmente a resistencia á mamite e aos parasitos) deberían ocupar un lugar de relevancia, aínda a expensas da produción de leite (Ahlman et al., 2014). Tamén son características importantes a ter en conta a fertilidade, pés e patas robustos, boa produción de graxa e proteína, baixos recontos de células somáticas, capacidade de inxestión de alimentos e capacidade de conversión de alimentos (Haas and Bapst, 2004; Pryce et al., 2004; Horning, 2006; Rodríguez-Bermúdez et al., 2016). Os produtores ecolóxicos están xeralmente máis interesados en fomentar as características funcionais cando se seleccionan animais para recría do que o están os gandeiros convencionais, isto débese a razóns económicas e de ética (Pryce et al., 2004). En Europa, os gandeiros ecolóxicos prefiren vacas con boas características funcionais que sexan capaces de sobrevivir nas condicións ambientais propias da gandería ecolóxica, que se engloban no concepto clásico de lonxevidade.

Na produción de bovinos de leite considerouse que a lonxevidade é un reflexo da capacidade da vaca para evitar ser eliminada debido á baixa produción, infertilidade ou enfermidades (Vollema and Groen, 1996). Mentres que as vacas poderían vivir 20 anos ou máis, na actualidade poucas vacas en produción de leite pasan dos 6 anos nas explotacións máis modernas (Rushen and Passillé, 2013). Esta caída na lonxevidade relaciónase co feito de que os programas de selección da raza Holstein enfocáronse historicamente cara a produción de leite a expensas das características funcionais, incluída a lonxevidade (Xue et al., 2011). O descenso na lonxevidade nas granxas de leite débese xeralmente á eliminación involuntaria. Esta é necesaria xa que reduce o sufrimento individual dos animais, é produto xeralmente de enfermidades ou problemas reprodutivos que causan problemas de benestar animal. A eliminación involuntaria reduce o beneficio das granxas de leite e resulta contraproducente cos obxectivos de sostibilidade na produción de leite (Ahlman et al., 2011; Rushen and Passillé, 2013). Nos sistemas intensivos onde a incidencia de laminite é maior, a eliminación debido á mesma é un dos principais riscos de eliminación involuntaria (Haskell et al., 2006; von Keyserlingk et al., 2012), tamén o son a metrite e os problemas reprodutivos (Pinedo and

De Vries, 2010; De Vries, 2013; Fouz et al., 2014), a mamite (Bergsten, 2013; Fouz et al., 2014) así como as feridas nos cascos (Barrientos et al., 2013).

A lonxevidade das vacas de leite desde o punto de vista da duración cunha produción aceptable é especialmente relevante na produción ecolóxica (Ahlman et al., 2011; Slagboom et al., 2016). Como xa se mencionou anteriormente, os estudos desenvolvidos en relación coa lonxevidade e as causas de eliminación nas vacas de leite en ecolóxico son escasos. Nun estudo realizado en Ontario (Canadá), encontrouse que a infertilidade era a principal causa de eliminación nos sistemas ecolóxicos, seguido da mamite e os problemas de podoloxía, aínda que os gandeiros que traballaban con explotacións menos produtivas tamén mencionaron a baixa produción (Rozzi, 2012). Os gandeiros de ambas explotacións, as máis e as menos produtivas, mencionaron que a idade do animal era máis relevante nas causas de eliminación que o tipo de vaca, lesión ou temperamento. No que respecta a Europa, encontráronse resultados similares nun estudo desenvolvido en Suecia (Ahlman, 2010; Ahlman et al., 2011), sendo as principais razóns de eliminación nos sistemas ecolóxicos a mala saúde do ubre, seguida da infertilidade, baixa produción e problemas podais. Polo contrario, nun estudo recente nos sistemas ecolóxicos do norte de España (Rodríguez-Bermúdez et al., 2016) encontraron que os animais se eliminaban principalmente debido á idade (73,2%), seguida da infertilidade (14,3%), mamite (10,7%) e laminite (1,8%); a pesar destes resultados os gandeiros manifestan non estar contentos cos animais empregados para producir.

Os gandeiros en ecolóxico deben ter outras prioridades a parte da xa mencionada lonxevidade cando buscan unha vaca adecuada para as súas granxas. Aínda que moitos gandeiros continúan a se especializar na produción de leite, moitos outros transformaron as súas explotacións en granxas multifuncionais (van der Ploeg and Renting, 2000; Ventura and Milone, 2000) nas que se produce queixo e iogures, onde incluso teñen tendas dentro da propia granxa (venda de leite, derivados ou carne), se desenvolven actividades de conservacións da natureza, ecoturismo ou recreación (Nauta et al., 2009). Estas diferenzas nas estratexias de venda poden implicar diferentes necesidades respecto ás características raciais (Groen et al., 1995; Diepen et al., 2007). Nas granxas multifuncionais, as características diferentes da produción de leite poden ter máis relevancia. O leite das vacas de raza Jersey conten máis graxa e proteína que o das Holstein (Blake et al., 1980) polo que producen maiores cantidades de queixo por unidade de leite normalizado, cunha maior capacidade para formar o coágulo (Auldist et al., 2004). Tendo en conta isto, as granxas que produzan queixo ou outros derivados lácteos poden obter maior beneficio se usan vacas de raza Jersey ou os seus cruces con Hosltein (Bjelland et al., 2011). Outra característica que os gandeiros con granxas multifuncionais valoran é a capacidade da raza para producir carne de suficiente calidade para ser vendida como co-produto (Diepen et al., 2007; Nauta et al., 2009), como é o caso das razas de dobre aptitude como a Meuse-Rhine-Yssel, Normanda, Fleckvieh, Milking-Shorthorn, Parda Alpina e Montbeliarde. Esta é unha boa maneira de obter beneficio a través da venda de xatos machos nacidos nas explotacións (Serra et al., 2004; Diepen et al., 2007; Rengab-Genetics, 2013), así como da venda de xovencas ou vacas que teñan que eliminarse (por razóns diferentes a enfermidades). Ademais, convén ter presente que usar razas locais ou en perigo de extinción pode servir como unha ferramenta publicitaria ou axudar a atraer visitantes (Van der Ploeg, 2003); deste xeito, os consumidores poden chegar a asociar os seus produtos favoritos cunha determinada raza (Boelling et al., 2003). De feito, o 41% das vacas en produción en granxas multifuncionais dos Países Baixos son razas locais, xa que as razas tradicionais poden presentarse á sociedade e aos consumidores como animais que presentan un claro distintivo ecolóxico (Nauta et al., 2009).

7. COMPORTAMENTO DAS DIFERENTES RAZAS EN ECOLÓXICO E PASTOREO (PROS E CONTRAS)

A identificación de razas que estean ben adaptadas ás condicións de produción ecolóxica é un aspecto amplamente discutido e existe un crecente debate en canto ao uso de razas convencionais na gandería ecolóxica (Nauta et al., 2009). De acordo cos estudos realizados por Diepen et al. (2007) as razas ou liñas raciais deberían seleccionarse evitando enfermidades específicas e problemas de saúde asociados á produción intensiva. As maiores preocupacións están ligadas á habilidade das razas altamente produtivas para adaptarse ás condicións de produción ecolóxica que se caracterizan por unha menor inxestión de proteína e enerxía e un uso limitado dos tratamentos veterinarios. A produción ecolóxica ten ademais que se adaptar ás condicións locais polo que se requiren animais diferentes para adaptarse a estas condicións de produción tamén distintas (Rozzi et al., 2007).

Actualmente é case imposible encontrar animais seleccionados especificamente para a produción ecolóxica, polo que se suxeriu que se trataba dun círculo vicioso arredor da cría animal. Os gandeiros non saben que tipo de animal necesitan e refúxianse nas coñecidas razas probadas en convencional. Os gandeiros en ecolóxicos expresan preferencias similares a aqueles de convencional con respecto aos obxectivos de produción e a varios aspectos produtivos, conformación e funcionalidade dos animais (Martin-Collado et al., 2015; Slagboom et al., 2016). Polo contrario as súas escollas e preferencias expresadas con respecto ás razas e cruces son moi variadas, mentres que os gandeiros en convencional xeralmente manifestan que a Holstein é a mellor raza, en ecolóxico xorden dúbidas e opinións contrarias facendo necesaria unha maior investigación ao respecto. Estas diferenzas son debidas á recente aparición do sector ecolóxico, que fai que sexa un sector aínda en desenvolvemento que está a probar cal é a raza que mellor se adapta. Ademais, hai que ter en conta que os gandeiros ecolóxicos carecen de información acerca do comportamento das razas e cruces nas condicións ecolóxicas. Neste contexto, moitos gandeiros están probando tanto coas Holstein puras herdadas do sector convencional coma con cruces e outras razas, aínda que a información dispoñible acerca do seu comportamento produtivo sexa escasa. Aínda máis escasa é a dispoñible sobre as Frisoas rústicas, sendo estas pouco coñecidas dentro do sector ecolóxico.

7.1. Razas puras diferentes das Holstein

A nivel mundial é amplamente aceptado que as razas locais son máis robustas e están xeneticamente mellor adaptadas á zona á que pertencen que as vacas de raza Holstein (Sundrum, 2001; Diepen et al., 2007). Ademais, suxeriuse que as razas locais están mellor adaptadas aos sistemas ecolóxicos e que son importantes para manter a diversidade xenética (Ahlman, 2010). Estas razas están mellor adaptadas aos sistemas ecolóxicos porque son capaces de utilizar alimentos de menor calidade, son máis resistentes ao estrés climático e aos parasitos e enfermidades locais que as Holstein. Por outro lado, o uso de razas locais en ecolóxico favorece a conservación da varianza xenética dentro da especie, deste xeito estas razas poden conservarse para ser usadas por futuras xeracións de gandeiros (Nauta, 2001). Ademais, o mantemento de razas autóctonas pode ser bonificado por medio da percepción de subvencións da Unión Europea ou dos gobernos rexionais, con motivo de favorecer a conservación das características xenéticas e da herdanza cultural (BOE, 2011; EC, 2014).
De acordo coa Organización das Nacións Unidas para a Alimentación e a Agricultura (FAO) (FAO, 2002), unha raza local é un grupo específico de animais con características externas que permitan agrupalos e distinguilos doutros da mesma especie e que levan suficiente tempo habitando unha zona coma para estar adaptadas a un ou máis sistemas tradicionais de produción ou ás condicións ambientais desa zona. Tendo en conta esta definición poden considerarse razas locais europeas as seguintes razas bovinas: Jersey, Parda Alpina, Fleckvieh, as razas escandinavas, Normanda, Montbeliarde, entre outras razas.
Na actualidade os estudos realizados para avaliar o comportamento produtivo da raza Holstein respecto a outras razas nos sistemas ecolóxicos son limitados. O estudo máis completo, desde o punto de vista do noso coñecemento, é o desenvolvido por Haas et al. (2013) nos Países Baixos onde se analiza o comportamento produtivo de oito razas leiteiras ou de dobre aptitude: Holstein, Frisoa Holandesa, Parda Alpina, Jersey, Montbeliarde, Groningen White Headed, Meuse-Rhine-Yssel e Fleckvieh. Nas condicións nas que se desenvolveu o estudo as vacas Holstein produciron máis leite, seguidas a continuación polas Pardas Alpinas e as Motbeliarde (90 e 82% da produción das Holstein respectivamente), mentres que as vacas Jersey foron as menos produtivas (61%). Porén os contidos de proteína e graxa foron maiores no leite producido polas Jersey que no producido polas Hosltein, de feito só as vacas de raza Fleckvieh produciron cantidades menores que estas últimas. En canto aos recontos de células somáticas (RCS) como indicadores da calidade sanitaria do leite, no caso das Jersey encontráronse maiores RCS que nas outras razas, como tamén se encontrou noutros estudos desenvolvidos en sistemas convencionais (VanRaden and Sanders, 2003; Caraviello, 2004; Sewalem et al., 2006; Berry et al., 2007). Estes resultados explícanse posiblemente por un efecto de dilución do leite observado ao aumentar a produción láctea (Villar and López-alonso, 2015). A avaliación da eficiencia reprodutiva mostra que as vacas Fleckvieh e Groningen White Headed obteñen mellores taxas de fertilidade mentres que as Holstein e as Pardas Alpinas obteñen os peores índices.
En Suíza, os estudos desenvolvidos por Roesch et al. (2005) obtiveron resultados similares ao avaliar o comportamento das vacas de leite en ecolóxico (englobando datos de 60 explotacións cunha diversidade racial do 55,1% cruces de Holstein e Fleckvieh, 19,7% Holstein puras, 18,8% Fleckvieh puras e 6,4% Pardas Alpinas, Jersey e Montbeliarde). A raza

ten unha grande importancia na produción de leite, de feito, os autores encontraron unha menor produción de leite nas vacas de raza Fleckvieh mentres que os cruces de Holstein e as vacas doutras razas (Montbeliarde, Parda Alpina, e incluso as Jersey) producen relativamente maiores volumes de leite. Os resultados da análise loxística que incluíron outros factores relacionados coa produción de leite revelaron que a raza Holstein estaba asociada significativamente con producións de leite altas (por enriba da media).

Outro estudo desenvolvido en Austria comparou as vacas Pardas Alpinas e as Hosltein (Horn et al., 2012, 2013); hai que ter en conta que as Holstein incluídas neste estudo pertencen a unha liña seleccionada dando prioridade ás características reprodutivas. De xeito que en contra do esperado as Pardas Alpinas producían máis leite con maior contido de graxa e proteína, pero mostraban unha peor eficiencia reprodutiva (medida en función do intervalo entre partos) que as vacas Hosltein. Isto corrobora que como foi mostrado por outros autores as vacas de raza Hosltein poden ser seleccionadas para producir en sistemas de pastoreo, aínda que iso leve asociadas menores producións de leite (Pryce et al., 1999b; c).

Como xa se comentou anteriormente os estudos desenvolvidos en ecolóxico son escasos, unha boa aproximación que nos permite obter información do comportamento produtivo das distintas razas é observar as diferenzas que mostran nos sistemas convencionais a pastoreo. Dentro de Europa téñense realizado estudos de gran relevancia en Irlanda, un deles comparou a produción das razas Normanda, Montbeliarde e dúas liñas de Holstein ou Frisón (holandesas e irlandesas) (Dillon et al., 2003b). Aínda que as vacas Frisoas holandesas producen máis leite e graxa e proteína totais que outras razas, as Normandas producen leite con maiores porcentaxes de graxa e proteína que as Montbeliarde e as Frisoas irlandesas e holandesas (Dillon et al., 2003b). A condición corporal (CC) das Normandas e Montbeliarde foi maior que as de ambas liñas de Frisoas (Dillon et al., 2003b). Isto é debido a que unha xenética superior para a produción de leite trae consigo unha menor CC ao longo da lactación (Dechow et al., 2001). De igual forma, as Normandas e Montbeliardes mostran mellor eficiencia reprodutiva que calquera das Frisoas (Dillon et al., 2003a), isto é probablemente debido a un efecto negativo nas características reprodutivas da selección xenética para a produción de leite (Evans et al., 2002). Finalmente, as taxas de supervivencia aos 6-8 anos das razas Montbeliarde (49,2%) e Normanda (55,8%) é maior que o das Frisoas irlandesas (20,6%) e holandesas (39,7%) (Dillon et al., 2003a). Noutros estudos realizados nos sistemas irlandeses de pastoreo, as vacas Hosltein ou Frisoas produciron máis leite que as Jersey (Prendiville et al., 2010, 2011a; b), porén non se encontraron diferenzas no RCS ou na saúde do ubre. Como cabía esperar as vacas Jersey producían leite con maiores contidos de graxa e proteína (Prendiville et al., 2011b) e a CC e capacidade de inxestión de materia seca foi maior na Jersey que nas outras razas (Prendiville et al., 2009, 2011a), os cruces das diferentes razas produciron mellor que as razas puras.

Existe unha limitación cando se decide seleccionar razas diferentes da Holstein ou Frisoa que é a falta en moitos casos de libros de rexistro e programas de selección nas razas con número limitado de exemplares. Polo que os posibles beneficios aportados por estas razas nas características funcionais pode interferir nas características produtivas (Rozzi, 2012). Neste caso é o gandeiro quen ten que asumir a realización do test de proxenie no seu propio rabaño,

este feito pode levar a desaxustes na información. Polo tanto, a mellora das características funcionais acaba resultando nun descenso na produción de leite e conformación do ubre.
Aínda así, a información dispoñible para os sistemas ecolóxicos e convencionais de pastoreo indican que as razas rústicas están mellor adaptadas ás condicións locais, mostrando mellor lonxevidade e mellor eficiencia reprodutiva que as vacas Holstein. Porén, as razas locais soen producir menores cantidades de leite que as Holstein, aínda que xeralmente os contido de graxa e proteína son maiores nas razas puras diferentes das Holstein. As razas locais poden obter un beneficio aceptable naqueles países onde o pagamento do leite se faga en base ao contido de sólidos totais (Davis et al., 2001), de todos os xeitos hai que ter en conta que a produción leiteira de certas razas locais é tan escasa que a produción non é sostible economicamente (Pryce et al., 2004). Tamén convén ter en consideración que o leite das vacas de raza Jersey coagula máis rapidamente e forma un coágulo máis firme que o das Holstein, estas características poden ser de interese para aqueles gandeiros que teñan como obxectivo a produción de queixo (Auldist et al., 2004).

7.2. Cruces de Holstein con razas rústicas

Ata fai pouco tempo considerábase que os cruces ofrecían pouca vantaxe para os produtores de leite en convencional, probablemente debido ao escaso potencial para a produción de leite da maioría das razas en comparación coa raza Frisoa (Prendiville et al., 2011b). Porén, un descenso no mérito xenético para as características funcionais, particularmente fertilidade e saúde (que inciden de forma importante na lonxevidade) resultou nun renovado interese dos cruces na década pasada para o seu uso nos sistemas convencionais de produción de leite (Weigel and Barlass, 2003; Heins et al., 2006a), de xeito que algúns produtores de leite convencionais están a incluír os cruces nos seus programas de cría (Funk, 2006; Hansen, 2006; Walsh et al., 2007; Blöttner et al., 2011). Aínda así, excepto en Nova Zelandia, o cruzamento de vacas de leite ten escasa aceptación a nivel mundial (Buckley et al., 2014). De todos xeitos, o cruzamento dos animais pode ser efectivo para eliminar a consanguinidade (Rozzi et al., 2007; Buckley et al., 2014), factor que causa preocupación (Rozzi, 2012), e para maximizar a heterose (Brotherstone and Goddard, 2005; Rozzi et al., 2007; Begley et al., 2009; Oltenacu and Broom, 2010; Bjelland et al., 2011; Blöttner et al., 2011; Xue et al., 2011) ao introducir características desexables doutras razas (Xue et al., 2011; Buckley et al., 2014).
Os gandeiros ecolóxicos ven como unha boa opción cruzar as altamente produtivas Holstein con razas locais, de feito os gandeiros en sistemas ecolóxicos fano con máis frecuencia do que se fai en convencional. Por exemplo, un estudo desenvolvido en Ontario (Canadá) atopou que o 40% dos gandeiros en ecolóxico cruzaran todo ou unha parte do seu rabaño en comparación co 1% dos gandeiros en convencional (Rozzi et al., 2007). As razas usadas para levar a cabo os cruzamentos en ecolóxico son diferentes das que se usan en convencional, mentres que en convencional os gandeiros usan normalmente Jerseys e Pardas Alpinas para levar a cabo os cruzamentos coas Hosltein, os gandeiros ecolóxicos probaron a facer cruzamentos con outras razas coma a Dutch Belted, Milking Shorthorn e Fleckvieh; os cruces con Dutch Belted son frecuentes e realízanse co obxectivo de incrementar a rusticidade e a capacidade de produción naquelas vacas que van ser alimentadas exclusivamente con forraxes (Rozzi, 2012). Ademais, nas granxas ecolóxicas o grao e tipo (raza usada) de cruce

depende da intensidade produtiva da propia explotación, o cruzamento é máis frecuente nas granxas de produción moderada, e a Parda Alpina é a raza seleccionada polo seu tamaño e capacidade produtiva.
A información acerca do comportamento dos cruces en ecolóxico é escasa. Os cruces entre as vacas Holstein e as outras razas europeas xeralmente producen cantidades de leite intermedias ás de ambas razas parentais (Haas et al., 2013). En Alemaña, Swalve (2007) encontrou que os cruces Holstein e Vermella Sueca tiñan vantaxes produtivas en termos de produción de leite e de contidos de graxa e proteína, pero menores de RCS que as Holstein. Os cruces de Holstein e Parda Alpina producen menores cantidades de leite con maiores contidos de graxa e proteína, polo que a diferenza de contido de proteína e graxa relativa á producida polas Holstein é despreciable. Finalmente, Haas et al. (2013) observaron que os cruces entre as Holstein e outras razas coma a Dutch Friesian, a Parda Alpina, Groningen White Headed, Jersey, Meuse-Rhine-Yssel, Montbeliarde e Fleckvieh melloran a fertilidade e ás veces a saúde do ubre (excepto Jersey e Groningen White Headed). Resultados similares aos encontrados por Swalve (2007) para os cruces entre Holstein e as Vermellas Suecas e as Pardas Alpinas.
A información dispoñible acerca dos cruces en sistemas convencionais en pastoreo de Nova Zelandia, cunha ampla experiencia nos cruzamentos de Jersey con Holstein, pode ser de grande axuda para o sector ecolóxico (Buckley et al., 2014). Moitos estudos que se levaron a cabo nos últimos anos, tanto en Nova Zelandia coma noutros países, baseáronse na superioridade dos cruces comparados coas súas liñas parentais (Holstein, Ayrshire e Jersey) (Lopez-Villalobos and Garrick, 2002). Isto é debido a un alto potencial para aumentar os beneficios a través do cruzamento (Lopez-Villalobos et al., 2000) debido á súa alta capacidade de inxestión de pasto (Prendiville et al., 2009) e á eficiencia de conversión dos alimentos en leite (Garrick, 2002), así como a mellora na fertilidade (Auldist et al., 2007) e a lonxevidade (Harris et al., 1996). As vacas Jersey, coñecidas por producir leite cun alto contido de graxa poden usarse nos programas de cruzamento con Holstein para mellorar a porcentaxe de graxa nun só cruce (Bluhm, 2009). En termos reprodutivos, os cruces de Holstein compórtanse mellor que as razas puras Holstein, con altas taxas de concepción e xestación (Auldist et al., 2007). Existen estudos levados a cabo en sistemas de pastoreo en Irlanda que obtiveron resultados similares aos obtidos en Nova Zelandia (Prendiville et al., 2009, 2010, 2011a; b), por exemplo os cruces de Holstein (nai) x Jersey (pai) producían cantidades intermedias de leite entre ambas razas parentais, onde as Hosltein producían maiores cantidade de leite e as Jersey mellores contidos de graxa e proteína. Non houbo diferenzas en relación ao RCS e mamite. Porén, a condición corporal foi maior nos animais cruzados e nas vacas Jersey que nas vacas Holstein.
Unha vez que os gandeiros saben que razas queren cruzar, o seguinte dilema é decidir que facer despois do primeiro cruce. Unha posible estratexia sería producir cruces en primeira xeración que requiriría manter algunhas vacas en raza pura e inseminar as mellores produtoras con razas pura mentres que as outras vacas puras se cruzarían co touro desexado para producir reposición de cruces para a explotación. Outras opcións inclúen o uso dun programa de cruzamento rotacional continuo ou inclusive producir razas compostas. Un cruce rotacional de dúas vías mantén un 67% da heterose directa, mentres que o triplo ou o

cuádruplo manteñen respectivamente o 86% e o 94% da heterose directa. O reto neste caso estaría en encontrar varias razas de adecuado mérito xenético para producir unha poboación de cruce que é mellor (economicamente) que unha poboación de raza pura (Pryce and Veerkamp, 2001).

Porén, o retrocruce de animais non produce sempre bos resultados, por exemplo, un estudo onde se retrocruzou as vacas Holstein x Parda Alpina con Pardas Alpinas deu como resultado menores producións leiteiras (Dechow et al., 2007). Noutro, a heterose esperada estivo próxima a cero no segundo e terceiro cruces. Un estudo recente levado a cabo na Arxentina encontrou que unha vez se realizan os primeiros cruzamentos (Holstein x Jersey, Holstein x Guernsey, Hosltein x Parda Alpina), as características da Holstein poden recuperarse inseminando as vacas cruzadas cun touro de raza Holstein (Mancuso, 2017). Finalmente, cando se realizan cruces múltiples e non se pode ter un test de proxenie para a produción leiteira, unha solución pode ser inseminar as vacas cruzadas con touros de carne para obter un beneficio engadido da venda dos tenreiros (Dal Zotto et al., 2009).

En conclusión, o cruzamento das vacas Holstein de alta produción e das razas locais pode ser unha opción viable para os gandeiros ecolóxicos. Aínda que esta aproximación está ben establecida para razas como a Jersey, necesítase máis investigación con outras razas antes de usala a longa escala (Ahlman, 2010). A decisión de producir cruces baséase normalmente nun desexo de mellorar as características funcionais aproveitando a heterose. Aínda que o efecto da heterose pode ser positivo ou negativo e os efectos globais son difíciles de predicir (Bluhm, 2009). Ademais, a elección da raza é un punto crítico porque como xa se apuntou, os libros xenealóxicos e os programas de selección poden non estar ben establecidos nas razas menores, o que leva aos gandeiros a realizar o test de proxenie por eles mesmos.

7.3. Frisoas rústicas

A Holstein norteamericana é sen dúbida algunha a mellor raza produtora de leite en condicións intensivas. Esta raza é o resultado dunha selección xenética intensiva para produción de leite, que levou a un decrecemento na saúde e na eficiencia reprodutiva. Porén, as vacas Holstein manteñen xenes dos seus antecesores e mostran un comportamento produtivo e reprodutivo aínda razoable baixo condicións de pastoreo. De feito, un estudo en Reino Unido demostrou que cando se escollen liñas adecuadas, a raza Holstein é a máis beneficiosa para usarse tanto en sistemas convencionais coma ecolóxicos (Brotherstone and Goddard, 2005). Demostrouse tamén que en condicións experimentais baseadas no pastoreo e na suplementación moderada de concentrado, o máximo beneficio económico obtívose coas vacas Holstein cando estas presentaban unha baixa porcentaxe de xenética norteamericana (Baudracco et al., 2010). Isto pode explicar porqué algúns granxeiros non usan razas locais e prefiren continuar a usar vacas Hosltein (Nauta, 2001).

O mellor exemplo de vacas Holstein ben adaptadas a sistemas de pastoreo é sen ningunha dúbida o da Frisoa de Nova Zelandia. Estas vacas que foron inicialmente seleccionadas para a produción de graxa, e a continuación para produción de graxa e proteína e en contra do volume de leite, e máis recentemente para eficiencia económica, incluíndo custos de mantemento (Harris, 1998). O sistema de leite de Nova Zelandia baséase no pastoreo con baixas suplementacións; a maioría das vacas paren en primavera e o 90% do leite transfórmase en derivados lácteos. Aos gandeiros págaselles pola cantidade de proteína e graxa producida e faise unha dedución polo volume de leite producido (Harris and Kolver, 2001; Clark et al., 2006). En xeral, esta liña de Frisoa de Nova Zelandia produce leite con contidos de graxa e proteína superior e mostra mellor fertilidade, condición corporal, supervivencia e comportamento económico xeral que as Holstein norteamericanas (Harris and Kolver, 2001; Horan et al., 2005). Ademais, as vacas Frisoas de Nova Zelandia teñen menores requirimentos de manutención e de inxestión de materia seca na lactación temperá que as Holstein norteamericanas (Patton et al., 2008). Chegouse á conclusión de que as vacas Frisoas de Nova Zelandia seleccionadas en condicións de pastoreo están mellor adaptadas que as Holstein norteamericanas (Macdonald et al., 2005).

Algúns exemplos de vacas Frisoas europeas como por exemplo as liñas holandesas e irlandesas, manteñen algunhas características rústicas. No caso das Frisoas holandesas, existe un sistema de cría de animais especial, o sistema de cría familiar que foi desenvolto por criadores individuais que conservaban a Frisoa holandesa orixinal dos Países Baixos (Baars and Nauta, 2001). Este grupo de gandeiros representaban o 8% dos gandeiros en ecolóxico nos Países Baixos en 2001 (Nauta, 2001) e o obxectivo deste sistema de cría era manter a Frisoa orixinal (Fries-Hollands) (Endendijk and Baars, 2001). Os gandeiros seleccionan e crían a súa propia reposición, tanto machos coma femias (Nauta et al., 2005b), co que se producen animais altamente adaptados ao ambiente local (Nauta, 2001). Aínda que a taxa de consanguinidade era do 4,5% en 2005 (que é aceptable xa que a taxa de consanguinidade na Holstein é de máis do 6%), despois de varios anos de cría familiar estes vanse emparentando cada vez máis polo que os gandeiros ecolóxicos non ven esta opción como unha boa alternativa. Os sistemas convencionais irlandeses seleccionaron tamén unha liña particular de Frisoa. Demostrouse que esta liña sobrevive mellor en pastoreo (39,7% chegaron aos 6-8 anos) e mostraron mellor comportamento reprodutivo que as Holstein norteamericanas (21% duraron ata 6-8 anos) (Dillon et al., 2003a).

8. OPINIÓN DO CONSUMIDOR SOBRE PRODUTOS ECOLÓXICOS

Os produtos ecolóxicos teñen unha demanda crecente en todo o mundo, a pesar da relevancia da agricultura ecolóxica case non se fixeron intentos de configurar un perfil de consumidores deste segmento alimentario. A identificación de perfiles de consumidores de alimentos ecolóxicos e a posta en funcionamento de estratexias de mercado dirixidas a eles pode axudar aos gandeiros a ser menos dependentes das axudas públicas (Idda et al., 2008).

Segundo os datos do MAGRAMA(2012) o consumo de alimentos ecolóxicos en España é aínda limitado con respecto a outros países europeos pero a crecente demanda nos últimos anos fai que podamos prever unha expansión da agricultura ecolóxica (Mauleón, 2014). Os autores que estudaron o comportamento do consumidor manifestan que existe un alto nivel de confusión na identificación dos produtos ecolóxicos e que isto incide na posterior vontade de compra, xa que as persoas mellor informadas van usar criterios reais á hora de realizar a compra e non as súas propias percepcións (Briz and Ward, 2009). En Europa os produtos ecolóxicos están suxeitos ás regulacións da Unión Europea sobre etiquetado establecidas no

Regulamento (CE) 834/2007. Coa finalidade de que o consumidor poda identificalos, os produtos ecolóxicos deben levar impreso o logotipo da Unión Europea e un código numérico correspondente á entidade encargada do control do produto, ademais da propia marca e os termos específicos da produción ecolóxica. Aínda así, moitos consumidores non o saben ou non son capaces de recoñecelos (Pivato et al., 2008), e acaban por confundir esta etiquetaxe con outras similares como produtos que manifestan ser naturais ou coas denominacións de orixe ou categorías (Hughner et al., 2007).

En canto ao perfil de consumidor de ecolóxico a maioría dos estudos encontran que son mulleres de mediana idade (Hughner et al., 2007; Generalitat de Catalunya, 2015). Krystallis and Chryssochoidis (2005) e Hughner et al. (2007) manifestan que os xoves aínda que son os que mostran actitudes máis positivas cara aos produtos ecolóxicos non teñen tanta capacidade económica, e polo tanto, debido a este feito consomen menos alimentos ecolóxicos. Tamén se asocia un maior consumo de produtos ecolóxicos nas persoas con máis estudos, maior capacidade económica e con fillos (Krystallis and Chryssochoidis, 2005; Hughner et al., 2007; Idda et al., 2008; Roitner-Schobesberger et al., 2008; Generalitat de Catalunya, 2015).

Outro aspecto importante en relación cos produtos ecolóxicos é saber os motivos que teñen os consumidores tanto para consumilos coma para non facelo. En xeral os consumidores de ecolóxico teñen unha boa opinión deste tipo de produtos e soen consumilos por motivos relacionados coa saúde, a calidade e o medio ambiente (Idda et al., 2008; Mauleón, 2014; Ueasangkomsate and Santiteerakul, 2016; Baer-nawrocka and Szalaty, 2017), aínda que tamén xogan un papel importante a preservación da economía local, as tradicións e a cultura (Albardíaz-Segador, 2000; Idda et al., 2008). Por outro lado, os motivos máis habituais que se alegan para non consumir ecolóxico son principalmente o prezo, e en menor medida a desconfianza, a ignorancia e non atopar o produto nos lugares habituais de compra (Nielsen, 2010; Mauleón, 2014; Puelles-Gallo et al., 2014; Generalitat de Catalunya, 2015).

En relación coa percepción que os consumidores teñen dos produtos ecolóxicos está a vontade de pagar un sobreprezo por eles. É moi importante ter en conta este aspecto xa que os produtos ecolóxicos son normalmente máis caros que os convencionais, por iso é importante estimar a capacidade e vontade do consumidor a pagar este sobreprezo (Pivato et al., 2008). Os estudos realizados ata agora estiman que a vontade de pagar por un produto ecolóxico difire en función do tipo de produto, aínda que na maior parte dos casos se encontra entre un 15 e un 30% (Gil et al., 2000; Krystallis and Chryssochoidis, 2005; MAGRAMA, 2007). Aínda que a vontade de pagar por ecolóxico é cada vez maior, o prezo continua sendo unha barreira para unha grande parte dos potenciais consumidores (Nielsen, 2010; Generalitat de Catalunya, 2015). Convén ter en conta que o coñecemento e información que teñen os consumidores ten relación coa súa vontade a pagar máis por un produto ecolóxico en relación cun convencional (Puelles-Gallo et al., 2014), pois o feito de entender porqué son máis caros xustifica que estean dispostos a pagar por estes produtos (Maxwell, 2002).

Nauta et al. (2009) mencionaba que as granxas de leite ecolóxicas poden comportarse como entidades multifuncionais, dedicándose non só como vendedoras de leite, senón como transformadoras pondo a disposición do consumidor unha ampla variedade de produtos lácteos (queixo, iogures, manteiga,…) así como inclusive carne. Estas granxas tamén poden funcionar como puntos dedicados ao ecoturismo, para todos os grupos de idade ou ben como granxas escolas destinadas á aprendizaxe infantil. Este sector de venda tamén forma parte do consumo ecolóxico que afecta á gandería, por iso sería interesante ter estudos relacionados con estes aspectos, desafortunadamente a investigación sobre a importancia que o consumidor lle dá ao uso de determinadas razas ou cruces na produción ecolóxica está pouco estudado. Tendo en conta que nos últimos anos existe unha crecente demanda dos produtos ecolóxicos (Albardíaz-Segador, 2000)) debido a que os consumidores os asocian cunha protección das tradicións (Cicia et al., 2006), e que as razas locais son parte da tradición (Nauta et al., 2009) pode que os consumidores estean dispostos a pagar por produtos derivados destas razas locais ou tradicionais que no noso caso se corresponderían con razas diferentes da Frisoa. De feito, un dos poucos estudos que existe ao respecto foi feito no sector da carne en Finlandia onde a maioría dos entrevistados mostrábanse a favor de pagar un prezo maior polo consumo de carne procedente de razas vacúas finlandesas (Tienhaara et al., 2015).

Para entender mellor o papel que as vacas xogan no ecoturismo hai que entender que estes animais teñen unha posición única dentro das especies de animais domésticos, tendo roles destacados na agricultura, na economía, na cultura e na relixión ao longo da historia e ata as sociedades actuais (Bradley et al., 1998; Li et al., 2007). Como xa se comentou anteriormente, a raza Frisoa domina actualmente as poboacións de vacas a nivel mundial incluso a nivel ecolóxico (Oltenacu and Broom, 2010; Felius et al., 2015) a expensas das razas locais que se atopan en perigo de extinción ou en moi baixa proporción (Tienhaara et al., 2015). Estas razas autóctonas están especializadas nun hábitat ou nunha produción particular e aínda que non son tan produtivas coma as Frisoas son un importante recurso que se debe protexer para o futuro (Medugorac et al., 2009). O ecoturismo pode xogar un papel importante na súa protección, por iso sería interesante ter estudos que mostren ata que punto os consumidores están dispostos a pagar pola súa preservación.

9. AUTENTICACIÓN DE PRODUTOS ECOLÓXICOS

A Unión Europea seguindo o Regulamento no 834/2007e o Regulamento no 889/2008 establece as normas de control dos produtos ecolóxicos, deste xeito a través das autoridades de inspección local controla os produtos desde as granxas garantindo o tipo de produción e certificando os alimentos como ecolóxicos. Os inspectores deben cando menos realizar unha inspección física ao ano, e ademais están obrigados a realizar visitas aleatorias. Aínda así, a desconfianza é un dos motivos principais para non consumir produtos ecolóxicos (Puelles-Gallo et al., 2014), isto é debido a que o consumidor non pode comprobar directamente se un produto é ou non ecolóxico (Pivato et al., 2008), o que fai que non confíen na orixe dos produtos ecolóxicos aínda que realmente estarían interesados en consumilos se tivesen a certeza da súa orixe. O escepticismo dos consumidores diminuiría se puidesen contrastar a orixe dos produtos ou monitorizalos dalgún xeito e asegurarse que as normas se cumpriron

(Perrini et al., 2010). De feito, desde os anos 80 a autenticidade dos produtos recoñeceuse como un criterio importante de calidade e a identificación de adulteracións nos produtos, así como o garante da calidade e da orixe xeográfica ou do tipo de produción é unha demanda dos laboratorios de control dos alimentos (Ashurst and Dennis, 1996). A alimentación dos animais baixo os estándares ecolóxicos ten uns custos elevados. Durante as inspeccións establecidas pola Unión Europea os inspectores a parte de facer comprobacións documentais toman mostras dos produtos para a súa posterior análise co obxectivo de realizar verificacións de se os animais foron ou non mantidos en condicións ecolóxicas en canto á nutrición e prácticas de manexo (EC, 2007; EC, 2008).

O leite é un produto que os consumidores ven como facilmente adulterable con leite convencional (Zain et al., 2016). Desafortunadamente os seus compoñentes principais (concentración de graxa, proteína e lactosa) non permiten a diferenciación entre ecolóxico e convencional, xa que están influenciados por moitos factores, entre eles a raza (Sundberg et al., 2010). A súa composición química foi amplamente estudada nos últimos anos (Schwendel et al., 2015; Srednicka-Tober et al., 2016), particularmente en canto ao perfil de ácidos graxos (Butler et al., 2011; Capuano et al., 2013; Schwendel et al., 2015). De feito, a maioría dos estudos que se fixeron céntranse no estudo dos ácidos graxos poliinsaturados (PUFA), o leite producido en ecolóxico obtense do emprego dunha dieta rica en forraxes que dá como resultado un alto contido de PUFAs no leite, porén os resultados obtidos non son determinantes en canto aos perfiles de ácidos graxos (Ellis et al., 2006; Butler et al., 2011). A explicación destas discrepancias son as diferenzas na cantidade e no tipo de forraxe utilizado para alimentar as vacas. Alimentar estes animais a base de cultivos como o feo ou o ensilado no canto de proporcionarlles forraxe fresca resulta nunha diminución dos contidos de ácido linolénico conxugado (ALC), aínda así, Weller and Bowling (2002) demostraron que se se substitúen as forraxes conservadas por herba fresca o ALC aumenta a súa concentración no leite. Ademais a raza tamén ten unha influencia no contido de ALC, presentando as vacas Jersey menores concentracións do que a Holstein, polo que nun sistema onde a variabilidade racial é máis alta tamén pode representar un problema engadido. Este sistema tamén presenta variacións con respecto ás estacións do ano debido ás diferenzas no crecemento da forraxe, a inxesta dos brotes de primavera está asociada a un aumento do contido en PUFA. Tamén se tentou empregar como sistema de autenticación o ácido fitánico, que procede do fitol liberado da clorofila, e que funciona como indicador da cantidade de forraxe fresca presente na dieta (Vetter and Schroder, 2010; Schröder et al., 2011). Porén este sistema non permite distinguir as vacas ecolóxicas das convencionais con similar acceso á forraxe verde. Esta mesma limitación como molécula marcadora tamén a presenta o ácido α-linolénico (ALA) (Molkentin, 2009), o leite ecolóxico ten xeralmente contidos altos de ALA debido ao maior consumo de forraxe fresca na dieta, pero a suplementación cun 5% de aceite de liñaza duplica os niveis de ALA no leite convencional (Flowers et al., 2008). Por outra parte, a caracterización do leite ecolóxico e convencional pódese realizar a través de metabolitos como o hipurato, prolina, ribosa 5-fosfato e carnitina, aínda que non se sabe ata que punto estes metabolitos están influídos pola dieta ou as rutas metabólicas (Boudonck et al., 2009). Actualmente sábese que o ácido hipúrico non é adecuado para realizar a diferenciación porque o seu contido depende da dieta máis que do sistema (Boudonck et al., 2009; Carpio et al., 2010). Recentemente, Capuano et al. (2014) estudaron a posibilidade de distinguir entre mostras de leite de vacas con e sen saída ao pasto usando a espectroscopía infravermella por transformadas de Fourier, porén, a clasificación das mostras entre ecolóxico e convencional hai que facela con precaución e non se puideron sacar conclusións certas do uso deste método.

Outro punto importante e que depende da alimentación dos animais son os minerais. Nos sistemas de produción de leite en intensivo as racións supleméntanse con minerais, mentres que nos sistemas ecolóxicos os suplementos minerais están limitados e dependen máis dos minerais que reciben do solo polo pastoreo, e isto vai a condicionar os niveis de minerais no leite. Varios estudos demostraron que o leite ecolóxico contén xeralmente menores concentracións de minerais traza que o leite convencional (Rey-Crespo et al., 2013; Schwendel et al., 2015; Srednicka-Tober et al., 2016). A normativa sobre a produción ecolóxica é moi restritiva no uso de minerais inorgánicos en produción gandeira, xa que prohibe explicitamente o uso de fertilizantes químicos e limita o uso de suplementos minerais, restrinxindo o seu uso a situacións onde sexan necesarios para recuperar a saúde animal e sempre baixo a supervisión do consello regulador. A composición mineral, en concreto os elementos traza, pero tamén os metais tóxicos poderían ser un bo marcador da orixe ecolóxica do alimento, xa que a composición mineral dos produtos difire entre ecolóxico e convencional (Yadav et al., 2010). Sábese con certeza que o a composición mineral do leite está afectada por varios factores, aínda que a maior influencia tena a dieta, con todo, tamén está en certo modo afectada pola xenética da vaca (Van Hulzen et al., 2009), o manexo na granxa e o ambiente (Gabryszuk et al., 2008). Os factores que teñen influencia na composición mineral do solo e do pasto como poden ser os fertilizantes (Mckenzie and Jacobs, 2002), as augas residuais (Percival, 2003), o tipo de solo (Mut et al., 2009) e a proximidade a áreas mineiras ou actividades industriais (Gabryszuk et al., 2008; Smith et al., 2009). No noroeste de España Rey-Crespo et al. (2013) encontraron diferenzas entre o leite ecolóxico e convencional nos contidos de elementos traza e metais tóxicos debido ao consumo de concentrado e de solo. Ademais do perfil dos elementos traza e minerais tóxicos do leite tamén varía o perfil mineral dos animais criados en sistemas ecolóxicos con respecto aos convencionais (López-Alonso et al., 2017), xa que os animais alimentados baixo as condicións de ecolóxico inxiren porcións de solo ao pastorear mentres que os convencionais reciben suplementos minerais no penso (principalmente, cobalto, cobre, iodo, manganeso, selenio e zinc) que determinan o seu estatus mineral. Polo tanto, isto suxire que o perfil mineral no sangue dos animais podería permitirnos coñecer, dun xeito relativamente sinxelo, se os animais foron criados ou non seguindo os requirimentos da normativa ecolóxica, e polo tanto permitiría garantir a orixe dos produtos derivados deles (carne e leite).

Dentro dos elementos traza esenciais, o iodo e o selenio foron os máis estudados no ámbito da investigación do leite ecolóxico e convencional, debido a que son elementos esencias para a vida dos animais e das persoas, e que as súas concentracións no leite dependen principalmente da dieta. Estes elementos teñen unha regulación homeostática renal e polo tanto o contido no leite é un reflexo do inxerido polo animal (Rey-Crespo et al., 2013). As vacas de leite en convencional supleméntanse desde fai décadas con iodo para previr deficiencias deste mineral (Bath et al., 2012), o iodo inxerido na dieta excrétase no leite en maiores concentracións nas vacas suplementadas a través do concentrado que naquelas vacas que se atopan a pastoreo (Gabryszuk et al., 2008). Nun estudo desenvolvido en Reino Unido demostrouse que aínda que existen variacións rexionais nos contidos de iodo no leite, as vacas en convencional producen leite cun un 42% máis de iodo que as ecolóxicas (Bath et al., 2012), tendo resultados similares outros estudos desenvolvidos en Alemaña (Johner et al., 2012), Noruega (Dahl et al., 2003) e España (Rey-Crespo et al., 2013). En todos estes estudos a concentración de iodo foi menor nos sistemas ecolóxicos, esta diferenza observouse de maneira acusada no verán pois a alimentación a base de pastoreo nesta estación é maior. O uso de desinfectantes iodados pode facer que aumenten os niveis de iodo no leite e pode explicar a variabilidade nas concentracións de iodo observadas no leite convencional (Bath et al., 2012; Rey-Crespo et al., 2013).

O selenio tamén é un mineral esencial, e os ruminantes son susceptibles a padecer deficiencias do mesmo, debido a unha falta de absorción na dieta (Van Hulzen et al., 2009). Isto sucede xeralmente en animais alimentados con grandes cantidades de pasto, sendo moito más frecuente que nas vacas alimentadas con ensilado ou racións de carro mesturador (Gabryszuk et al., 2008). Nalgunhas áreas os niveis de selenio do solo son menores e as vacas que se alimentan en convencional a base de feo, cereais ou pasto teñen menores niveis de selenio que as vacas cunha dieta de carro mesturador (Pilarczyk et al., 2011).

Dentro dos elementos traza que teñen regulación homeostática intestinal, a concentración mineral na dieta xoga un papel menos importante na concentración mineral posterior no leite. Aínda así, o alto nivel de suplementación mineral dos concentrados convencionais en comparación coa xeralmente baixa, e ás veces desequilibrada, concentración mineral dos forraxes producidos a nivel local en ecolóxico fai que se observen diferenzas significativas entre as mostras de leite ecolóxico e convencional (Rey-Crespo et al., 2013). Ademais, o consumo de solo durante o pastoreo tamén fai que os animais estean expostos aos minerais presentes nel (López-Alonso et al., 2012) e polo tanto excreten no leite certos elementos que estaban presentes en altas concentracións no medio. En xeral podemos dicir que os elementos traza presentes nos suplementos minerais (cobalto, cobre, iodo, manganeso, selenio e zinc) fan que as concentracións sexan maiores no leite convencional, pero cando o principal aporte de minerais é o solo ou a forraxe, estes elementos procedentes dos correctores minerais non están presentes. Rey-Crespo et al. (2013) observaron que as maiores concentracións de cobre, iodo, selenio e zinc no leite convencional comparado co ecolóxico se explica pola alta suplementación mineral.

As concentracións de minerais tóxicos no leite de vaca foron un aspecto moi estudado (Licata et al., 2004; Gabryszuk et al., 2008; Qin et al., 2009; Abdulkhaliq et al., 2012) debido ás preocupacións que causa o impacto que poden ter sobre a saúde humana. Os factores que inflúen principalmente nas concentracións de metais pesados son o ambiente e a dieta, aínda que non todas as razas se ven igualmente afectadas (Hermansen et al., 2005), outro factor importante é que existen correlacións entre eles (Pilarczyk et al., 2013). A fonte principal de metais pesados (arsénico, cadmio, chumbo e mercurio) nos sistemas agrícolas son os fertilizantes e trazas por contaminación dos suplementos minerais (Gray et al., 2003; Mirlean et al., 2008).

A quimiometría e os patróns matemáticos de recoñecemento de modelos baseados na información obtida das análises químicas usáronse de cara a desenvolver sistemas de autenticación de alimentos. Para a realización destes modelos utilízanse diversas compoñentes alimentarias (elementos traza, minerais, metais, ratios de isótopos estables, compostos de sabor volátiles, vitaminas, proteínas, aminoácidos, etc.). Deste xeito desenvolvéronse modelos de autenticación eficientes para as froitas e vexetais, cereais, leite, queixo e outros lácteos, carne, viño, cervexa, sidra e outras bebidas alcohólicas, café, té, mel e aceite (Rebolo et al., 2000; Karoui and Baerdemaeker, 2007; Luykx and Van Ruth, 2008; Iglesias-Rodríguez et al., 2010; Herrero-Latorre et al., 2013; Luo et al., 2015; Dong et al., 2016, 2017). Os minerais e elementos traza poden dar información relevante para desenvolver estudos quimiométricos que permitan realizar a autenticación de produtos xa que están relacionados co solo e o ambiente no que o alimento foi producido, o contido mineral dos alimentos soe permanecer estable, o tratamento das mostras é moi simple mediante dixestión, pódense obter determinacións multielemento de forma precisa mediante espectrometría de emisión (ICP-AES) e de masas (ICP-MS) (Gonzalvez et al., 2009).

10. XUSTIFICACIÓN DO TEMA E PERFIL DA TESE

A investigación que pretende desenvolverse no marco desta tese doutoral quere dar resposta a dúas grandes cuestións dentro da gandería ecolóxica de leite, por un lado a adaptación dos animais ás especiais condicións do sistema e por outro á certificación da procedencia ecolóxica dos animais e dos seus produtos.

Para a primeira cuestión, partimos dos datos aportados do proxecto VALECO (ref. AGL2010-21026), un estudo a escala nacional cuxa pretensión é analizar a situación da gandería ecolóxica de leite no norte de España. Durante este proxecto realizáronse enquisas aos gandeiros onde se constatou a existencia dunha grande preocupación pola mala adaptación dos animais a ecolóxico. Os animais de alta produción están preparados para soportar grandes lactacións, sempre e cando se lles suplementen grandes cantidades de concentrados para cubrir as necesidades enerxéticas. Cando estes animais se introducen nun sistema de manexo ecolóxico tenden a padecer enfermidades que acaban por xerar grandes perdas económicas. Deste xeito, esta tese doutoral centrarase no estudo das razas leiteiras en ecolóxico valorando a súa produción, características reprodutivas e funcionais, co fin de atopar que raza ou cruce é máis adecuado para a produción de leite ecolóxico no norte de España, tendo en conta que nesta área se produce o 80% da produción nacional. Ao mesmo tempo tamén se valorará a través de enquisas a opinión que ten o consumidor dos produtos ecolóxicos, facendo un especial fincapé nos aspectos raciais do vacún de leite, co fin de explorar o interese comercial das distintas razas.

En canto á autenticación da produción ecolóxica así como dos produtos destinados á venda procedentes destes sistemas, cómpre sinalar que é un aspecto moi relevante xa que é necesario garantir que os produtos que chegan ao mercado con etiqueta ecolóxica foron realmente producidos neste sistema. Existe certa preocupación por parte dos consumidores sobre a autenticidade dos produtos ecolóxicos, polo que a través dos estudos desenvolvidos na presente Tese de Doutoramento queremos aportar unha ferramenta que permita discernir entre ecolóxico e convencional.

OBXECTIVOS

OBXECTIVOS

O principal obxectivo da presente Tese de Doutoramento foi analizar por un lado o comportamento de distintas razas nos sistemas ecolóxicos do norte de España e por outro autenticar a procedencia ecolóxica dos produtos. Para desenvolver este proxecto, fixáronse unha serie de obxectivos concretos que corresponden con cada un dos capítulos que compoñen esta Tese de Doutoramento.

I. Analizar a situación racial nos sistemas ecolóxicos a nivel mundial en canto a diversidade racial, razóns para a falta de adaptación das vacas usadas actualmente, características que se deben potenciar, comportamento das diferentes razas en ecolóxico e cara onde debe dirixirse a selección racial enfocada á produción ecolóxica.

II. Analizar o comportamento produtivo (produción de leite, composición nutricional e reconto de células somáticas) das vacas Holstein nos sistemas ecolóxicos do norte de España en comparación co seu comportamento nos sistemas convencionais da mesma rexión. Nas granxas ecolóxicas onde existía diversidade racial comparouse o comportamento produtivo das Holstein co de outras razas puras e cruces.

III. Realizar unha avaliación preliminar da situación reprodutiva das vacas en ecolóxico no norte de España. Para iso analizáronse parámetros reprodutivos (número de servizos por xestación, intervalo entre partos, intervalo parto-primeira inseminación, intervalo parto-inseminación fecundante, idade á primeira inseminación, idade á inseminación fecundante e idade ao primeiro parto) das vacas Holstein nos sistemas ecolóxicos en comparación coa mesma raza nos sistemas convencionais e con outras razas puras ou cruces en ecolóxico.

IV. Caracterizar a eficiencia (causas de eliminación, lonxevidade, días en leite ata a eliminación, eficiencia para a produción de leite e saúde do ubre, tipo de parto, facilidade de parto e eficiencia reprodutiva) de varias razas e cruces nos sistemas ecolóxicos.

V. Caracterizar os consumidores de ecolóxico en Galiza, particularmente en canto ao perfil do consumidor, o coñecemento dos consumidores sobre os produtos ecolóxicos, as razóns para consumir ou non alimentos ecolóxicos, aspectos e hábitos de consumo e vontade de pagar polos produtos ecolóxicos, así como valoración das razas rústicas ou locais para a produción ecolóxica e vontade de contribuír na súa protección.

VI. Desenvolver un método de autenticación da orixe ecolóxica do leite no norte de España en base á súa concentración de metais esenciais e tóxicos determinados por ICP-MS. A autenticación da procedencia fíxose en base a unha análise química e posterior tratamento de datos por técnicas quimiométricas para desenvolver uns modelos de clasificación das mostras de leite en base ao tipo de produción: ecolóxica e convencional.

VII. Desenvolver un procedemento de recoñecemento de patróns supervisados baseado na análise quimiométrica da concentración de metais esenciais e tóxicos no sangue (soro) para autenticar as vacas ecolóxicas a nivel da granxa e polo tanto verificar que están producindo de acordo coa normativa ecolóxica (alto contido de pasto e sen uso de concentrados convencionais con suplemento mineral).

CAPÍTULO I

O artigo titulado “**Breeding in organic dairy farming. What types of cows are needed?**" que conforma o capítulo I está “in press” na revista Journal of Dairy Research, volume 86 issue 1, February 2019.

LOPEZ ALONSO MARIA MARTA

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Breeding in organic dairy farming. What types of cows are needed?

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Abstract

Organic farming is an environmentally friendly production system that promotes the use of local forage while strongly limiting the input of chemicals, including allopathic treatments. As organic dairy farming has grown, farmers have realised that the available *conventional* cows are not well adapted to the new situations and that more “robust” cows, able to function well in the constraining organic environment, are needed to yield acceptable longevity and productivity. In this review paper, the current breed diversity in organic dairy farming is analysed with the aim of identifying the types of cow that would best fulfil organic breeding goals. Unlike the conventional sector, organic dairy farming is very heterogeneous and no single type of cow can adapt well to all scenarios. There are advantages and disadvantages to the use of existing breeds (rustic Holstein-Friesian, other rustic breeds and crosses), and strong genotype x environment interactions demand different strategies for very diverse situations. Organic dairy farms producing milk for systems that recompense milk volume would benefit from using high milk yielding cows, and rustic Holstein-Friesian cows may be the best option in such cases. Although most Holstein-Friesian cows are currently selected for use in conventional systems, this situation could be reversed by the implementation of an organic merit index that includes organic breeding goals. Farms producing milk either for systems that recompense milk solids or for transformation into dairy products would benefit from using breeds other than Holstein-Friesian or their crosses. Organic farmers who focus on rural tourism, farm schools or other businesses in which marketing strategies must be taken into account could benefit from using local breeds (when possible) or other rustic breeds that are highly valued by consumers.

1. Introduction

Organic agriculture emerged as a reaction to the industrialization of agriculture and its associated environmental and social problems (Röös et al. 2018). Organic livestock production focuses predominantly on forage-based systems, with emphasis on improving animal health and welfare, while reducing the use of conventional veterinary treatments, prophylactic drugs, chemical fertilisers and pesticides (Diepen et al. 2007, Rozzi et al. 2007, Ahlman et al. 2011, Horn et al. 2012). Together these factors make organic systems highly dependent on the environment, and a more holistic view of the farming system is required in order to achieve adequate productivity and resilience (Gouttenoire et al. 2013).

In the European Union (EU), organic livestock production is considered in Council regulation (EC) No 834/2007 and Commission regulation (EU) No 889/2008, which establish that animals on organic farms should (whenever possible) have access to open air or grazing areas, respect animal welfare, restrict the number of medical treatments, and strongly limit the use of chemically synthesised products (Table 1). In relation to the livestock, the Commission regulation specifically states that "In the choice of breeds account shall be taken of the capacity of animals to adapt to local conditions, their vitality and their resistance to disease or health problems". Despite these recommendations, little effort has been made to produce animals that are well adapted to organic conditions, and most dairy farmers maintain the same livestock on converting to organic systems. In fact, with few exceptions, dairy cattle on organic farms are still selected on the basis of information about conventional systems. Recent studies estimate that the main challenge for sustainable organic and low-input dairy farming is to identify genotypes that are best adapted to forage-based production systems (Peeters & Wezel 2017). Moreover, in the last few years both critics and proponents of organic agriculture have concluded that yields in organic agriculture must increase (Röös et al. 2018). This increase is necessary not only to feed a growing, more affluent global population but also so that organic farms will become more 'environmentally efficient'. However, breeding for higher yields has the risk of producing less robust animals with potential health problems, including low fertility (Röös et al. 2018).

It is well known that during the last half of the 20th century, genetic selection of dairy cattle mainly focused on the Holstein-Friesian breed to improve milk production. The resulting cow can be considered a high maintenance animal for use in extremely standardised intensive systems. However, the environment in organic production systems is very different, mainly with regard to feeding regimes and medical treatments (Ahlman 2010). The selection process has also resulted in reduced reproductive efficiency, extended calving intervals, increased health problems, increased culling rates and decreased productive life (Bluhm 2009), especially when these highly selected cows are reared outside of intensive nutritional and environmental management systems. Thus, highly productive Holstein-Friesian cattle could show a limited capacity to adapt to the low-input diets on organic farms, resulting in low longevity (Kolver 2003) and productive performance (Diepen et al. 2007).

In this context, as organic dairy farming has grown in Europe, farmers have realised that the available *conventional* cows are not well adapted to the new organic requirements (Nauta et al. 2006a,b). In general, organic farmers demand more robust cows (Ahlman et al. 2011), where robustness is understood as the ability to function well in the constraining organic environment (Strandberg & Roxström 2000). The preferences of organic farmers differ from those of conventional farmers, with breeding objectives focused on disease resistance and longevity at the expense of milk production (Ahlman et al. 2014).

A new approach to defining the most suitable type of cow for organic farms is clearly needed. In this review paper, we consider i) the current situation of breed diversity in dairy farming, ii) the reasons why modern dairy cows are not adapted to pasture-based and organic systems, iii) which traits should be improved to produce cows suited to organic systems, iv) the performance of different dairy breeds (pros/cons) in organic and pastured-based systems worldwide, and finally v) the direction in which selection of breeds for organic production should be aimed.

2. Current breed diversity in dairy farming

With a few exceptions (see below), worldwide dairy production is dominated by the American Holstein-Friesian breed (Oltenacu & Broom 2010) (Figure 1). The breed was developed in the US from animals imported from Northern Europe in the late 1800s, but was largely limited to North America until the early 1970s when large-scale exports began (Oltenacu & Broom 2010). The extraordinary productive potential of American Holstein-Friesian cows when fed high quality diets led to the rapid development of highly specialized and technologically intensive conventional farms, able to offer equilibrated feed in a controlled and comfortable environment. In this favourable scenario, American Holstein-Friesian genes were quickly incorporated into the European dairy herd, thereby largely replacing the original Friesian breed as well as other local breeds (Brotherstone & Goddard 2005). The expansion of this dairy farm model, i.e. American Holstein-Friesian cows under intensive farming, lead to a large increase in milk production.

Although nutrition and management have helped to improve American Holstein-Friesian milk production, the dramatic increase in yield per cow was mainly due to the rapid progress in genetics (Brotherstone & Goddard 2005, Oltenacu & Broom 2010). It has been estimated that genetic selection accounts for more than 55% of the phenotypic gains in yield traits (Pryce & Veerkamp 2001). This type of breeding has arisen as a result of high selection intensity and narrow breeding objectives aimed at increasing productivity, and the potential to increase efficiency by including traits that reduce input costs has been overlooked for decades. Such traits are often referred to as functional traits (i.e. animal health, udder health, longevity and reproductive traits) and have been shown to be negatively correlated with milk production (Ahlman 2010) (Figure 2).

Exceptions to the intensive American Holstein-Friesian productive model include pasture-based systems and systems focused on other rustic breeds such as pasture-adapted Holstein-Friesian, crosses or local breeds. The New Zealand system is, without a doubt, the most important pasture-based system exported worldwide. It is a low input system comparable to the organic dairy sector from a nutritional point of view (Basset-Mens et al. 2009). Numerous examples of native breeds are found worldwide in smaller and local scale conventional milk production systems. Within Europe, Fleckvieh and Brown Swiss are the most common dairy breeds used in Austria and Switzerland (Haas and Bapst, 2004). In Nordic countries such as Sweden, Swedish Reds occur in higher proportions (45.8%) than is usual worldwide, with other European breeds and crosses representing 6.4% of all cattle breeds (Ahlman 2010).

Breed diversity in organic farming is similar to that described above for the conventional sector. American Holstein-Friesian cattle also dominate in organic dairy herds and show a similar increasing trend to that observed in conventional farming systems, e.g. in Germany (Nauta et al. 2006a), Canada (Rozzi et al. 2007) and Spain (Rodríguez-Bermúdez et al. 2016), although some countries depart from this tendency and maintain other local breeds.

In the Netherlands, organic farms specialising in milk production use purebred Holstein-Friesian cows (29%) and crosses with more robust breeds (51%), such as Brown Swiss, Montbeliarde and the dual breed Maas-Rijn-Ijssel. On multifunctional farms, the

Holstein-Friesian breed represents a small fraction (2%) of all breeds used, with cross-bred (57%) and native Dutch breeds (34%) (such as Maas-Rijn-Ijssel, Groninger White Face and Dutch Friesians) predominating (Nauta et al. 2009). On Swedish organic farms, most cows are the Swedish Red breed (54.3%), and the proportion of Holstein-Friesian cows (35.5%) is lower than in conventional herds (46.9%), in favour of rarer breeds such as Jersey (1.5%), the Swedish Polled breed (1.2%) and various crosses (7.7%) (Ahlman 2010). In Austria and Switzerland, local breeds (Brown Swiss and Fleckvieh) are used in conventional systems. This also occurs in organic production systems in Switzerland, with Brown Swiss (51.7%) and Fleckvieh (34.6%) predominating (Haas & Bapst 2004).

3. Why are dairy cow breeds not adapted to pasture-based organic systems?

As mentioned above, European and North American dairy herds have been selected for high milk production under intensive farming conditions. Even under optimal management conditions, selection aimed at increasing milk yield has led to a decrease in health and reproductive efficiency in dairy cattle worldwide, as these traits are negatively correlated (Pryce & Veerkamp 2001, Evans et al. 2002, Brotherstone & Goddard 2005, Oltenacu & Broom 2010).

The reproductive performance of highly productive American Holstein-Friesian cows is greatly decreased when the cows are maintained in other environments. This has led to doubts as to whether these high input genotypes are suitable for forage-based organic farming systems (Nauta et al. 2006b, Horn et al. 2012), which are low input systems that require high fertility and reproductive performance rather than individual milk yield (Dillon et al. 2003a,b).

High-yielding cows partition a high proportion of energy towards milk yield (Dillon et al. 2003a), but they are not able to achieve this without high-quality supplements. When these cows are fed only pasture their daily feed intake may decrease by 20% (Kolver 2003) and they cannot, therefore, express their genetic potential and are at risk of suffering metabolic disorders in early lactation. It will therefore be difficult for such cows to adapt to low input, organic systems. Moreover, in pasture-based dairy systems, high milk yielding cows display lower fertility, lower body condition and are culled at a higher rate than cows of average genetic merit (Rozzi et al. 2007). In pasture-based systems, such as used in New Zealand, Holstein-Friesian cows with a high potential for milk production also display lower survival rates, poor fertility and body condition, so that their profitability is greatly reduced at the end of their lifetime (Harris & Kolver 2001).

To address the loss of performance of Holstein-Friesian in some farming systems, the genotype x environment (GxE) interaction has been considered. GxE interaction can be defined as a change in the response of genotypes to different environments or to changes in the relative merit of genotypes in the different environments. GxE interactions are especially important when animals are reared under specific environmental conditions (such as organic production) for their potential to maintain genetic diversity. When animals are genetically adapted to specific conditions, they will be more productive and production costs will be lower (Charlesworth & Hughes 2000).

GxE interactions for milk production are well described for conventional herds. Dairy producers in several countries have expressed concern regarding the declining fertility of cows with high proportions of Holstein-Friesian genes (Kearney et al. 2004). Some studies indicate that the already high negative genetic correlations between production, fertility and health in modern dairy cows reared in intensive production environments will increase further when cows are held in less intensive production environments (Harris & Kolver 2001). However we do not completely agree with this point of view, as organic systems must find a type of cow that is well adapted to organic systems (characterised by lower productive pressure), thus allowing the breed to perform better in terms of reproduction and resistance to local infections.

Within the organic sector, GxE interactions have been observed in Holstein-Friesian cows bred for production traits in the Netherlands (Nauta et al. 2006b) and for fertility traits in Sweden (Ahlman 2010). Due to GxE interactions, bulls selected for use in conventional systems may not be suitable for organic systems (Nauta et al. 2006b). If a trait such as milk yield is controlled by different sets of genes in different environments, it is possible that sire rankings will differ between systems (Pryce et al. 1999; Ahlman, 2010). Identification of GxE interactions is therefore one of the main challenges facing organic dairy systems, in order to prevent livestock performance from being constrained by the environment. Identification of GxE interactions should be considered positively to enable organically reared cows to express their productive performance in an environment where animal welfare is given particular importance under low productive pressure.

4. Which traits should be improved?

The search for the ideal dairy cow is not only of concern in organic farming systems. Producers worldwide have recognised that profitability does not necessarily depend on high milk production, especially as the cost of maintaining a dairy herd continues to rise (Bluhm 2009).

Farmers who run low input systems generally prefer more robust animals that maintain high yields but suffer few health problems (Nauta 2001). Studies in New Zealand (Harris & Winkleman 2000) and Ireland (Dillon et al. 2003a, b), where dairy production is based on pasture, have indicated that the most profitable cows for these environments are different from those selected under a high-concentrate regime.

Milk production is not the only trait that must be considered. Although information is scarce, organic farmers questioned about which traits they would prioritize emphasized longevity, roughage intake and disease resistance, especially resistance to mastitis and parasites, even at the expense of milk production (Ahlman et al. 2014). Furthermore, fertility, strong feet and legs, high milk fat and protein yield, low somatic cell count (SCC), feed intake and feed conversion are also important parameters (Haas & Bapst 2004, Rodríguez-Bermúdez et al. 2016).

In cattle production, longevity has been considered to reflect the capacity of a cow to avoid being culled due to low production, low fertility or illness (Vollema & Groen 1996). While cattle can potentially live for 20 years or longer, few dairy cattle live longer than 6 years on most modern dairy farms (Rushen & Passillé 2013). The decline in longevity in dairy farming generally results from *involuntary culling*. This clearly reduces the profitability of dairy farms and does not satisfy the aims of sustainable dairy production (Ahlman et al. 2011, Rushen & Passillé 2013). Dairy cow longevity, also understood as *durability with acceptable production*, is especially important in organic production (Ahlman et al. 2011, Slagboom et al. 2016). As with the other aspects considered here, studies evaluating longevity and the causes of culling in organic systems are scarce. In a survey carried out in Ontario (Canada), infertility was found to be the principal reason for culling in organic systems, followed by mastitis and foot problems, even though owners of less productive farms also mentioned low productivity (Rozzi et al. 2007). Farmers from both the most and least productive organic farms reported that the age of the animal was a more important reason for culling than type of cow, injury or temperament. Within Europe, similar findings were obtained in a study carried out in Sweden (Ahlman 2010, Ahlman et al. 2011), with the main reasons for culling in organic herds being poor udder health, followed by low fertility, low production and foot problems. By contrast, a recent study in organic dairy farms in Northern Spain (Rodríguez-Bermúdez et al. 2016) found that the age of animal was the main reason for culling (73.2%), distantly followed by infertility (14.3%), mastitis (10.7%) and laminitis (1.8%). These findings were attributed to farmers not being able to afford to cull animals with subclinical pathologies, as indicated by a higher culling rate than replacement rate. This has led to farmers being dissatisfied with the cows available for organic production systems.

Organic farmers may have other priorities in addition to longevity when choosing the most suitable cows for their farms. While some organic farmers continued to specialise, many others have transformed their farms into multifunctional businesses producing cheese and yogurt, providing farm gate shops (selling milk and meat products) and promoting or involving nature development and conservation, crop production, care farming, eco-tourism and/or recreation (Nauta et al. 2009). Such differences in farming strategies may imply different demands regarding breed characteristics (Diepen et al. 2007). On multifunctional farms, for example, characteristics other than milk production may be important. Jersey cow milk contains more fat and protein than Holstein-Friesian milk, leading to higher yields of cheese per unit of standardized milk, with faster formation rates (Auldist et al. 2004). Other characteristic that farmers in multifunctional systems value is the capacity of a breed to produce meat of sufficient quality to be sold as a co-product (Diepen et al. 2007, Nauta et al. 2009), as with dual purpose breeds such as Meuse Rhine Yssel, Normande, Fleckvieh, Milking Shorthorn, Brown Swiss and Montbeliarde. This is a good way of obtaining profit from male calves born on the farms (Diepen et al. 2007), as well as from heifers/cows that must be culled (for reasons other than disease). Using local and rare breeds can also serve as a marketing tool and can help attract farm visitors (Van der Ploeg 2003). Moreover, consumers may equate their favourite product with a specific (local) breed. Indeed, taking consumers' opinions about breed protection into account may be useful, as consumers may associate some breeds with what they expect to find on organic farms (local or traditional breeds) and may be willing to pay a premium for this. In fact, 41% of cattle reared on multifunctional farms in Netherlands are local breeds, because these can be presented to society and consumers as having a clear and distinct organic identity (Nauta et al. 2009).

5. Performance of different breeds (pros and cons) in organic and pastured-based systems worldwide

The identification of breeds that are best suited to organic production is a subject of much debate (Nauta et al. 2009). According to Diepen et al. (2007), breeds or strains of animals should be selected to avoid specific diseases or health problems associated with intensive production. The main concerns are related to the ability of highly productive breeds to adapt to organic environments, characterised by lower energy and protein intake and limited use of antibiotics. Sustainable organic animal production should also be adjusted to local conditions, and different types of animals may be required for different production situations (Rozzi et al. 2007).

It is almost impossible at present to find animals that have been bred specifically for organic production systems, and it has therefore been suggested that there is a vicious circle regarding animal breeding. Farmers do not know what type of animal they need and take refuge in "tried and trusted" conventional breeds. Organic dairy farmers express similar preferences to those expressed by conventional farmers regarding *breeding goals* and the various aspects of production, conformation and functionality of animals (Slagboom et al. 2016). By contrast, their actual choices and expressed preferences regarding breeds or cross-breeds are quite varied, unlike conventional farmers who generally agree that Holstein-Friesian cows are the best. This difference can be explained by the fact that organic dairy farming is a young, developing sector and the search for suitable breeds of cattle is at an early stage. There is also a lack of good information about the qualities and performance of breeds and cross-breeds for organic production. In this context, many organic farmers are experimenting with both pure Holstein-Friesian cows inherited from the conventional sector and crosses between these and other breeds, although very little information is available about the resulting cross-breeds. The use of rustic Holstein-Friesian cows is even less well explored.

5.1. Pure-bred cattle other than Holstein-Friesian

It is widely accepted that local breeds are more robust and genetically better adapted to their environment than Holstein-Friesian cows (Diepen et al. 2007). Local breeds have been suggested to suit organic production and to be important for retaining genetic diversity (Ahlman 2010). They adapt well to organic systems because they utilise lower quality feed, are more resilient to climatic stress and are more resistant to local parasites and diseases than Holstein-Friesian cows. Use of local breeds also preserves the genetic variance of species. Such breeds can be saved for future generations of farmers by reintroducing them into organic farming systems (Nauta 2001). Moreover, the rearing of autochthonous breeds could be subsidized by the EU or regional governments to conserve genetic traits or cultural heritage (Commission Regulation (EU) No 702/2014 2014) and could be utilized as a marketing tool.

Few studies have been carried out to evaluate the performance of other pure breeds relative to Holstein-Friesian in organic dairy farming systems. As far we are aware, the most complete survey to date was conducted in the Netherlands with eight different breeds: Holstein-Friesian, Dutch Friesian, Brown Swiss, Montbeliarde, Jersey (considered as milk-aptitude breeds) and Groningen White Headed, Meuse Rhine Yssel and Fleckvieh (dual-aptitude breeds) (Haas et al., 2013). Under the study conditions, Holstein-Friesian produced the highest milk yields, followed by Brown Swiss and Montbeliarde (90 and 82% of the Holstein-Friesian´s milk production respectively), whereas Jersey cows produced the lowest yields (61%). However, the protein and fat contents of Jersey cow milk were much higher than those of Holstein-Friesian milk (only Fleckvieh obtained lower scores). Furthermore, SCC (an indicator of milk quality) was higher in Jersey cow milk than in milk from all other breeds, as found in other studies carried out in conventional systems (Berry et al. 2007) and possibly explained by a dilution effect as milk yield increases (Villar & López-Alonso 2015). Evaluation of reproductive performance showed that Fleckvieh and Groningen White Headed cows obtained the highest scores for fertility, whereas Holstein-Friesian and Brown Swiss cows obtained the lowest scores.

Similar results were obtained in a study carried out in Switzerland (Roesch et al. 2005) to evaluate the performance of organic dairy cows (involving 60 farms with a breed diversity of 55.1% Holstein-Friesian x Fleckvieh, 19.7% Holstein-Friesian, 18.8%

Fleckvieh and 6.4% Brown Swiss, Jersey and Montbeliarde). Breed had a strong impact on milk yield: Fleckvieh cows produced low volumes of milk, whereas pure-bred Holstein cattle and cows of other breeds (Montbeliard, Brown Swiss, and even Jersey) produced relatively high volumes of milk.

A study carried out in Austria compared only Brown Swiss and Holstein-Friesian cows (Horn et al. 2012); the Holstein-Friesian cows included in the study were selected for their reproductive performance, and Brown Swiss were reared in conventional systems. Interestingly, the Brown Swiss cows produced more milk with higher fat and protein contents, but showed poorer reproductive efficiency (measured as inter-parturition intervals) than the Holstein-Friesian cows. The authors concluded that Holstein-Friesian cows can be selected for use in pasture-based systems, although at the expense of milk production (Pryce et al. 1999). The results of this study may seem contradictory, but they simply confirm the fact that both the breed and the type of selection are important. Independently of the breeds used in organic dairy farming, the particular cows selected must be adapted to specific environmental and management conditions.

Finally, a recent study carried out by our research group (Rodríguez-Bermúdez et al. 2017) to evaluate the performance of diverse breeds (Holstein-Friesian, Swedish Red, Brown Swiss and crosses of Holstein-Friesian) on organic dairy farms in North Spain showed that Holstein-Friesian cows tend to produce more milk, but with significantly lower fat and protein contents, than the other breeds. No differences were observed in SCC in any case.

As studies of organic farming systems are scarce, one way of obtaining information about the performance of other breeds in organic systems is to observe how they perform in conventional pasture-based systems. Within Europe, some relevant studies have been conducted in Ireland. One study compared the performance of Normande and Montbeliarde cattle with that of Dutch and Irish strains of Holstein-Friesian in pasture-based systems (Dillon et al. 2003a, b). Dutch Holstein-Friesian cows produce more milk than the other breeds, and Normande cows produced milk with higher fat and protein contents than that produced by Montbeliarde and Dutch and Irish Holstein-Friesians (Dillon et al. 2003a). Normande and Montbeliarde displayed better reproductive performance than both strains of Holstein-Friesian (Dillon et al. 2003b), probably due to the negative effect of genetic selection for milk yield on reproductive performance

(Evans et al. 2002). Finally, up to 6-8 years, the survival rates of Montbeliarde (49.2%) and Normande cows (55.8%) were higher than those of Irish Holstein-Friesian (20.6%) and Dutch Holstein-Friesian (39.7%) (Dillon et al. 2003b). In other studies in Ireland, Holstein-Friesian cows were found to produce significantly more milk than Jersey cows (Prendiville et al. 2011), although there were no differences in SCC or udder health. As expected, Jersey cow milk contained significantly higher amounts of protein and fat (Prendiville et al. 2011) and the body condition score (BCS) and dry matter intake (DMI) were higher in Jersey cows than in the other breeds considered (Prendiville et al. 2009).

Overall, the available information for both organic and pastured-based conventional systems indicates that rustic breeds are better adapted to local conditions, displaying greater longevity and better reproductive performance than Holstein-Friesian cows. By contrast, local breeds always produce less milk than Holstein-Friesians, although the fat and protein contents of the milk are generally higher. Local breeds would therefore be acceptable in countries where the payment system is based on solids or where consumers are willing to pay for different types of products or for breed protection Moreover, Jersey milk coagulates more quickly and forms a firmer curd than Holstein-Friesian milk, characteristics that may be of interest for farmers wishing to produce cheese (Auldist et al. 2004). Finally, the possible lack of herd books and selection programs for breeds other than Holstein-Friesian may hamper the selection procedure.

5.2. Cross-breeding Holstein-Friesian with rustic breeds

Until relatively recently, cross-breeding was considered to offer little advantage to conventional dairy producers, probably due to the lower milk production potential of most breeds relative to the Holstein-Friesian (Prendiville et al. 2011). However, a decrease in additive genetic merit for functional traits, particularly fertility and health (which are important for longevity) has resulted in renewed interest in cross-breeding conventional dairy cattle in the past decade (Lopez-Villalobos, 2000), and some conventional dairy producers now include cross-breeding in their breeding programs. Cross-breeding highly productive Holstein-Friesian and local breeds is perceived as a good option for organic farmers. In fact, many more organic farmers than conventional farmers cross-breed cattle. For example, in a survey carried out in Ontario (Canada), Rozzi et al. (2007) found that about 40% of organic farmers questioned had cross-bred some or all of their cows, compared to conventional producers questioned. The breeds used for cross-breeding in organic farming are different from those used in conventional systems. While Jersey and Brown Swiss are the breeds most commonly chosen by conventional producers for crossing with Holstein-Friesian, organic producers have also experimented with other breeds, such as Dutch Belted, Milking Shorthorn and Fleckvieh; crosses with Dutch Belted are common and designed to increase the breed rusticity and production capacity when cows are only given forage.

Information about cross-breed performance on organic farms is scarce. Cross-breeds between Holstein-Friesian cows and other European breeds generally produce milk yields that are intermediate between those of both pure breeds (Haas et al. 2013). Some studies show that cross-breeds produce milk with higher protein and fat contents than milk produced by Holstein-Friesian cows (Rodríguez-Bermúdez et al. 2017); however, Haas et al. (2013) observed that crosses again performed better than both parental breeds (heterosis). No differences were found regarding SCC, which is more closely related to the management system than to breed type (Orjales et al. 2016, Rodríguez-Bermúdez et al. 2017). In Germany, Swalve (2007) found that in comparison with purebred Holstein-Friesian cows, Holstein-Friesian x Swedish Red crosses yielded advantages in terms of milk production, fat and protein contents of milk (all higher) and SCC (lower). Finally, Haas et al. (2013) observed that crosses between Holstein-Friesian cows and other breeds such as Dutch Friesian, Brown Swiss, Groningen White Headed, Jersey, Meuse Rhine Yssel, Montbeliarde and Fleckvieh improved fertility and sometimes udder health (except Jersey and Groningen White Headed). Similar results were found by Swalve (2007) for crosses between Holstein-Friesian and Swedish Red or Brown Swiss cows. Most of these studies can be considered preliminary, as they involved very few farms where breed diversity exits. As the organic dairy sector is currently growing, new studies involving a more farms and with well-planned experimental designs must be conducted to measure the performance of cross-breeding herds under organic productive systems.

Considering the available information on cross-breeding in conventional pasture-based systems, the New Zealand Jersey x Holstein-Friesian experience is important (Buckley et al. 2014). Many studies have been conducted in recent years, both within and outside of New Zealand, based on evidence of the average superiority of cross-bred cows compared with any of the parental lines (Holstein-Friesian, Ayrshire and Jersey). This is due to the high potential for increased profits to be gained from cross-breeds (Lopez-Villalobos et al. 2000) because of their high capacity for pasture intake (Prendiville et al. 2009) and efficiency of conversion of feed to milk (Garrick 2002), as well as improved fertility (Auldist et al. 2007) and longevity (Harris et al. 1996). Jersey cows, known to produce milk with high butterfat content, could be used in cross-breeding programs with Holstein-Friesian cows to improve butterfat percentage in a single cross (Bluhm 2009). In terms of reproduction, Holstein-Friesian x Jersey crosses performed better than pure Holstein-Friesian, with higher conception and pregnancy rates (Auldist et al. 2007). Studies carried out in pasture-based systems in Ireland obtained similar results to those obtained in New Zealand (Prendiville et al. 2009, 2011), i.e. Holstein-Friesian (dam) x Jersey (sire) cross-breeds produced intermediate milk yield and fat and protein contents than both pure-bred parents, with Holstein-Friesian performing better for milk production and Jersey for fat and protein contents. No differences were found in relation to SCC and mastitis.

Once farmers know which breeds they wish to cross, the next dilemma is to decide what to do after the first cross. One possible strategy would be to produce first crosses, which would involve maintaining some pure-bred cows and mating the best performers while mating the other pure-bred cows with the desired sire to produce replacements for the cross-bred proportion of the herd. Other options include using continuous rotational cross-breeding strategies or even producing composite breeds. A two-breed rotational cross maintains 67% of the direct heterosis, while three- and four- breed crosses maintain respectively 86% and 94% of the direct heterosis. The challenge is to find several breeds of suitable merit to produce a cross-bred population that is better (economically) than the pure-bred population (Pryce & Veerkamp 2001).

Backcrossing animals does not always produce good results. For example, backcrossing Holstein-Friesian x Brown Swiss crosses with a Brown Swiss resulted in lower milk yields in one study (Dechow et al. 2007). In another, expected heterosis was close to zero in second and third breed cross-breeding systems due to unfavourable recombination effects on yield (Pedersen & Christensen 1989). A recent study conducted in Argentina found that once first crosses (Holstein-Friesian x Jersey, Holstein-Friesian x Guernsey, Holstein-Friesian x Brown Swiss) have been carried out, Holstein-Friesian traits of interest can be recovered by breeding cross-bred dams with a Holstein-Friesian bull (Mancuso 2017).

In conclusion, cross-breeding highly productive Holstein-Friesian and local breeds may be a viable option for organic producers. Although this approach seems well-established for breeds such as Jersey, further investigation with other breeds is required before it is applied on a large scale (Ahlman 2010). The decision to produce cross-breeds is usually based on a desire to improve functional traits by taking advantage of heterosis. However, the effects of heterosis can be positive or negative, and the overall effects are difficult to predict (Bluhm 2009). In addition, the choice of breeds is critical because, as already pointed out, herd books or selection programs may not have been established for minor breeds, as some farmers carry out progeny testing on their own herds.

5.3. Rustic Holstein-Friesian

It seems that Holstein-Friesian cows maintain genes from their ancestors and still show reasonable reproductive and productive performance under pasture conditions. In fact, a study in the UK has shown that when suitable strains are chosen, Holstein-Friesians are the most profitable breed for use in both conventional and organic systems (Brotherstone & Goddard 2005). It has also been demonstrated that, under experimental conditions based on grazed pastures and moderate concentrate supplementation, maximum economic profit was obtained with Holstein-Friesian cows with a low percentage of North American genes (Baudracco et al. 2010). This may explain why some farmers do not use local breeds and prefer to continue using Holstein-Friesian cows (Nauta 2001).

The best example of Holstein-Friesian cattle adapted to pasture-based systems is without any doubt the New-Zealand Holstein-Friesian. These cattle were initially selected for fat yield, then for fat and protein and against milk volume, and more recently for economic efficiency, including maintenance costs (Harris 1998). The New Zealand dairy system is pasture-based with low supplementation; most of the cows calve in spring and 90% of the milk is made into dairy products. Farmers are paid for the amount of protein and fat produced and a deduction is made for milk volume produced (Harris & Kolver 2001). In general, this strain of New Zealand Holstein-Friesian produces milk with higher fat and protein contents and it displays better fertility, BCS, survival and overall economic performance than the North American Holstein-Friesian (Harris & Kolver 2001). Moreover, New Zealand Holstein-Friesian cows have lower maintenance requirements and DMI in early lactation than the North American Holstein-Friesian (Patton et al. 2008). It has been concluded that New Zealand Holstein-Friesian cows selected under pastoral feeding are better adapted to pasture-based systems than North American Holstein-Friesian cows (Macdonald et al. 2005). However, New Zealand Holstein-Friesian adapted to pasture-based systems may not be the best alternative for use in European organic farms, as they are selected to produce high quantities of milk solids, and the milk payment system in Europe mainly considers volume. European organic farmers must have their own rustic Holstein-Friesian with good reproduction and disease resistance but that maintains good milk yield production.

Some examples of European Holstein-Friesian cows, i.e. Dutch and Irish strains, maintain some rustic traits. In the case of Dutch Friesian, a breeding system called family breeding was developed by a group of individual breeders of the remaining Dutch-Friesian cows in the Netherlands. This group of farmers represented only 8% of organic farms in Netherlands in 2001 (Nauta 2001, Nauta et al. 2009). The purpose of this breeding system was to maintain the original Dutch Friesian breed (Fries-Hollands) (Endendijk & Baars 2001). Farmers select and breed their own replacement animals, both female and male, thus producing animals that are highly adapted to the local environment (Nauta 2001). However, the Dutch-Friesian family breeding system depends on farmers' breeding skills, and professional support may be required for the continued success of the system. Although the inbreeding rate was 4.5% in 2005 (which is acceptable with the rate of more than 6% in Holstein-Friesian cattle), after many years of family breeding the animals become increasingly more closely related, and organic farmers therefore do not regard the system as a good option. Conventional Irish systems have also selected a particular Holstein-Friesian strain, which has been demonstrated to survive better on pasture (39.7% lasted for 6-8 years) and shows better reproductive performance than the American Holstein-Friesian (21% lasted for 6-8 years) (Dillon et al. 2003b).

6. Which direction should selection of breeds for organic sector take in coming years?

This analysis of how different breeds and crosses perform in organic dairy systems worldwide clearly shows that there are advantages and disadvantages associated with all. The importance of the various pros and cons varies depending on the individual conditions on a particular farm. It is also clear that opting to use different breeds is risky and will remain costly, as a medium/long-term process, until homogenous herds are established.

As most organic dairy farms have been reconverted from more or less intensive conventional farms, where the predominant breed is Holstein-Friesian, the recommended option for most organic farms seems to be to continue using the Holstein-Friesian breed (while identifying those cows best adapted to the particular conditions of these productive systems), although bearing in mind that trying out different breeds may also be worthwhile under certain circumstances.

Once it has been decided which breed or crosses best fit the particular interests of organic farmers, the next, but not less important, decision to make involves selection of which particular individuals to use, either pure-bred or cross-bred. Therefore, the challenge in the coming years in organic dairy breeding is to provide an organic genetic merit index that satisfies the famers' needs.

Some efforts have been made to elaborate total merit indexes for organic dairy production, in Switzerland, Austria, Germany and Canada (Haas and Bapst, 2004; Rozzi et al., 2007). These indexes were thought to enable farmers to identify the conventional sires best adapted to organic production. Unfortunately, these first efforts were rather unsuccessful because of inadequate support (Ahlman, 2010). Although the organic sector is increasing, it remains a minority, and the market volume of this productive sector may not be profitable for maintaining bulls only for organic farms. A potentially good alternative would be to develop breeding indexes adapted to pasture-based systems, which would not only be suitable for organic systems but also for conventional systems with high grazing intensity. An adequate body of knowledge and practical applicability already exists in countries such as Ireland and New Zealand, where the solids (kilograms of fat and protein) and high fertility indexes are maximized, and milk yield production, live weight and somatic cell counts are minimized (in terms of genetic value). Moreover, recent technological developments have led to the identification of cows that are more resistance to diseases (based on genomic tests) which may be useful for selecting the least susceptible individuals in the herd for breeding, in the first step to increase the herd "robustness".

All the above-mentioned tools have been developed for conventional dairy systems, so that breeding values must be converted to organic systems based on information obtained under organic conditions. Only then will organic farmers be able to select best breeding bulls and cows for organic production (Nauta et al., 2006b). If breeding values are converted or estimated, bulls will have to be re-ranked as the classification will be different, as a result of GxE interactions (Nauta et al., 2006b; Ahlman, 2010). In our opinion, selection indexes for organic production should place more emphasis on functional traits (especially fertility and longevity) than on production traits, as well as on the capacity of the animals to perform well in pasture-based systems (i.e. considering robustness of feet and legs and grazing capacity). For farmers transforming milk into dairy products, special emphasis should be placed on solids production and the transformation capacity.

Conclusions

Unlike the conventional farming sector, organic dairy farming on both local and large scales is very heterogeneous, and no single type of cow will be suitable for all scenarios. Because of the legislation associated with organic farming (mainly involving nutrition and allopathic treatments) and the high dependence on the environment, organic farmers generally demand robust cows that are sufficiently productive to yield profits. Analysis of the available data indicates that (i) there is no single alternative breed (rustic Holstein-Friesian, other rustic breeds or crosses) as there are advantages and disadvantages associated with all, and (ii) the strong genotype x environment interactions demand different strategies to deal with very diverse situations. For example, farms producing milk for payment systems that recompense volume would obtain benefits from high milk yielding cows, i.e. rustic Holstein-Friesian may be the best option. Although most Holstein-Friesian cows are currently selected for use in conventional systems, this situation could be reversed by the implementation of an organic merit index that takes into account organic breeding goals. On the other hand, farms producing milk either for systems that recompense milk solids or for transformation into dairy products would benefit from using pure-bred cows other than Holstein-Friesian or cross-breeds. Finally, organic farmers who focus on rural tourism, farm schools, or other businesses where marketing strategies must be taken into account, could benefit from using local breeds (when possible) or any other rustic breed valued by customers.

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Figure 1. Map showing the evolution and current situation of Holstein-Friesian (HF) worldwide. Data source http://www.whff.info/documentation/statistics.php

Figure 2. Diagram showing the correlations between milk yield and functional and health traits in dairy cows.

Table 1. Summary of EU regulations concerning organic dairy farming (EC, 2008)

Animal management

- Access to open air or grazing areas.
- Stocking density: maximum 2 dairy cows/ha (equivalent to 170 kg N/ha/year).
- Animal-health management mainly based on prevention of disease.
- Sufficient space for natural behaviour.

Breed choice

- Selected to prevent diseases/health problems associated with intensive production.
- Preference to indigenous breeds and strains.
- Breed choice should take account the capacity to adapt to local conditions, vitality and resistance to disease.

Animal welfare

- EU welfare standards.
- Mutilations (dehorning) banned.
- Minimum suffering (adequate anaesthesia and/or analgesia, qualified personnel).

Animal nutrition

- Feed in accordance with the rules of organic farming, by taking into account the physiological needs. Minerals, trace elements and vitamins under well-defined conditions.
- At least 50% of the feed from the farm (if this not possible, from the same region).
- Maximum use of grazing pasturage.
- At least 60% of the dry matter in daily rations consist of roughage, fresh or dried fodder, or silage.
- Calves fed on maternal milk (preference to natural milk) for a minimum of 3 months.
- No synthetic pesticides or fertilisers.
- No genetically modified organisms.

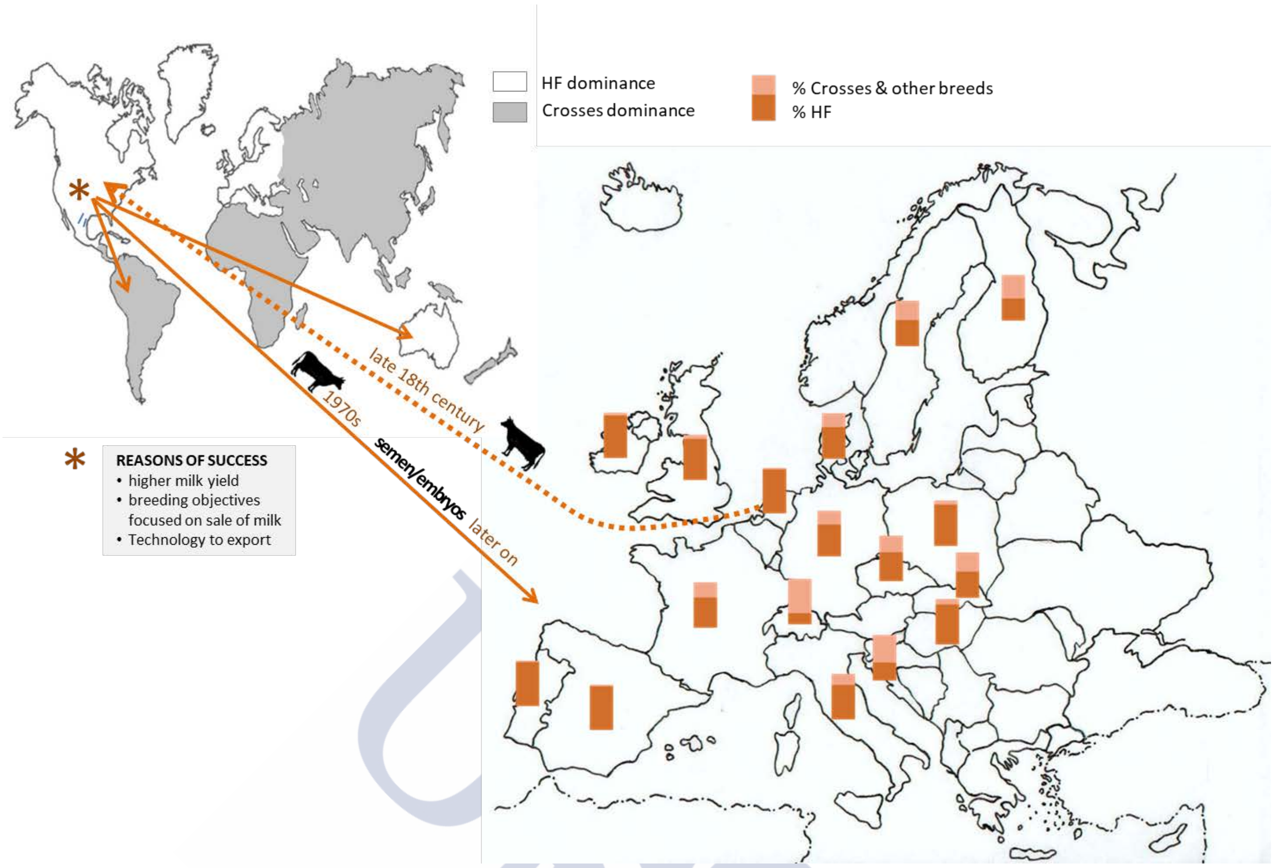
Veterinary management

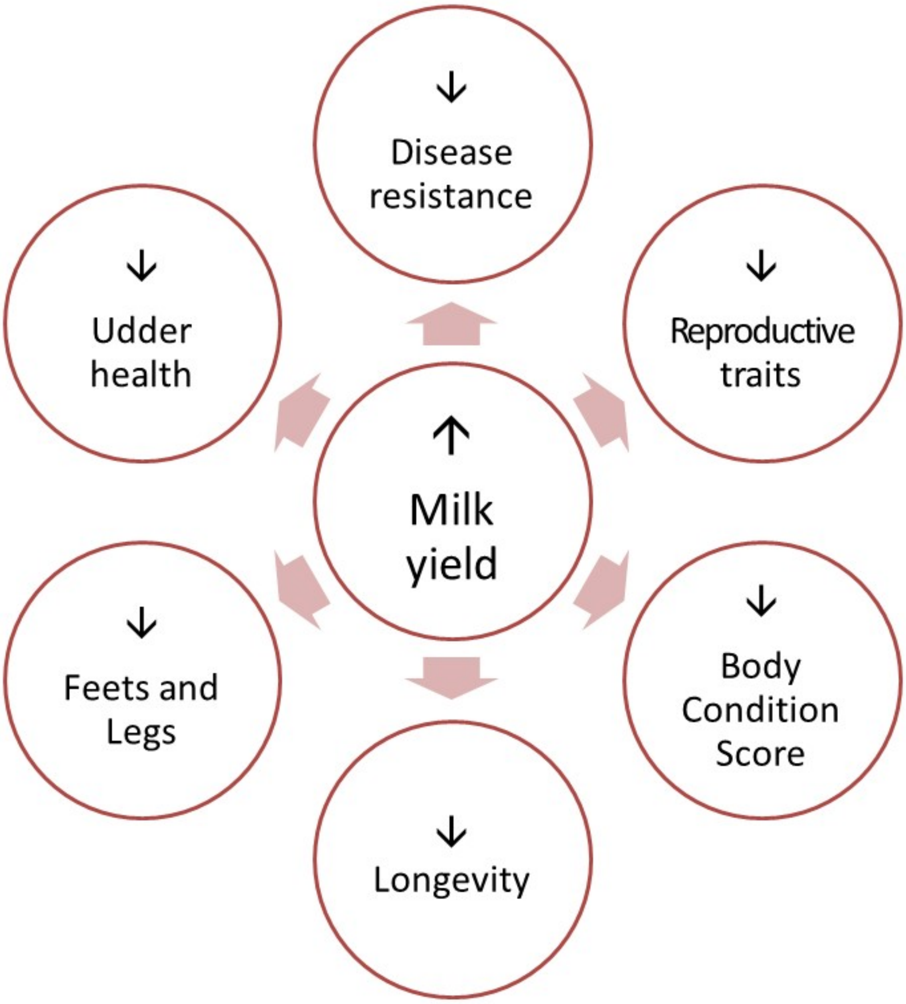
- Animal-health management should be based on disease prevention.
- Preventive use of chemically synthesised allopathic medicinal products (including antibiotics) is not permitted.
- The aforementioned allopathic medicinal products is allowed when the use of phytotherapeutic, homeopathic and other products is not appropriate.
- Use of growth promoting agents and hormones is prohibited.

Table 2. Pros and cons of the use of Holstein-Friesian, other pure-bred and cross-bred cows in organic dairy systems.

	Pros	Cons
Pure-bred cattle other than Holstein-Friesian	• Robust and genetically better adapted to local conditions (lower feed quality, parasites, diseases, climatic stress, etc) • Greater longevity and fertility • Some breeds have better fat and protein milk contents • Higher value of newborn males and culled cows	• Lower milk production • Lack of herd books
Cross-breeding Holstein-Friesian with rustic breeds	• Improved fertility, longevity and udder health • High capacity for pasture intake • Usually intermediate production between Holstein-Friesian and other pure breeds • Tendency to produce higher fat and protein contents than Holstein-Friesian • Higher value of newborn males and culled cows	• Dilemma about what to do after the first cross to obtain reposition • No direct payments to farmers within the framework of the common agricultural policy [1] • Lower valuation in agrarian insurance than pure breeds
Rustic Holstein-Friesian	• Reasonable reproductive and productive performance under pasture conditions • Lower maintenance requirements than North American Holstein-Friesian • Better milk production than other pure breeds	• Strains adapted to organic systems should be selected

(1) REGULATION (EU) No 1307/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy


HF dominance
Crosses dominance
% Crosses & other breeds
% HF
late 18th century
1970s
semen/embryos
later on
*
REASONS OF SUCCESS
• higher milk yield
• breeding objectives focused on sale of milk
• Technology to export


↓ Disease resistance
↓ Udder health
↓ Reproductive traits
↑ Milk yield
↓ Feets and Legs
↓ Body Condition Score
↓ Longevity

CAPÍTULO II

CAPÍTULO II

Rodríguez-Bermúdez R, Miranda M, Orjales I, Rey-Crespo F, Muñoz N, López-Alonso M. 2017. Holstein-Friesian milk performance in organic farming in North Spain: Comparison with other systems and breeds. *Spanish Journal of Agricultural Research*. 15 (1): 1-10.

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CAPÍTULO III

O artigo titulado “**Reproductive performance in organic dairy farming in northern Spain. What can be improved**" que conforma o capítulo III está enviado para publicación na revista International Journal of Agricultural Sustainability.

International Journal of Agricultural Sustainability

Reproductive performance in organic dairy farming in northern Spain. What can be improved?

--Manuscript Draft--

Full Title:	Reproductive performance in organic dairy farming in northern Spain. What can be improved?
Manuscript Number:	
Article Type:	Original Article
Keywords:	organic systems; dairy cattle; breeds
Abstract:	Organic farming has traditionally given preference to indigenous breeds that are well adapted to local conditions; however, current trends towards increased yields may produce less robust animals with potentially low fertility. The Holstein-Friesian breed dominates dairy sector, although there is a general concern that these cows may not be well adapted to organic systems. This study aims to evaluate the reproductive performance of organic dairy herds in northern Spain, by comparing organically-reared Holstein-Friesian with their counterparts reared on conventional farms and also with other organically reared breeds and crosses. Reproductive parameters were obtained for individual cows on organic, conventional pasture-based and conventional zero-grazing farms. The reproductive performance of Holstein-Friesian cows was slightly better in organic systems than in pasture-based conventional systems, but not than in zero-grazing conventional systems. The comparison of reproductive performance of Holstein-Friesian from organic and conventional systems and with other organically reared breeds and crosses enabled us to demonstrate that it is not the organic system that constrains the reproductive performance of Holstein-Friesian, but that the manifestation of estrus is less marked than in other breeds. Breeding selection considering reproductive traits and appropriate management of estrus detection would improve the reproductive performance of Holstein-Friesian cows.
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Reproductive performance in organic dairy farming in northern Spain. What can be improved?

Abstract

Organic farming has traditionally given preference to indigenous breeds that are well adapted to local conditions; however, current trends towards increased yields may produce less robust animals with potentially low fertility. The Holstein-Friesian breed dominates dairy sector, although there is a general concern that these cows may not be well adapted to organic systems. This study aims to evaluate the reproductive performance of organic dairy herds in northern Spain, by comparing organically-reared Holstein-Friesian with their counterparts reared on conventional farms and also with other organically reared breeds and crosses. Reproductive parameters were obtained for individual cows on organic, conventional pasture-based and conventional zero-grazing farms. The reproductive performance of Holstein-Friesian cows was slightly better in organic systems than in pasture-based conventional systems, but not than in zero-grazing conventional systems. The comparison of reproductive performance of Holstein-Friesian from organic and conventional systems and with other organically reared breeds and crosses enabled us to demonstrate that it is not the organic system that constrains the reproductive performance of Holstein-Friesian, but that the manifestation of estrus is less marked than in other breeds. Breeding selection considering reproductive traits and appropriate management of estrus detection would improve the reproductive performance of Holstein-Friesian cows.

Key words: organic systems, dairy, breeds, calving, services, crosses

Introduction

Organic agriculture first emerged in response to the industrialization of agriculture and the associated environmental and social problems (Röös et al., 2018). Basically, organic farming promotes the use of local feed resources, prohibits the use of pesticides and greatly limits the use of chemical products such as fertilizers and allopathic treatments (Sundberg, Berglund, Rydhmer, & Strandberg, 2009). Organic systems are therefore highly dependent on the environment, and a more holistic view of the farming system is required for adequate productivity and resilience to be reached (Gouttenoire, Cournut, & Ingrand, 2013). Different aspects of organic objectives associated with animal management, prevention methods in animal health, animal housing, animal welfare, animal nutrition and veterinary management are covered in the EU regulations related to organic agriculture, the International Federation of Organic Agricultural Movement (IFOAM) norms, and the agroecological literature (for a review, see Migliorini & Wezel, 2017). However, the proposed practices related to breed choice are similar in all regulations, with preference given to indigenous breeds adapted to local condition and evasion of hyper-specialization.

Organic agriculture currently performs well in most domains of sustainability, such as animal welfare, farm profitability and low pesticide use; however, yields are generally lower than in conventional farming. Critics as well as many proponents of organic agriculture share the common view that in organic agriculture yields must increase (Röös et al., 2018). Such an increase is necessary not only to feed a growing, more affluent global population but also to ensure that organic farming systems become more environmentally efficient. Although organic agriculture is usually associated with lower environmental burdens per hectare than conventional farming, adverse impacts are often similar or higher per kilogram of product owing to lower outputs. However, breeding for higher yields leads to the risk of producing less robust animals with more health problems, including low fertility (Röös et al., 2018).

In the recent past, breed selection of conventional dairy cattle has focused almost exclusively on Holstein-Friesian cattle reared in intensively managed systems with the aim of improving milk production (Nauta, Veerkamp, Brascamp, & Bovenhuis, 2006). The resulting cattle can be considered high maintenance animals for use in extremely standardized intensive systems. However, the conditions in organic production systems are very different from those in conventional systems, mainly in relation to feeding regimes and medical treatments (Ahlman, 2010). The selection process has also resulted in reduced reproductive efficiency, extended calving intervals, increased health problems, increased culling rates and decreased productive life (Bluhm, 2009), especially when these highly selected cows are reared outside of intensive nutritional and environmental management systems. Thus, highly productive Holstein-Friesian cattle show a limited capacity to adapt to the low-input diets on organic farms, resulting in lower life expectancy and productive performance (Garmo et al., 2009; Nauta al., 2006). This has led researchers to question whether Holstein-Friesian cattle can adapt sufficiently well to organic and other low-input (forage-based) systems (Horn, Steinwidder, Podstatzky, Gasteiner, & Zollitsch, 2012; Nauta et al., 2006).

In a recent study of organic dairy herds in northern Spain, we found that organic farmers are generally not satisfied with the reproductive performance of their Holstein-Friesian cows and would like to see breeding programs that emphasize reproduction as well as other functional traits such as health and longevity (Rodríguez-Bermúdez et al., 2016). Most dairy farmers converting to organic production maintain their conventional Holstein-Friesian livestock (selected for high production) but rear them under very different conditions as regards nutrition and medical treatments. Only a small proportion of farmers (18%) have begun to introduce other breeds or cross-breeds, but without any clear idea of which breed or type of cow would best suit their needs (Rodríguez-Bermúdez et al., 2016). Although there is general agreement in the relevant literature and legislation that rustic breeds may be suitable for organic systems, very few field studies have evaluated this possibility.

The objective of this study was to conduct a preliminary evaluation of the reproductive performance of organic dairy herds in northern Spain. This was done by comparing reproductive parameters (number of services per conception, calving interval, calving to first service interval, calving to conception interval, age at first service, age at first conception and age at first calving) of organically-reared Holstein-Friesian cows with those of their conventionally-reared counterparts (in pastured-based and zero-grazing systems) and of other organically reared breeds and crosses. As the scenario of breed diversity in organic dairy farming in northern Spain (dominated by the Holstein-Friesian breed selected for conventional systems) is similar across Europe, this information will be valuable for determining which breed type may best adapt to the local conditions of the organic dairy systems in a wider context.

Materials and methods

Farms involved

The data analyzed in this study were collected within a broader research project evaluating and comparing the nutritional and health status of organic and conventional dairy cattle in northern Spain (Spanish Government Ref. AGL 2010-21026) and involved 80% of the organic herds in the region. The data were obtained from representative and comparable organic (n=10), conventional pasture-based (n=5) and conventional zero-grazing (n=5) farms. Information on these farms is summarized in Table 1. Holstein-Friesian was the only breed present on all the conventional farms and on 3 of the organic farms. The other 7 organic farms used different breeds in addition to Holstein-Friesian, including pure-bred Swedish Red, Brown Swiss, Fleckvieh, Montbeliarde, Normande or Jersey, and crosses between each of these and Holstein-Friesian (Figure 1); not all breeds or crosses were present on all farms.

Data collection

The farmers participating in the study were asked questions regarding reproductive management (see Table 2). Reproductive data on individual cows were collected during visits to farms or were obtained from regional milk records between 2013 and 2017. The following reproductive parameters were considered: number of services per conception, calving interval, calving to first service interval, calving to conception interval, age at first service, age at first conception and age at first calving. All data were expressed in days, except number of services per conception.

The number of services per conception was taken into account for those heifers and cows with a positive pregnancy test. Calving interval was calculated as the difference between calving dates. Calving to first service interval was calculated as the difference between the calving and first service date for all cows that calved. Calving to conception interval was calculated by the difference between calving and last service date when cows had a positive pregnancy test. Age at first service was calculated for heifers having a first service as the difference between date of birth and first service date. Age at first conception was calculated as the difference between birth and last service date for those heifers with a positive pregnancy test. Age at first calving was calculated for heifers after first calving as the difference between birth date and first calving date.

Statistical analysis

All statistical analyses were performed using SPSS program for Windows (V.21.0). Data normality was checked by using the Kolmogorov-Smirnov test. The level of statistical significance considered was $p<0.05$.

The data on Holstein-Friesian cows reared in organic, conventional pasture-based and zero-grazing conventional systems were analyzed using Factorial Linear Mixed Models. All reproductive parameters were considered dependent variables. Farm was included as a random factor and Farm_System and Lactation_Group were included as fixed factors. The following lactation groups (LG) were considered: LG-1 (heifers, from birth to first calving), LG-2 (from first to third calving) and LG-3 (from third calving onwards). *Post-hoc* analysis (Bonferroni test) was conducted for subsequent intergroup comparisons for each variable.

The general form of the linear model used was as follows:

$Y_i = X_i\beta+Z_ib_i+e$

where Y_i=response vector for the *i*-th group (all reproductive parameters), X_i= fixed effects matrix model (Farm_System and Lactation_Group), β=vector of fixed coefficients, Z_i= random effects matrix model (Farm), b_i=vector of random coefficients, e=vector of within groups errors.

When considering the effect of breed on reproductive performance on the organic farms, all crosses between Holstein-Friesian and other breeds (i.e. Holstein-Friesian x Swedish Red, Holstein-Friesian x Brown Swiss, Holstein-Friesian x Fleckvieh, Holstein-Friesian x Montbeliarde, Holstein-Friesian x Normande, Holstein-Friesian x Jersey) and all pure-breeds other than Holstein-Friesian (i.e. Swedish Red, Brown Swiss, Fleckvieh, Montbeliarde, Normande, Jersey) were grouped together in order to increase the statistical power of the tests. All variables were analyzed using the same criteria as for production systems, in this case with breed as a fixed factor. Post-hoc analysis (Bonferroni test) was conducted for subsequent intergroup comparisons for each variable.

The general form of the linear model used was as follows:

$Y_i = X_i\beta+Z_ib_i+e$

where Y_i=response vector for the *i*-th group (all reproductive parameters), X_i= fixed effects matrix model (Breed and Lactation_Group), β=vector of fixed coefficients, Z_i= random effects matrix model (Farm), b_i=vector of random coefficients, e=vector of within groups errors.

Results

Reproductive management in organic, pasture-based and zero-grazing conventional dairy farming systems in northern Spain

Information on the reproductive management in organic, pasture-based and zero-grazing conventional dairy farming systems in northern Spain is summarized in Table 2. Regarding the type of service, artificial insemination was used on all zero-grazing conventional farms (usually carried out by the farmers); on pasture-based conventional farms service was carried out by combination of artificial insemination (usually carried out by the farmers themselves) and natural mating; and only artificial insemination was used on most organic farms, while some combined artificial insemination (carried out by farmers or veterinarians) and natural mating. All farmers received specialist advice from vets regarding cattle reproduction. The use of reproductive treatments on the different types of farms varied widely: no reproductive treatments were used on organic farms (as required by law, except to treat severely ill cows); and few or no reproductive treatments were used on the pasture-based conventional farms; treatments aimed at programming or synchronizing - and thus strictly controlling reproduction - were frequently used on the zero-grazing conventional farms. The production systems also differed widely regarding the management of estrus (heat) detection. Thus, while organic and zero-grazing systems have well-established heat detection routines, with designated staff responsible for this activity, in pasture-based systems the farmers try to detect oestrus during other activities such as feeding the animals and cleaning the stalls. Finally, on organic farms with diverse breeds, no differences in reproductive management of the different breeds were observed.

Comparison of the reproductive performance of Holstein-Friesian cows in organic, pasture-based and zero-grazing dairy farming conventional systems

The data on Holstein-Friesian reproductive parameters in organic, conventional pasture-based and zero-grazing conventional dairy farming systems are summarized in Figure 1. The results of the Linear Mixed Model analysis indicate that only around 11% of the variability was explained by the farm. As expected, the lactation group (LG) was a significant factor in the Linear Mixed Model ($F_{2,2864}$=73.3, p<0.001) for number of services per conception (LG-1 had fewer services per conception in all systems than the other lactation groups); however, there were no differences between farming systems for number of services per conception ($F_{2,2864}$=0.258, p=0.775). Furthermore, no statistically significant differences were observed between farming system for calving interval ($F_{2,3173}$=2.41, p=0.120), age at 1st service ($F_{2, 704}$=0.054, p=0.947), age at 1st conception ($F_{2, 772}$=0.595, p=0.552) or age at 1st calving ($F_{2, 1464}$=0.812, p=0.445). By contrast, statistically significant differences between farming systems were found for calving to 1st service interval and calving to conception interval. Organically reared Holstein-Friesian cows had shorter calving to first service ($F_{2,2405}$=4.77, p<0.05) and calving to conception ($F_{2,2360}$=8.01,p<0.05) intervals than pasture-based conventional Holstein-Friesian cows, but similar values to zero-grazing conventional animals.

Comparison of reproductive parameters of Holstein-Friesian, other purebred and crossbred cows within organic systems

The data on reproductive parameters in Holstein-Friesian crosses and pure-breeds other than Holstein-Friesian in organic farms are summarized in Figure 2. The results of the Linear Mixed Model analysis indicate that only around 12% of the variability was explained by the farm. No statistically significant differences for lactation group ($F_{2,1574}$=2.21, *p*=0.110) or breed ($F_{2,1574}$=1.91, *p*=0.148) were found for number of services per conception. No statistically significant differences between breeds for age at 1st service ($F_{2,280}$=0.054, *p*=0.947), age at 1st conception ($F_{2,295}$=0.595, *p*=0.552) or age at 1st calving ($F_{2,742}$=0.812, *p*=0.445) were found. On the contrary, the calving intervals were significantly higher in Holstein-Friesians cows ($F_{2,1867}$=9.41,*p*<0.001) than in other breeds (either pure or cross-breeds). Although numerically higher in the Holstein-Friesian than in the other groups, significant differences were only observed relative to the cross-bred cows for calving to first service intervals ($F_{2,1438}$=7.09, *p*<0.001) and calving to conception intervals ($F_{2,1305}$=10.5, *p*<0.001).

Discussion

Comparison of the reproductive performance of Holstein-Friesian cows in organic, pasture-based and zero-grazing dairy farming conventional systems

Overall our findings show that the reproductive performance of Holstein-Friesian cows was slightly better on organic farms (only for calving to first service and calving to conception intervals) than on pasture-based conventional farms, but not than on zero-grazing conventional farms in northern Spain. Similar results have been found in other studies comparing organic and conventional systems, with the fertility of organic herds being slightly higher than that of conventional herds, irrespective of lactation number. However, most studies have compared both systems without taking into account breed composition, and Holstein-Friesian and Swedish Red are the predominant breeds in the herds studied. Reksen, Tverdal, & Ropstad (1999) evaluated the reproductive performance of cattle reared on organic and conventional farms in Norway and obtained similar results for both groups, except for days open (higher number in organic systems). In a later study comparing health management in organic and conventional dairy herds, Valle, Lien, Flaten, Koesling, & Ebbesvik (2007) did not observe any differences regarding calving interval. In a similar study carried out on an experimental farm in Sweden (Fall, Forslund, & Emanuelson, 2008), there were no differences in reproductive performance between organic and conventional herds, apart from calving to first service interval in cows with 3 or more lactations (with lower intervals in the organically reared cows).

Sundberg et al. (2009) reported that cow fertility was slightly higher under organic management than under conventional management, irrespective of lactation number; these authors also observed slight differences for calving to first and last insemination intervals, calving interval and number of inseminations (with higher fertility in organic cattle). Similarly, Ahlman (2010) observed slightly higher (statistically significant) fertility in organic herds (shorter calving to first and last service interval and calving intervals and lower total number of inseminations) than in conventional herds. In both of these studies, differences between organic and conventional systems were assumed to be related to differences in milk yield. Analysis of the relationship between milk production and reproductive performance in lactating Holstein-Friesian cows showed that the duration of oestrus, standing events and standing time were shorter (and consequently more difficult to detect) in high milk-yielding than in low milk-yielding cows. This has been attributed to lower serum of estradiol concentrations in the former (Lopez, Satter, & Wiltbank, 2004) and to the fact that cows selected exclusively for high milk production have a longer interval to the commencement of luteal activity after calving than cows bred for different purposes (Garmo et al., 2009). The relationship between milk yield and reproductive performance in Holstein-Friesian cattle reared in different production systems was not considered in the present study as not all of the organic farms are registered with a dairy control body; however, the results of a previous study in northern Spain indicate that daily milk production was significantly lower in Holstein-Friesian cows reared on organic farms than in those reared on zero-grazing farms (54%), but only slightly lower than in those reared on pasture-based conventional farms (10%) (Rodríguez-Bermúdez et al., 2017). These findings suggest that milk yield is probably not the main reason of the differences in reproductive performance between organic and pasture-based conventional systems observed in the present study.

Detailed analysis of the reproductive management of farms (Table 2, Figure 1) indicates that the low level of effort in estrus detection may at least partly explain the poorer results on pasture-based conventional farms. Although estrus detection in cows requires several periods of intensive observation daily, which is expensive and time consuming, failure to detect estrus accurately is finally much more costly. Cows should be observed at least 2-3 times a day for a minimum of 20-30 minutes in order to detect around 80% of cows in estrus (Van Vliet & Van Eerdenburg, 1996). Moreover, farmers should not attempt to detect estrus while carrying out other farm activities, such as moving the cows from one field to another, when they are unlikely to be able to give their full attention to the task of detection, or milking, as cows do not generally display estrous behavior on concrete floors (Senger, 1994; Rodtian, King, Subrod, & Pongpiachan, 1996). Our findings show that estrus detection on conventional pasture-based farms is not adequate, as specific times have not been set aside for this task, which tends to be carried out at the same time as other farm tasks such as milking, cleaning stalls and feeding animals.

On the other hand, the good reproductive performance in terms of estrus detection on intensive conventional (zero-grazing) farms may also be due to the application of reproductive treatments (Table 2, Figure 1). Hormonal treatments are used to increase the probability of estrus detection and insemination to increase pregnancy rates in dairy cattle (Lucy, McDougall, & Nation, 2004). In the present study, zero-grazing conventional farms were found to use reproductive treatments more frequently than conventional pasture-based farms (note that in organic farming the use of reproduction treatments is forbidden unless clinical illness is present; EC, 2007).

Comparison of reproductive parameters of Holstein-Friesian, other purebred and crossbred cows within organic systems

The results of our study seem to indicate that differences in the reproductive parameters between breeds within the same organic farm may be related to differences in expression of estrus, which farmers must be able to identify before the cows are inseminated. Estrus duration is much shorter in Holstein-Friesian than in Norwegian Red cows, which also participate in greater number of sexually active groups for longer and display different (more frequent) mounting activity (Sveberg et al., 2015). Similar results were obtained in a study comparing Holstein-Friesian with Normande cows, with the former showing less obvious signs of estrus (Cutullic, Delaby, Causer, Michel, & Disenhaus, 2009).

Studies evaluating breed-related reproductive performance in organic systems are scarce. Swalve (2007) compared pure-bred Holstein-Friesian and their crosses with Brown-Swiss and Swedish Red reared on farms in Germany and observed a significantly higher number of services per conception in Holstein-Friesian cows. In a study carried out in The Netherlands, in which the suitability of cross-bred animals for organic systems was analyzed, the calving interval was longest in pure Holstein-Friesian and shortest in pure-bred Fleckvieh (Haas, Smolders, Hoorneman, Nauta, & Veerkamp, 2013). Finally, in a study conducted in Austria under Alpine conditions, Holstein-Friesian cows (selected for superior lifetime performance and fertility) were found to be reproductively more efficient than Brown Swiss, although the Brown Swiss were also more productive (Horn et al., 2012). There is much information available regarding conventional pasture-based systems, and the findings are generally consistent with observations made in organic systems. On the one hand, the reproductive performance of Holstein-Friesian cattle with a large proportion of North American genes is low relative to that of other pure breeds such as Normande and Montbeliarde (in terms of longer calving to conception interval and pregnancy rate; (Dillon et al., 2003), Norwegian Red (6 and 13 weeks in calf, pregnancy rate at first service, calving to first service and to conception intervals and number of services per conception; Begley, Pierce, & Buckley, 2009) or Jersey cows (higher conception rates and higher percentages of pregnant cows; Washburn, White, Green, & Benson, 2002). The *Holsteinisation* phenomenon affects female fertility (Lindhe & Philipsson, 1998; Royal et al., 2000; Buaban et al., 2015), which can be explained by the more intense selection for milk production in the Holstein-Friesian breed (Pryce, Royal, Garnsworthy, & Mao, 2004; Dillon, Berry, Evans, Buckley, & Horan, 2006). On the other hand, the best results for reproductive performance have been observed for crosses between Holstein-Friesian and other breeds. Cross-breeding Holstein-Friesian with Jersey resulted in fewer days to first observed heat, higher conception rate to first service and higher pregnancy rate relative to the parental breeds (Lopez-Villalobos, Garrick, Holmes, Blair, & Spelman, 2000; Pyman, Auldist, Grainger, & Macmillan, 2005; Auldist, Pyman, Grainger, & Macmillan, 2007; Prendiville, Shalloo, Pierce, & Buckley, 2011). Comparison of the reproductive performance of crosses between Holstein-Friesian and Norwegian Red showed a clear improvement in fertility relative to the pure-bred Holstein-Friesian (Begley et al., 2009); however, only small improvements were observed when comparing crosses between Holstein-Friesian and Normande or Montbeliarde with the parental breeds (Walsh et al., 2007, 2008). Finally, in a study analyzing data from the Irish National database and including many breeds and crosses (Holstein-Friesian, British Friesian, New Zealand Friesian, Jersey, Norwegian Red and Montbeliard), Buckley, Lopez-Villalobos, & Heins (2014) confirmed higher fertility rates in cross-bred cows. The better reproductive performance of cross-bred cows may be an example of heterosis or hybrid vigor (Dechow, Rogers, Cooper, Phelps, & Mosholder, 2007; Buckley et al., 2014), whereby cross-bred animals generally exhibit enhanced reproductive fitness relative to the parental breeds (VanRaden & Miller, 2006). Cross-breeding may be an effective way of counteracting the negative consequences that selection programs based on milk production have on reproductive efficiency (Buckley et al., 2014).

Conclusion

As far we are aware this is the first study to evaluate the reproductive performance in an organic herd by comparing not only the different breeds and their crosses, but also considering other conventional systems in the same region. The aim was not only to determine which breed performs best in a particular production system, but also to compare the performance of the same breeds in other productive systems in the region. Most organic dairy farms in the region were originally pastured-based conventional farms that underwent a period of adaptation to the standards of the organic agriculture, and most organic farmers continue to use the same cows as before. Comparison of the reproductive performance of organically reared Holstein-Friesian cows with that of their counterparts in pastured-based and zero-grazing conventional systems and of other organically reared breeds and crosses allows us to demonstrate that it is not the organic system that constrains the Holstein-Friesian reproductive performance, but that the breed itself has less marked estrus expression than other breeds.

If organic farmers are satisfied with the other aspects of the dairy production of their Holstein-Friesian cows (apart from the reproductive performance) the less obvious estrus manifestation could be counteracted by including reproductive performance traits both in the breeding goal and in the selection criteria, as well as with improved estrus detection management. There is comprehensive information available to deal with these issues. However, estrus detection is time consuming and not all farmers may be interested in the effort involved in estrus detection of the Holstein-Friesian cow. In this case, the use of more rustic breeds may be a good solution, particularly when the milk yield is not the main objective.

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Table 1. Summarized details of the organic, pasture-based and zero-grazing conventional farms included in this study. Data are expressed as mean and range in brackets.(1) including pure-bred Swedish Red, Brown Swiss, Fleckvieh, Montbeliarde, Normande or Jersey, and crosses between each of these and Holstein-Friesian; not all breeds or crosses were present on all farms.

	Organic (n=10)	Conventional	
		Pasture-based (n=5)	Zero-grazing (n=5)
Type of farm	Free-stall	Free-stall	Free-stall
Number of milking cows	58 (22-207)	54 (36-63)	51 (86-32)
Milk yield (kg/cow/year)	6501 (4500-8450)	6600 (4206-8070)	9070 (6399-11135)
Age of cows (years)	5.73 (5.39-6.21)	5.09 (4.75-5.25)	4.75 (4.38-5.23)
Concentrate intake (kg/animal per day)	3.7 (2.0-6.3)	5.2 (3.6-7.2)	8.2 (5.4-10.2)
Forage intake (kg/animal per day)	13.7 (11.4-19.2)	13.9 (12.9-14.7)	14.4 (13.6-15.3)
Breeds	Holstein Friesian (n=3) Holstein Friesian+ other pure breeds+ crosses (n=7) [1]	Holstein Friesian	Holstein Friesian

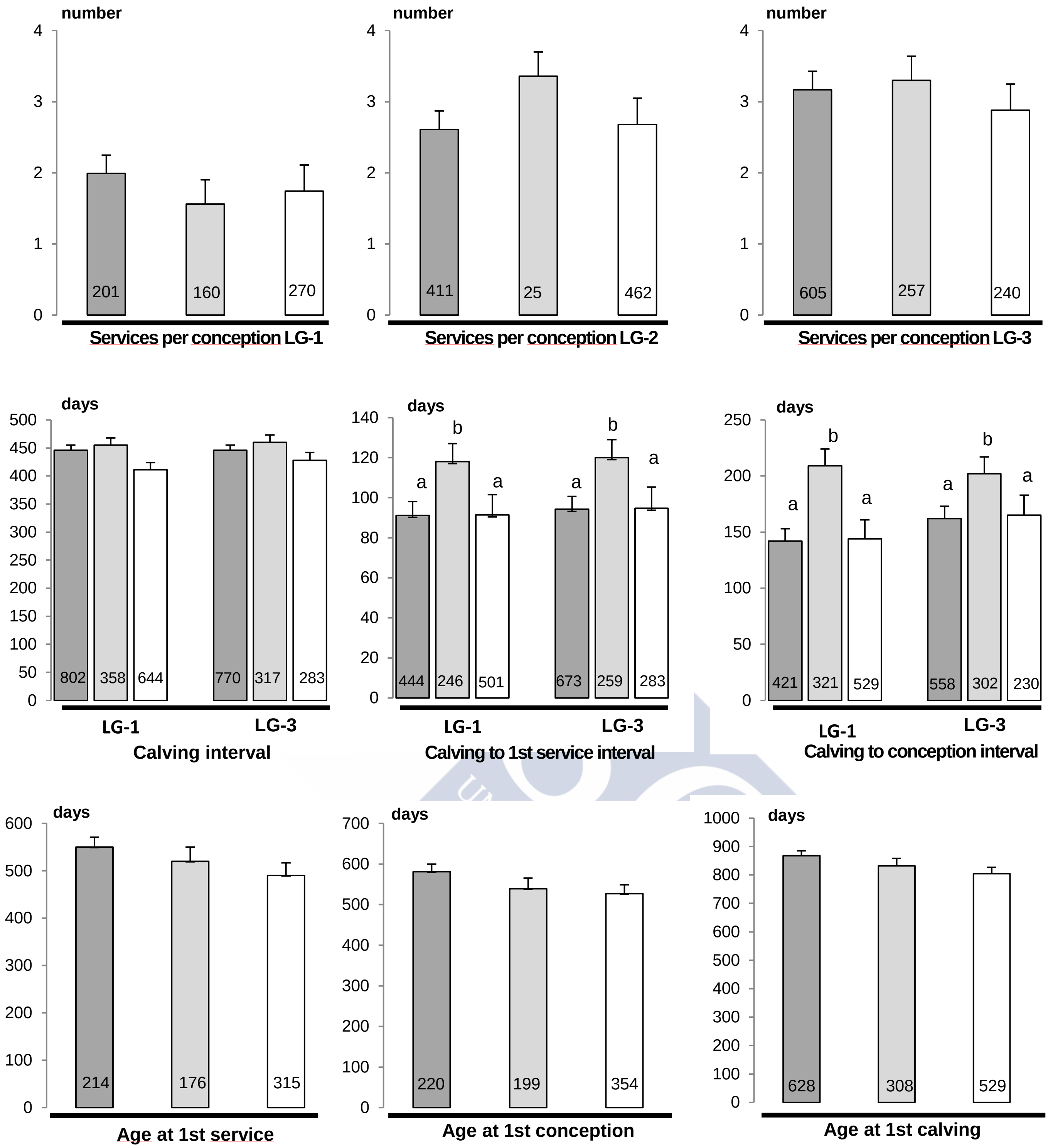
Table 2. Details of reproductive management of organic, pasture-based and zero-grazing conventional systems in northern Spain. AI: Artificial Insemination; NM: Natural Mating; H: Heifers; M: multiparous.

Question	Organic (n=10)	Conventional	
		Pasture-based (n=5)	Zero-grazing (n=5)
Do you use AI or NM?	AI (n=6) AI + NM (n=3) NM (n=1)	NM + AI (n=5)	IA (n=5)
If AI and NM are used, how are they managed?	H (NM)+ M (AI) (n=1) H (NM+IA)+ M (AI) (n=1) H (NM+AI) + M (NM) (n=1)	H (NM+AI) + M (NM+AI) (n=2) H (AI) + M (NM+AI) (n=2) H (NM+AI) + M (AI) (n=1)	
Who performs the AI?	Farmer (n=3) Farmer + Vet (n=3) Vet (n=3)	Farmer (n=4) Vet (n=1)	Farmer (n=4) Vet (n=1)
Do you use the services of a veterinary reproduction specialist?	Yes (n=10)	Yes (n=5)	Yes (n=5)
Do you use reproductive treatments on the farm?	No (n=7) Yes (n=3)	No (n=3) Yes (n=2)	Yes (n=5)
What type of reproductive treatments (if any), do you use?	Hormonal treatments Exceptionally in severe illness (n=3)	Hormonal treatments routinely (n=1) Hormonal treatments Exceptionally in severe illness (n=1)	Hormonal treatments routinely (n=5)
How do you carry out oestrus (heat) detection?	Visual 2-3 times/day (n=7) Visual without pattern (n=1) Visual + pedometer +ultrasound (n=1) NM (n=1)	Visual without pattern (n=4) Visual 2 times/day (n=1)	Visual 2-3 times/day (n=5)
Do you differentiate between breeds in relation to reproductive management?	No (n=10)	No (n=5)	No (n=5)

Figure 1. Results of the reproductive performance (expressed as mean and standard error) of Holstein-Friesian cows in organic (), conventional pasture-based () and zero-grazing conventional () systems in northern Spain. Different letters indicate statistically significant differences between farm systems (*p<0.05*). LG-1= Heifers; LG-2=cows from 1^{st} to 3^{rd} lactation; LG-3= cows from 3^{rd} lactation onwards. Numbers within the bars indicate number of observations.

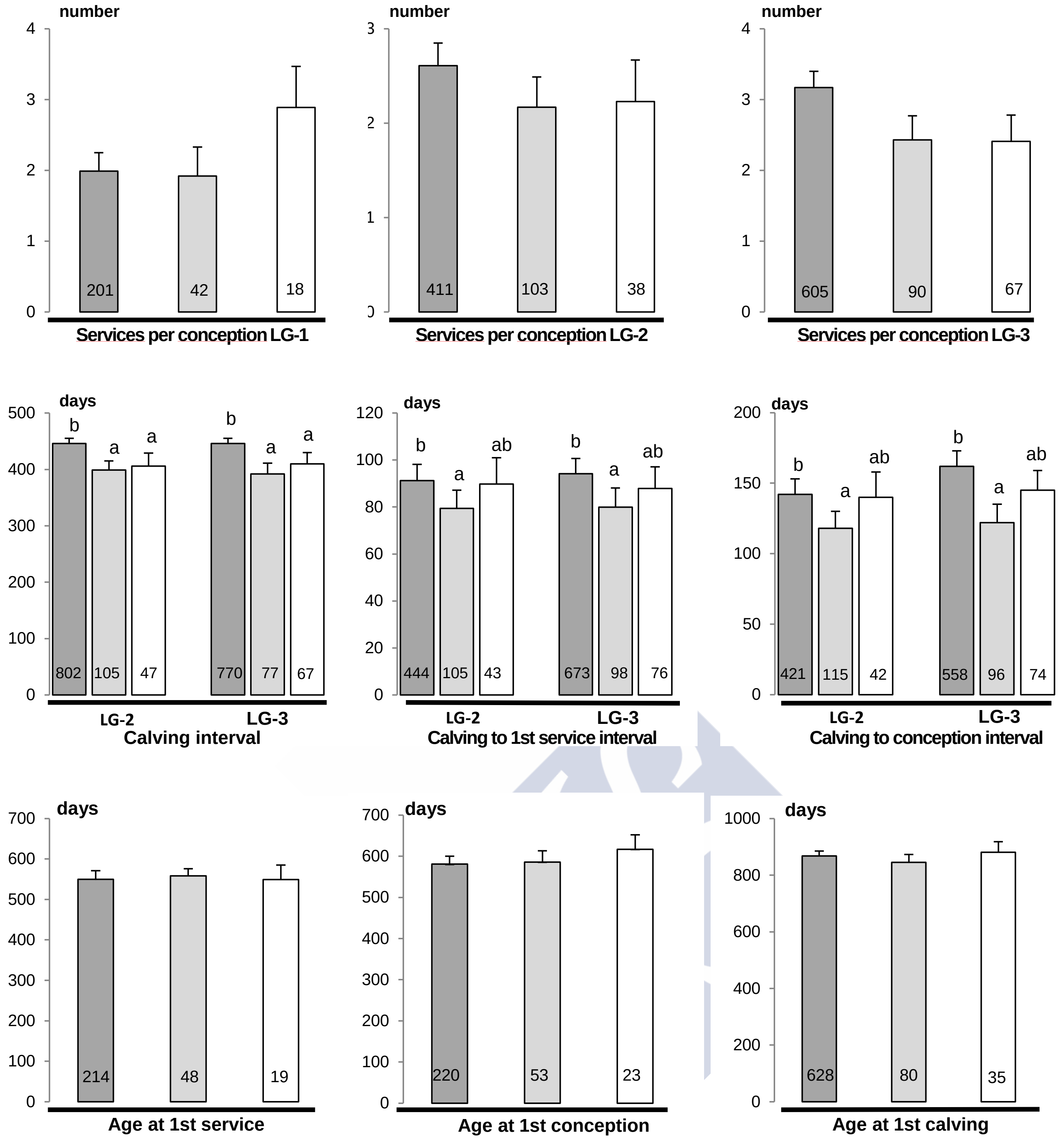
Figure 2. Results of the reproductive performance (expressed as mean and standard error) of Holstein-Friesian cows (), other breeds () and crosses between Holstein-Friesian and other breeds () in northern Spain. Different letters indicate statistically significant differences between farm systems (*p<0.05*). LG-1= Heifers; LG-2=cows from 1^{st} to 3^{rd} lactation; LG-3= cows from 3^{rd} lactation onwards. Numbers within the bars indicate number of observations.

Figure



number
201
160
270
Services per conception LG-1
number
411
25
462
Services per conception LG-2
number
605
257
240
Services per conception LG-3
days
802
358
644
770
317
283
LG-1
LG-3
Calving interval
days
a
b
a
a
b
a
444
246
501
673
259
283
LG-1
LG-3
Calving to 1st service interval
days
a
b
a
a
b
a
421
321
529
558
302
230
LG-1
LG-3
Calving to conception interval
days
214
176
315
Age at 1st service
days
220
199
354
Age at 1st conception
days
628
308
529
Age at 1st calving

Figure


number
4
3
2
1
0
201
42
18
Services per conception LG-1
number
3
2
1
0
411
103
38
Services per conception LG-2
number
4
3
2
1
0
605
90
67
Services per conception LG-3
days
500
400
300
200
100
0
b
a
a
b
a
a
802
105
47
770
77
67
LG-2
LG-3
Calving interval
days
120
100
80
60
40
20
0
b
a
ab
b
a
ab
444
105
43
673
98
76
LG-2
LG-3
Calving to 1st service interval
days
200
150
100
50
0
b
a
ab
b
a
ab
421
115
42
558
96
74
LG-2
LG-3
Calving to conception interval
days
700
600
500
400
300
200
100
0
214
48
19
Age at 1st service
days
700
600
500
400
300
200
100
0
220
53
23
Age at 1st conception
days
1000
800
600
400
200
0
628
80
35
Age at 1st calving

CAPÍTULO IV

O artigo titulado "**Breed performance in organic dairy farming in Northern Spain**" que conforma o capítulo IV está enviado para publicación na revista Spanish Journal of Agricultural Research.

Breed performance in organic dairy farming in Northern Spain

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The present article contains 5 tables and 2 figures.

Running title: Breed performance in organic dairy systems

Topic: animal breeding, genetics and reproduction

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Abstract

Organic farm management combines best environmental practices, a high level of biodiversity, preservation of natural resources and high animal welfare standards. To meet these criteria, farmers must have livestock well adapted to local organic conditions and information about how different breeds and crosses perform under different conditions. The objective of this study was to compare the performance of different pure breeds and cross-breeds of cattle in organic dairy systems in Northern Spain. The data analysed were obtained from monthly records kept between 2010 and 2016 on organic farms registered in the regional Milk Recording System. Analysis of various traits indicated that the Holstein-Friesian breed suits the organic production system in the study region. Although the reproductive performance of Holstein-Friesian cows was poorer (in terms of number of services per conception) than that of cross-breed and Brown Swiss cows, the Holstein-Friesian produced more milk and lived longer. In addition, there was no difference in calving type or calving ease between the different breed groups. The better milk fat and protein yields produced by the crosses may be useful traits for farmers interested in milk transformation. The advantage of continuing to use Holstein-Friesian cattle is that the breed is predominant worldwide and the genealogy is well documented. If Holstein-Friesian cattle continue to be used, the main priority will be to search for well-adapted bulls (particularly for pasture-based conditions) and to elaborate a genetic merit index for organic and pasture-based systems with the aim of predicting and minimizing genotype x environment interactions.

Additional key words: organic systems, cattle, longevity, milk yield, protein yield, fat yield, reproduction

Abbreviations used: MRS (milk recording system), DHIP (Dairy Herd Improvement Program); DMC (days in milk until culling), ECM (energy-corrected milk); SCC (somatic cell count), LS (linear score), DIM (days in milk).

Introduction

Organic production is an overall farm management and food production system that combines best environmental practices, a high level of biodiversity, preservation of natural resources and the application of high animal welfare standards (EC, 2007). Organic regulations forbid the use of pesticides and greatly limit the use of chemical products (EC, 2007; Sundberg et al., 2009). Farmers must have available livestock that is well adapted to organic conditions to enable them to fulfil these special requirements. Indeed, European Union regulations state that farmers should take into account the capacity of livestock to adapt to local conditions and diseases when choosing breeds (EC, 2007). However, many farmers continue to use the same cows as used in conventional systems (highly productive Holstein-Friesian adapted to supplemented diets), despite the general agreement within the scientific community that these cattle are not well adapted to local and low-input conditions (Ahlman, 2010; Nauta, 2010). It is therefore important to characterize organic dairy husbandry at local levels.

The results of previous studies in Northern Spain conducted within the framework of an extensive research project evaluating the nutritional and health status of organic dairy cattle relative to conventionally reared cattle (AGL2010-21026) show that organic farmers are not satisfied with the Holstein-Friesian cows they are producing and are seeking new alternatives (Rodríguez-Bermúdez et al., 2016). The options include continuing with the Holstein-Friesian breed but identifying better adapted animals with desirable functional traits, or using cross-breeds or rustic pure-breeds. To enable farmers to choose the best option, information must be obtained about how different breeds perform in local conditions by comparing their strengths and weaknesses. For this purpose, in addition to production and reproductive performance, other parameters such as culling reasons, longevity, days in milk until culling, calving type and calving ease may be important in relation to sustainability, as they have a strong economic impact (Silva-Del Río et al., 2007; Ahlman et al., 2011; Dhakal et al., 2013), especially in organic systems with restrictions on management practices.

The objective of this study was to compare the performance (culling reasons, longevity, days in milk until culling, milk production performance and udder health, calving type, calving ease and reproduction performance) of different breeds and cross-breeds of cattle in organic dairy farming systems in Northern Spain.

Material and methods

Data collection

The data presented in this paper are included in the databases of AFRICOR-LUGO, the dairy farm association in charge of the Milk Recording System (MRS) in the province of Lugo (Northern Spain). The data comprise information collected monthly between January 2010 (initial certificate in organic production) and July 2016 on all organic farms (n=6; number of lactating cows per farm: 31-149) registered in the MRS. Two of the farms only used Holstein-Friesian, one used Holstein-Friesian and cross-breeds and the other three used Holstein-Friesian, Brown Swiss and cross-breeds. In all cases the crossbred-cows had Holstein-Friesian genes.

As the number of cows considered in the study was rather low, particularly for Brown Swiss (n=42) and cross-breeds (n=233) - both of which have only recently been incorporated in the farm systems (cf Holstein-Friesian n=403) - data on several lactations and parity of the same cows were grouped by lactation (group 1: 1st lactation; group 2: 2nd -3rd lactation; group 3: 4th lactation on) or parity (group 1: from birth to 1st parity; group 2: from 1st - 3rd parity; group 3: from 3rd parity onwards).

Culling reasons, longevity and days in milk until culling

Culling records from these farms were maintained by the monthly visits by the DHIP (Dairy Herd Improvement Program), during which the supervising technician inquired about the reason for loss of any animals since the previous visit. The reasons for losses were then coded according to the Royal Decree 368/2005 (BOE, 2005), following specific rules:

1. Death/urgent slaughter: animals are discarded when they are found prostrate or dead on the farm/animals sent for emergency slaughter (in cases such as metabolic disorders, accident, toxaemia, peritonitis, pericarditis or systemic infection).
2. Lack of productivity: animals are culled because of low production.
3. Mastitis: animals are culled because of udder problems such as mastitis, loss of quarters of the udder and sagging udder).
4. Infertility: animals are culled because of reproductive problems (such as abortions, metritis, infertility, sterility and mummified foetuses).
5. Loss in official disease eradication programs (zoonoses).

6. Others: animals are culled either for some reasons which are not included in the classification above or for multiple causes.

7. Lameness: animals are culled because of musculoskeletal problems (such as lameness and hoof infections).

Longevity was calculated as the difference between birth date and culling date. *Days in milk until culling* (DMC) was calculated as the difference between the last parity and the culling date.

Milk production performance and udder health

In addition, when a cow was dried off, total milk traits per lactation (including total milk yield and mean-adjusted % fat and protein from whole lactation) were recorded and normalized to 305-d by using Fleischmasnn's method (ICAR, 2014). Different parameters were evaluated in relation to milk production: kilograms of milk yield in a complete lactation of 305 days (*milk yield*), kilograms of fat yield in a complete lactation of 305 days (*fat yield*), kilograms of protein yield in a complete lactation of 305 days (*protein yield*); *energy-corrected milk* (ECM). ECM was calculated using the formula ECM= milk yield x (0.383 x % Fat + 0.242 x % Protein + 0.7832)/3.1138 (IFCN, 2018).

Monthly somatic cell counts (SCCs) were collected for each cow during the complete lactation and transformed into linear scores (LS). The mean values for each cow and lactation were then calculated in order to evaluate udder health. The following formula was used to calculate LS, according to the guidelines of the Dairy Herd Improvement Association (DHIA, 2017): LS=log(SCC/100)/0.693147)+3. LS were ranked into 10 categories (from 0 to 9). For SCC a threshold of 200,000 somatic cells/ml was considered an indicator of subclinical mastitis.

Calving type and calving ease

With regard to *calving type*, several items were considered and cows were grouped according to the following characteristics: individual delivery (male or female), twin birth (male twins, female twins, male and female twins) and shortened gestation (abortion followed by lactation, abortion not followed by lactation, abortion followed by male lactation, abortion followed by female lactation, shortened lactation).

Regarding *calving ease*, the following items were considered: delivered alone, some help with delivery, difficult delivery, caesarean or fetotomy and abnormal presentation.

Reproductive performance

Number of services per conception and *percentage of conception at first service* were calculated for all animals. *Age at first service*, *age at first conception* and *age at first calving* (expressed in days) were calculated for heifers as the difference between birth date and first service, first conception or first calving dates respectively. *Calving to first service, calving to conception* and *calving interval* were calculated (in days) for those cows that had calved more than once as the difference between first calving date and first service after calving, conception and second calving dates respectively. *Type of service* (artificial insemination or natural mating) was recorded to evaluate the influence of bull on fertility.

Statistical analysis

All statistical analysis was performed using SPSS program for Windows (V.21.0). Normality of data was checked using the Kolmogorov-Smirnov test. Statistical significance was considered at $p<0.05$.

Culling reasons, calving type and calving ease were explored by cross-tabulation analysis. For all variables, the analysis was performed by comparing different breeds in total and by lactation. As calving ease in the study region may be associated with differences in management due to farm size, the farms were divided into three groups (small<50; medium 50-100; large>100), and analyses were repeated by taking into account differences in calving ease in relation to farm size.

Longevity and DMC data were not normally distributed. The longevity of the different breed groups was analysed using the Kaplan-Meier statistic. For longevity analysis, age was placed as hour and a variable denominated *survival* was established, with live, dead or sold as the possible options for survival status. Longevity was compared in relation to breed and the *Log Rank* test was used to determine any significant differences. DMC in the different breed groups was analysed using the non-parametric *Kruskal-Wallis test*. DMC was placed as variable and breed as grouping variable, and the lactation group was considered as before (1^{st} lactation, 2^{nd} -3^{rd} lactation and 4^{th} or more lactation).

Milk production and udder health in the different breed groups were analysed using a Factorial Linear Mixed Model. All milk production and udder health parameters (milk yield, fat yield, protein yield, ECM, LS) were considered dependent variables. Farm was considered a random factor, and breed and lactation were considered fixed factors. *Post-hoc* analysis (*Bonferroni test*) was conducted for subsequent group comparison within each variable. For SCC analysis, the samples were divided in two groups on the basis of a cut-off value of 200,000 somatic cells/ml. Cross-tabulation analysis was subsequently used to compare the groups by breed and lactation number.

The general form of the linear model used was as follows:

$Y_i = X_i\beta+Z_ib_i+e$

where Y_i=response vector for the *i*-th group (all milk and udder health parameters), X_i= fixed effects matrix model (Breed and Lactation_Group), β=vector of fixed coefficients, Z_i= random effects matrix model (Farm), b_i=vector of random coefficients, e=vector of within groups errors.

As the data were not normally distributed, a non-parametric *Kruskal-Wallis* test was used to compare reproductive performance (number of services per conception, age at first service, age at first conception, age at first calving, calving to first service, calving to conception and calving interval) of the different groups. In order to analyse the influence of type of mating on fertility, services were divided in two groups (natural mating and artificial insemination). Cross-tabulation was used to analyse the influence of type of mating and conception at first service by comparing different breeds overall and parity. The percentage of conception at first service was analysed by comparing different breeds overall and considering parity.

Results

Culling reasons, longevity and days in milk until culling

The data on culling reasons for different breeds of organic dairy cattle are summarized in Figure 1. The results of cross-tabulation analysis show statistically significant differences (Chi-square test, $p<0.05$). Overall, similar results were found for the cross-breed and Brown Swiss groups, in which mastitis was the main reason for culling (37.8%, 33.3%% respectively) followed at a considerable distance by infertility and others (infertility, 22.6%

and 16.7%; others, 22.6% and 16.7% respectively). By contrast, in the Holstein-Friesian group the main cause of culling was others (25.8%) followed by mastitis (22.5%) and death/urgent slaughter (22.4%), with infertility accounting for only 13.6% of the total. In fact, the Holstein-Friesian group included the highest percentage of cows culled because of death/urgent slaughter (22.4%) (crosses 12.9%; Brown Swiss cows 12.5%, respectively); the crosses included the lowest percentage of cows culled because of lameness (2.5%) (Brown Swiss 12.5%; Holstein-Friesian 9.7%) and the Brown Swiss group included the highest percentage of cows culled because of lack of productivity (8.3%) (Holstein-Friesian 4.7%; crosses 1.6%). Analysis of the culling reasons by breed and considering the lactation group (data not shown) showed the same pattern as for all cows overall; however, an increase in others was observed for all breeds, such as increased lactation number (Holstein-Friesian 3%, cross-breeds and Brown Swiss 2%).

Graphs of culling age (to estimate longevity) for the different groups are presented in Figure 2. Results of Kaplan-Meier analysis show statistically significant differences for *Log Rank* ($p<0.05$). Holstein-Friesian cows live 8.46% longer than cross-breeds and 7.70% longer than Brown Swiss.

No statistically significant differences were found for DMC in relation to breed (Table 1), and the median value being very similar for all groups (Holstein-Friesian: 306; cross-breed: 314; Brown Swiss: 300). Similar results were found considering lactation group (data not shown). However, the percentile-10 value was much lower for the Holstein-Friesian cows (56 days) than for the other groups (127 and 135 days for cross-breeds and Brown Swiss respectively); similarly, the percentile-90 value was much higher for Holstein-Friesian cows (532 days) than for Brown Swiss cows (427 days).

Milk production performance and udder health

The data on productive performance are summarized in Table 2. Farm was a significant factor in the linear mixed model, explaining 15.0% of the variability in milk yield, 30.5% of the variability in fat yield, 16.5% of the variability in protein yield and 23.8% of the variability in ECM. Milk yield, fat yield, protein yield and ECM increased significantly ($p<0.001$) with lactation number in all breeds. Breed was a significant factor ($p<0.001$) for milk yield, fat yield, protein yield and ECM. Holstein-Friesian cows had a significantly higher milk yield than Brown Swiss, and crosses were in an intermediate position. Crosses produced a significantly higher fat yield and intermediate or higher protein yield. The ECM was always lower for Brown Swiss than the other groups.

When considering the LS, *farm* explained 9.65% of the variability, with statistically significant differences (*p*<0.001) found for both breed and lactation number. The LS increased in all breeds as lactation number increased, and cross-breeds always had lower LS than the other two groups. For SCCs > 200,000 somatic cells/ml, a significant breed effect was found from the 2nd lactation onwards. Brown Swiss cows always had the highest percentage and the crosses had the lowest percentage of samples exceeding 200,000 somatic cells.

Calving type and calving ease

There were no differences (*p*>0.05) between breeds for *calving type* in organically reared cattle (Table 3). Individual delivery was predominant in all breeds, with lower percentages of twins (2.3 %, 3.3% and 0.7%; Holstein-Friesian, crosses and Brown Swiss, respectively) and shortened gestation (1.4%, 1.6% and 1.3%; respectively). Breed had a statistically significant (*p*<0.001) effect on *calving ease*. Overall, although all breeds gave birth alone or with some help (>95%), the cross-breed group included the highest percentage of cows that delivered alone and the lowest levels of difficult delivery and caesarean/fetotomy, and the Holstein-Friesian cows performed only slightly better than Brown Swiss cows. Similar results were obtained when data were split by number of parturition (data not shown), with the only exception of Brown Swiss in the 1st lactation, with 55.6% needing some help while 42.9% delivered alone.

The data on calving ease considering farm size (small, medium and big) are summarized in Table 4. Results of cross-tabulation analysis show statistically significant differences for farm size (Chi-square test, *p*<0.001). The cows were given some help during delivery on 19.3% of small and 16.6% of medium sized farms and on only 0.4% on large farms.

Reproductive performance

Breed had a statistically significant influence (*p*<0.001) on all reproductive parameters (Table 5). Overall, Holstein-Friesian heifers were the most precocious group (with shorter times to first service, conception and calving) and cross-breed heifers the least precocious. Moreover, the crosses required fewer services per conception, with a higher percentages of conception at first service. The Holstein-Friesian cows performed worst on this parameter. Although calving to first service interval was shorter in Holstein-Friesian cows, the calving to conception and calving intervals were longer than in Brown Swiss and cross-breed cows due to the lower conception rates. There were no statistically significant differences in conception rate between breeds for either artificial insemination or natural mating.

Discussion

Culling reasons, longevity and days in milk until culling

Culling reasons have been traditionally classified as voluntary (low productivity and farm management reasons) and involuntary (illness, infertility or death). Although involuntary culling is necessary to reduce suffering in individual animals, high levels of involuntary culling can have economic impacts on farms (Ahlman et al., 2011). Little information about culling reasons in organic systems is available in the scientific literature, and only broad comparison can be made owing to between-study differences. In Canada, where Holstein-Friesian is the dominant breed, the most important culling reasons in organic systems are poor fertility and mastitis (Rozzi et al., 2007). Similar observation were made in Sweden in a comparison of Holstein-Friesian and Swedish Red until third lactation (Ahlman, 2010; Ahlman et al., 2011), and although both breeds showed a similar culling pattern, the proportion of animals in the Holstein-Friesian group culled because of poor fertility was lower than in the Swedish Red group. In the present study, *others* (which includes other or multiple causes) was the main cause for culling in the Holstein-Friesian group (but was also important in the cross-breed and Brown Swiss cows). This is consistent with previous findings in North Spain, where organic farmers reported that cows were mainly culled because of advanced age (Rodríguez-Bermúdez et al., 2016) and suggest that in a relatively high proportion of animals no single main cause was identified for culling the cows. In the present study, the percentage of cows culled for other reasons increased with lactation number in all breed-groups, which is also consistent with previous findings for conventionally reared Holstein-Friesian cattle in North Spain (Fouz et al., 2014). According to these authors the variety of reasons for culling (chronic mastitis, lameness, infertility, lack of productivity, etc.) increases with the lactation number so that the cows are finally not profitable and are culled at the end of the lactation period. Our results suggest that Holstein-Friesian cows suffer less frequently from mastitis and infertility than the cross-breed or Brown Swiss cows. However, the SCC value (as indicative of the udder health) and reproductive performance do not seem to support this observation. By contrast, our findings seem to indicate that the probability that a Holstein-Friesian cow will suffer multiple pathologies (e.g. subclinical mastitis and infertility) but maintain an acceptable milk yield is higher than in the cross-breed and Brown Swiss cows, in which a single main reason for culling was usually identified. In fact, a larger number of Holstein-Friesian cows (as indicated by percentile-90 of DMC) were culled later on in lactation than in the other groups.

Another interesting finding of our study is that a higher percentage of cows in the Holstein-Friesian group was culled because of death/ urgent slaughter than in the cross-breed and Brown Swiss groups. Within the conventional dairy herd in North Spain, Fouz et al. (2014) linked these culling items to a negative energetic balance in the post-partum period. As the Holstein-Friesian breed mobilizes more body energy in early lactation than other breeds (Friggens et al., 2007) this could be aggravated by organic cattle having a greater risk of negative energy balance (Nauta et al., 2006). The present finding of lower percentile-10 for DMC in Holstein-Friesian cows (56 days) than in the other groups (127 and 135 for crosses and Brown Swiss respectively) is consistent with this possibility. Dead until 60 DIM (days in milk) usually correlates with post-partum pathologies (Pinedo et al., 2010). The lower incidence of lameness in the cross-breeds than in Brown Swiss and Holstein-Friesian is another interesting finding of the present study. This observation may be attributed to a lower incidence of clinical lameness of crosses, as found in New Zealand, with Holstein-Friesian x Jersey crosses having a much lower incidence of clinical lameness than both parental breeds (Chawala, 2011). Resistance to lameness is an important factor in pasture-based systems, and the better performance of crosses than of Holstein-Friesian cows in this respect has been noted (Lethbridge et al., 2008). Finally, Brown Swiss cows are culled more frequently because of lack of productivity, which is also related to the lower milk yield by pure breeds other than Holstein-Friesian cattle.

Longevity, which has been described as the capacity of a cow to avoid being culled due to low production, low fertility or illness (Vollema & Groen, 1996), is closely related to culling management. Longevity is also understood as durability with acceptable production, which is particularly important in organic production (Ahlman et al., 2011). Our observation that Holstein-Friesian cows live longer than other breeds is not consistent with the findings of other studies in other regions, in both organic (no or few differences) and conventional systems (Holstein-Friesian performed worse than cross-breeds in relation to longevity). In Swedish organic systems, Ahlman (2010) measured the productive life (difference between first calving date and culling date) of Holstein-Friesian and Swedish Red cows and obtained similar results for both breeds. Similarly, in organic systems in Germany, Swalve (2007) found that Holstein-Friesian x Swedish Red crosses survived better than pure Holstein-Friesian cows (although the Holstein-Friesian x Brown Swiss crosses yielded the worse results). In Irish pasture-based systems, Dillon et al. (2003) found that survival of Holstein-Friesian cows was worse than that of other breeds (Normande and Montbeliarde). Within conventional dairy farming, the superiority of crosses (crosses between Holstein-Friesian and Normande, Montbeliarde or Scandinavian Red; backcrosses of Holstein-Friesian x Jersey) in relation to longevity or survival relative to Holstein-Friesian (Heins et al., 2006a; Bjelland et al., 2011) is well established. In these studies the lower survival of Holstein-Friesian cattle was associated with poor fertility (Dillon et al., 2003; Heins et al., 2006a). Although our results show that Holstein-Friesian cows perform less well than cross-breed and Brown Swiss cows in relation to the reproduction parameters considered, this does not lead to a high rate culling because of infertility in this breed. On the contrary, a higher proportion of Holstein-Friesian cows were culled at the end of the lactation period due to multiple pathologies (identified as “others”).

Milk production performance and udder health

Although milk yield production has more than doubled in the last few decades, and the milk production of other breeds has not yet surpassed that of Holstein-Friesian cows (Bluhm, 2009), milk quality traits have become increasingly important to consumers (Maurice-Van Eijndhoven et al., 2011). This is particularly true in the organic sector, in which quality is particularly important. Although milk performance in organic farming systems has gained the attention of researchers, information related to the effect of breed on milk performance is scarce. It is well known that the milk produced by certain dairy breeds has a higher solid (fat and protein) content (Haas et al., 2013); however, the extent to which the milk solid content depends on the milk yield (dilution effect) or a different breed capacity to produce fat and protein is not clear. Moreover, the relative contribution of both factors may depend on the level of production on the farm (highly variable in organic systems). It is therefore difficult to compare the results of different studies, as prior standardization is required for this purpose. The most frequently used measure of production in DHIP records is the 305 days record, the adjustments standardize the length of a record to 305 days and frequency of milking to a twice per day standard (Cassell, 2009). Lactation records for cows should be standardized so that yields from different cows can be compared (Wiggans & Dickinson, 1985). Available data (only normalized studies have been considered) for organic farming shows that, as in our study, Holstein-Friesian cows produce more milk than other pure breeds or cross-breeds (which usually have intermediate milk yields). The most complete study to date, conducted in The Netherlands, compared Holstein-Friesian, Jersey, Meuse Rhine Yssel, Montbeliarde, Fleckvieh, Brown Swiss, Groningen White Headed, Dutch Friesian and the various crosses (Haas et al., 2013), reported that milk production was highest in cows that carried 100% Holstein-Friesian genes and lowest for cows that carried 100% Groningen White Headed genes. In our study, differences were also found in fat and protein yield, with the cross-breed cows producing highest yields, probably because of a combination of intermediate milk yield production and higher percentages of fat and protein, as previously reported (Rodríguez-Bermúdez et al., 2017). In this respect, studies involving organic farming have obtained variable results, with some reporting better production of other pure breeds (Haas et al., 2013) or Holstein-Friesian (Sundberg et al., 2009; Mullen et al., 2015). A heterosis effect has been found for both the milk contents (kg of fat and protein) and fat and protein corrected milk (Haas et al., 2013). As information related to organic dairy farming is very limited, and pasture-based systems have similar nutrition to organics, it may be useful to compare the milk performance of different breeds in the different systems. In an Irish pasture-based systems, Holstein-Friesian produced more milk yield than other pure breeds, with crosses usually in an intermediate position (Begley et al., 2009; Prendiville et al., 2009, 2010, 2011; Coffey et al., 2016). Fat yield and protein yield were higher in Holstein-Friesian and cross-breeds than in pure breeds (Prendiville et al., 2009, 2010; Coffey et al., 2016) in some studies; however, fat yield was sometimes higher in Holstein-Friesian, but protein yield was similar across all breeds and crosses (Begley et al., 2009; Prendiville et al., 2011).

Measurement of SCC is important when determining milk quality as it is the main farm level indicator of udder health. In organic systems, in which antibiotics are restricted (EC, 2007), prevention of mastitis is essential to avoid culling due to poor udder health. As was expected, in the present study LS and percentage of SCC surpassing >200,000 somatic cells increased with lactation number in all breed groups (Reneau, 1986). These increases become more evident when cows survive during many lactations (Tancin, 2013) as in organic systems (Orjales et al., 2016). Studies carried out in organic and pasture-based systems to evaluate the effect of breed on SCC, LS or udder health produce inconclusive results, although only broad comparisons can be made. Although in some studies no differences in SCC were observed between Holstein-Friesian and other breeds (Prendiville et al., 2010; Horn et al., 2012; Mullen et al., 2015), in other cases SCC were statistically significantly higher (Sundberg et al., 2009; Coffey et al., 2016) or lower (Swalve, 2007) in Holstein-Friesian than in other breeds or crosses. The effect of breed on SCC can be explained by two factors. On the one hand, udder conformation may predispose some breeds to suffer mastitis (in example Holstein-Friesian compared with Brown Swiss; Busato et al., 2000). On the other hand, a dilution effect may occur (in this case favouring low SCC in breeds as a Holstein-Friesian with higher milk yield). In the present study, the cross-breed had lower LS and % SCC>200,000 than both other groups, with Brown Swiss cattle usually having higher values, which could be explained by a combination of dilution effect and greater resistance of crosses (due to heterosis) to mastitis. The Holstein-Friesian group showed a greater increase in SCC with lactation number than in the other groups, suggesting that the udder conformation predisposes this breed to suffer from udder infections (clinic or subclinical) with advancing age (Busato et al., 2000). In addition, the higher SCC of Brown Swiss from second lactation onwards may be at least partly related to a lower dilution effect due to low milk yield.

Calving type and calving ease

In dairy production, twinning is not desirable because of certain negative impacts (Silva-Del Río et al., 2007; EFSA, 2009). These include the higher risk that cows that give birth to twins will be culled (Thomsen et al., 2007) and the lower rate of replacement of heifers owing to death of twin calves or to the development of freemartins (Nielsen et al., 1989).

All breed groups included in the present study have a standard rate of twinning (natural incidence of multiple ovulations in dairy cattle is around 1-5%; Sreenan & Diskin, 1989) with no statistically significant differences between them. This finding was unexpected as previous studies in conventional systems have reported higher twinning rates in Holstein-Friesian cows

(Hossein-Zadeh, 2010). As multiple ovulation is associated with milk production (Çobanoglu, 2010; Hossein-Zadeh, 2010), the lack of differences between breeds could be explained by the fact that milk yield was lower in Holstein-Friesian cows reared in organic than in conventional systems (Rodríguez-Bermúdez et al., 2017). Twinning is also associated with the systematic use of reproductive treatments (EFSA, 2009), which are restricted in organic systems (EC, 2007) but commonly used in conventional systems (Lucy et al., 2004).

Calving ease also has an economic impact in the dairy business (Dhakal et al., 2013) as it is related to calf mortality (Lombard et al., 2007), lower milk production and poor health (Heins et al., 2006b). Indeed, interest in crossbreeding to improve calving ease has increased in the past decade (Heins et al., 2006c). Many studies in pasture-based systems have shown the benefits of crossbreeding system in reducing calving difficulties (Heins et al., 2006b, c), reporting unfavourable heterosis for direct effects on calving ease and favourable heterosis for maternal effects (Sorensen et al., 2008). Few studies have considered calving ease in organic systems, and as far we are aware the only published study, conducted in Turkey (Aksakal & Bayram, 2009), reported similar results (90.9% of calves were born without assistance while a 9.1% of deliveries were considered difficult and help was required) to those obtained in the present study for crosses, although Holstein-Friesian and Brown Swiss cows apparently needed more help at delivery. However, in the study region (Northern Spain), agricultural technicians have noted that on small farms, the farmers tend to help cows to deliver even when this is not necessary. Analysis of the data in relation to farm size revealed differences between breeds only on the small and medium size farms (higher percentage of some help for crosses on small farms and for Brown Swiss on small and medium size farms), with the percentage of delivery alone being up to 97% in all breed groups on large farms. No differences in calving difficulty between Holstein-Friesian, Jersey and crosses have been observed in pasture-based systems in the US (Dhakal et al., 2013; Mullen et al., 2015).

Reproductive performance

A reduced ability to reproduce often indicates that the individual cow is less able to adapt to the environment (EFSA, 2009). Cows that perform adequately in organic systems are necessary as reproductive treatment options are restricted (EC, 2007) and there is also some interest in implementing a seasonal calving system, as typically used in pasture-based systems (Auldist et al., 2007).

Our findings indicate that in the organic farming systems considered in this study, the cross-breeds performed better than the Brown Swiss and Holstein-Friesian cows, with the latter showing the poorest reproductive performance. The most complete study of reproductive performance in organic systems was carried out in The Netherlands by Haas and coworkers (2013). As in our study, cross-breeds and other pure breeds have shorter calving intervals; the calving interval was higher for cows with 100% Holstein-Friesian genes and lowest for 100% Fleckvieh genes. These authors also found favorable regression coefficients for fertility for Fleckvieh and Gronigen White Headed and unfavourable for Holstein-Friesian and Brown Swiss, with favourable heterosis in first-generations crosses relative to the parental breeds. In another study of organic production, Holstein-Friesian cows were also found to perform less well than crosses or other pure breeds (Sundberg et al., 2009). However, in a comparison of rustic, less productive Holstein-Friesian and Brown Swiss cows, the former performed best (Horn et al., 2012). Indeed, Sundberg et al. (2009) pointed out that when Swedish Red produced more milk yield Holstein-Friesian had better fertility than Swedish Red cows.

The different results obtained in organic dairy farming systems seem to be explained by two well known facts. On the one hand it has been demonstrated that reproduction is strongly affected by milk production. The fertility of dairy cows is negatively associated with both genetic merit for milk production and the actual level of milk production, with the latter factor having the greatest negative effect, especially when considered over 305 days lactation (Mackey et al., 2007). Hence, the declining reproductive performance of dairy cattle in many countries has been associated with an increased proportion of genes derived from Holstein-Friesian sires of North American origin (Dillon et al., 2003; EFSA, 2009). On the other hand, it is also well known that the better performance of crosses than of pure parental breeds (Holstein-Friesian and other pure-breeds) is associated with heterosis, commonly referred to as hybrid vigour (Begley et al., 2009; Buckley et al., 2014). Thus, cross-breeding can provide an effective way of facing the negative consequences on reproductive efficiency of selection programs based on milk production (Buckley et al., 2014). The extent to which each of these two factors will affect the reproductive performance is difficult to determine, and it is likely to vary depending on the breed involved (i.e. more rustic breeds such as Brown Swiss or higher dairy aptitude such as Swedish Red).

In conclusion, according to analysis of the traits considered in this study, the Holstein-Friesian breed seems to suit the organic production system in Northern Spain. Although the reproductive performance of the cross-breeds and Brown Swiss was better (in terms of number of services per conception), the Holstein-Friesian cows produced more milk and lived longer. Calving type and calving ease did not differ between the breed groups. The higher milk fat and protein yields in the cross-breeds may be useful traits for farmers interested in milk transformation. In this respect, it may be useful to analyse the quality of milk produced by the different breeds in relation to elaboration of yogurt and cheese. The advantage of continuing to use Holstein-Friesian cattle is that it is the predominant breed worldwide and the genealogy is well documented. The priority is now to search for well adapted bulls (with a special focus on pasture-based conditions) and to elaborate a genetic merit index for organic and pasture-based systems with the aim of predicting and minimizing genotype x environment interactions.

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Table 1. Summarized data on days in milk until culling (DMC) of organically reared Holstein-Friesian, cross-breed and Brown Swiss cows in Northern Spain. DMC did not differ significantly (*p*>0.05) between breeds.

Breed	N	Median	P-10	P-90	Range
Holstein-Friesian	237	306	56	532	19-625
Cross-breed	115	314	127	478	31-616
Brown Swiss	24	300	135	427	60-475

Table 2. Summarized data (expressed as mean±SE) on productive performance of organically reared Holstein-Friesian, cross-breed and Brown Swiss cows in Northern Spain. Different letters within the same row indicate statistically significant differences between breeds (*p*<0.001). Different numbers within the same column indicate statistically significant differences between lactation groups (*p*<0.001).

	Holstein-Friesian	Cross-breed	Brown Swiss
Number of cows			
1st lactation	220	157	23
2nd-3rd lactations	343	264	48
≥4th lactations	416	212	46
Milk yield			
1st lactation	6007±79^{b1}	5902±94^{b1}	5136±245^{a1}
2nd - 3rd lactations	7378±63^{c2}	6574±72^{b2}	5807±170^{a2}
≥4th lactations	7510±58^{c2}	7208±81^{b3}	6316±173^{a3}
Fat yield			
1st lactation	208±4^{a1}	228±4^{b1}	212±11^{a1}
2nd -3rd lactations	261±3^{ab2}	263±3^{b2}	236±7^{a1}
≥4th lactations	269±3^{b2}	298±4^{c3}	251±8^{a2}
Protein yield			
1st lactation	180±2^{a1}	189±3^{b1}	174±7^{a1}
2nd - 3rd lactations	225±2^{c2}	215±2^{b2}	193±5^{a2}
≥4th lactations	228±2^{b2}	237±2^{c3}	209±5^{a3}
ECM			
1st lactation	5475±78^{1a}	5757±92^{1b}	5248±241^{1a}
2nd-3rd lactations	6823±62^{2c}	6572±71^{2b}	5867±166^{2a}
≥4th lactations	6965±57^{2b}	7319±79^{3c}	6299±170^{2a}
LS			
1st lactation	2.37±0.05^{1}	2.31±0.06^{1}	2.29±0.13^{1}
2nd - 3rd lactations	2.85±0.04^{b2}	2.30±0.05^{a1}	3.63±0.12^{c2}
≥4th lactations	3.57±0.04^{b3}	3.16±0.05^{a2}	3.70±0.11^{b2}
SCC > 200,000			
1st lactation	14.5%	15.3%	18.0%
2nd - 3rd lactations *	24.6%	16.3%	41.3%
≥4th lactations *	39.0%	35.2%	44.4%

Milk yield: kilograms of milk yield in a complete standardized lactation in 305 days; fat yield: kilograms of fat yield in a complete standardized lactation in 305 days; protein yield: kilograms of protein yield in a complete standardized lactation in 305 days; ECM: kilograms of milk correct by energy; LS: linear score; SCC: somatic cell count; *statistical differences within groups.

Table 3. Calving type (p>0.05) and calving ease (p<0.001) according to breed in organic systems in Northern Spain.

		Holstein-Friesian n=1247	Cross-breed n=755	Brown Swiss n=148
Calving type	Individual delivery	96.3%	95.1%	98%
	Twin birth	2.3%	3.3%	0.7%
	Shortened gestation	1.4%	1.6%	1.3%
Calving ease	Delivered alone	83.2%	92.9%	75%
	Some help	13.1%	6.2%	20.9%
	Difficult delivery	2.2%	0.5%	2.7%
	Caesarean or fetotomy	0.3%	0%	0%
	Abnormal presentation	1.2%	0.4%	1.4%

Table 4. Calving ease (p<0.001) according to farm size (small, medium and large) and breed (Holstein-Friesian (HF), Cross-breed (CR) and Brown Swiss (BS)) in organic systems in Northern Spain.

	Small				Medium				Large			
	HF	CR	BS	Total	HF	CR	BS	Total	HF	CR	BS	Total
n	195	94	85	374	968	70	23	1061	84	591	40	715
Delivered alone	86.9	63.4	68.7	77.0	81.2	82.6	63.0	80.8	97.6	98.7	97	98.5
Some help	7.1	36.6	28.9	19.3	15.3	15.9	28.0	16.6	1.2	0.3	0.0	0.4
Difficult delivery	3.0	0.0	1.2	1.8	2.2	0.0	8.0	1.2	0.0	0.7	3.0	0.7
Caesarean or fetotomy	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	1.2	0.0	0.0	0.1
Abnormal presentation	3.0	0.0	1.2	1.9	1.0	1.5	1.0	1.1	0.0	0.3	0.	0.3

Table 5. Summarized reproductive data (expressed as mean±SE) on organically reared Hosltein Friesian, Cross-breed and Brown-Swiss cattle in Northern Spain.

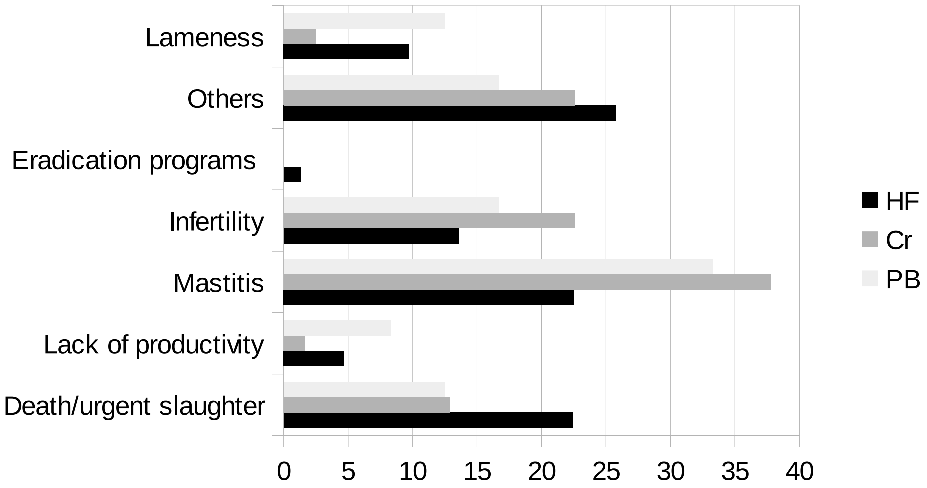
	Holstein-Friesian	Crosses	Brown Swiss	*P*
Birth to 1st parity (n)	256	177	28	
Number of services per conception	1.62±1.07	1.19±0.45	1.82±1.54	***
Age at 1st service (days)	501±6	652±11	570±19	***
Conception at 1st service (%)	65.6%	83.6%	60.7%	***
Natural Mating Conception Rate (%)	83.3%	#	#	
Artificial Insemination Conception Rate (%)	61.5%	#	#	
Age at 1st conception (days)	553±8	664±12	599±18	***
Age at 1st calving (days)	829±8	946±12	885±19	***
1st to 3rd parity (n)	425	310	62	
Number of services per conception	2.44±2.20	1.27±.0.56	2.11±1.85	***
Calving to 1st service interval (days)	88±2	102±3	92±8	***
Conception at 1st service (%)	42.0%	77.7%	50.0%	***
Natural Mating Conception Rate (%)	45.5%	75.0%	53.8%	*NS*
Artificial Insemination Conception Rate (%)	41.3%	83.2%	43.8%	NS
Calving to conception interval (days)	147±5	124±4	131±10	***
Calving interval (days)	428±100	406±79	416±9	***
3rd parity on (n)	575	272	61	
Number of services per conception	2.93±2.57	1.56±1.05	1.66±1.14	***
Calving to 1st service interval (days)	92±8	98±5	94±8	**
Conception at 1st service (%)	39.9%	66.5%	59.0%	***
Natural Mating Conception Rate (%)	32.5%	75.0%	42.9%	*NS*
Artificial Insemination Conception Rate (%)	34.1%	77.4%	63.4%	NS
Calving to conception interval (days)	173±4	135±5	119±9	***
Calving interval (days)	456±107	417±80	403±72	***

#: not calculated because of the small number of cows in the sample

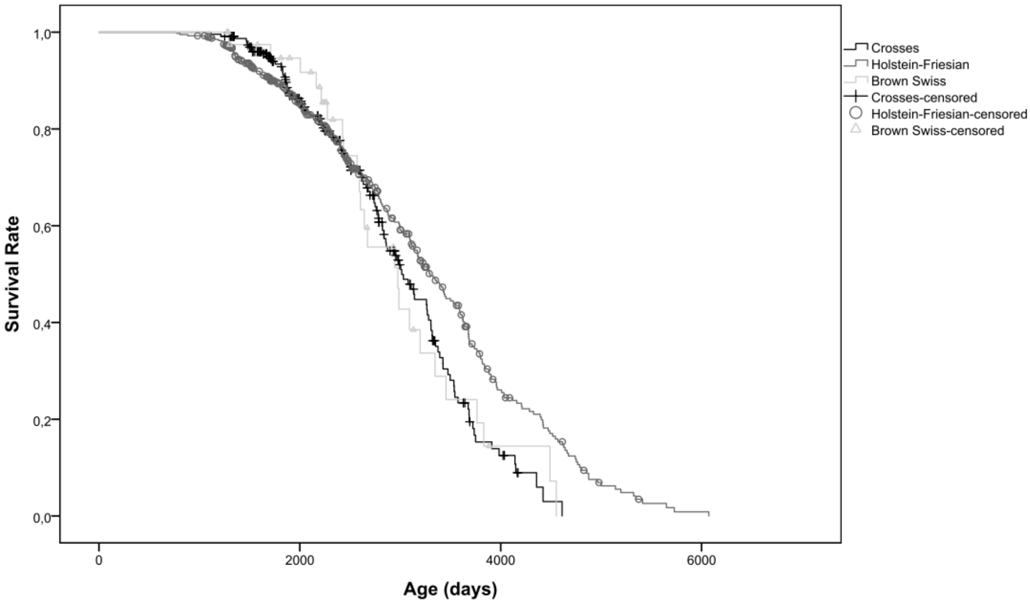
Figure legends

Figure 1. Culling reasons for different breeds and crosses on organic farms (n=6) in Northern Spain (p<0.05). For details about lactation groups, see text. HF (Holstein-Friesian, n=237), CR (cross-breed, n=115) and BS (Brown Swiss, n=24).

Figure 2. Kaplan-Meier graph of longevity for cow according to age (in days) and breed (Holstein-Friesian, n=403; cross-breed, n=233 and Brown Swiss, n=42) on organic farms in Northern Spain (p<0.05).


Lameness
Others
Eradication programs
Infertility
Mastitis
Lack of productivity
Death/urgent slaughter
0
5
10
15
20
25
30
35
40
HF
Cr
PB

1



1,0
0,8
0,6
0,4
0,2
0,0
Survival Rate
0
2000
4000
6000
Age (days)
Crosses
Holstein-Friesian
Brown Swiss
Crosses-censored
Holstein-Friesian-censored
Brown Swiss-censored

2

CAPÍTULO V

O artigo titulado “**Consumer perception of and attitudes towards organic food in Galicia (Northern Spain)**" que conforma o capítulo V está enviado para publicación na revista Food Policy.

Manuscript Details

Manuscript number	FOODPOLICY_2018_743
Title	Consumer perception of and attitudes towards organic food in Galicia (Northern Spain)
Article type	Full Length Article

Abstract

Although the organic sector is still relatively small, the demand for organic food is increasing throughout the world. Characterization of consumer perception of and attitudes towards organic food is important to enable the development of marketing policies aimed at attracting conventional consumers to the sector. Consumer behaviour studies must be conducted specifically for different regions and countries as perceptions and attitudes vary across the world. In the present study, a questionnaire was designed for administration to consumers in Galicia (Northern Spain). The questionnaire was administered to 830 consumers in 200 establishments to obtain data about consumers perception of and attitudes towards organic food. The survey results showed that one third of responders consume organic food and that the typical profile of an organic consumers is a middle-aged, medium-high class, university-educated female living in a large village, who shops in supermarkets and preferably consume vegetables, fruit and eggs. Most people who declared that they consume organic products confuse these with home and locally produced food, indicating the potential for growth of the organic sector by providing such consumers with appropriate information. Most consumers (including conventional consumers) have a good opinion of organic food and consider that it is better for health, is of better quality than conventional food and avoid pesticide residues. However, price continues to be a barrier to the consumption of organic produce. Most respondents stated that they would consume more organic food if the price was only between 10 and 30% higher than the conventional equivalent. Finally, organic consumers in Galicia showed positive attitudes towards using local breeds in organic agriculture, both for producing food and for ecotourism and educational activities. Such activities could contribute to conserving breed biodiversity and adding value to organic farming.

Keywords	dairy product, ecotourism, breed, motives for consumption, willingness to pay
Taxonomy	Social Sciences, Nutrition and Health

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Highlights (3-5 de 85 caracteres)

Consumers have a positive attitude towards organic food

Price continues to be a barrier for organic consumption

Most of consumers do not distinguish organic from home and locally produced food

Organic consumers are usually middle-aged, medium-high class, university women

Consumers are willing to pay more for traditional breed protection

Consumer perception of and attitudes towards organic food in Galicia (Northern Spain)

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The present article contains 9 figures and 1 annex

Abstract

Although the organic sector is still relatively small, the demand for organic food is increasing throughout the world. Characterization of consumer perception of and attitudes towards organic food is important to enable the development of marketing policies aimed at attracting conventional consumers to the sector. Consumer behaviour studies must be conducted specifically for different regions and countries as perceptions and attitudes vary across the world. In the present study, a questionnaire was designed for administration to consumers in Galicia (Northern Spain). The questionnaire was administered to 830 consumers in 200 establishments to obtain data about consumers perception of and attitudes towards organic food. The survey results showed that one third of responders consume organic food and that the typical profile of an organic consumers is a middle-aged, medium-high class, university-educated female living in a large village, who shops in supermarkets and preferably consume vegetables, fruit and eggs. Most people who declared that they consume organic products confuse these with home and locally produced food, indicating the potential for growth of the organic sector by providing such consumers with appropriate information. Most consumers (including conventional consumers) have a good opinion of organic food and consider that it is better for health, is of better quality than conventional food and avoid pesticide residues. However, price continues to be a barrier to the consumption of organic produce. Most respondents stated that they would consume more organic food if the price was only between 10 and 30% higher than the conventional equivalent. Finally, organic consumers in Galicia showed positive attitudes towards using local breeds in organic agriculture, both for producing food and for ecotourism and educational activities. Such activities could contribute to conserving breed biodiversity and adding value to organic farming.

Key words: dairy product, ecotourism, breed, motives for consumption, willingness to pay

Abbreviations used: GMO (Genetic Modified Organism), Spanish National Classification of Economic Activities (CNAE), IGE (Instituto Galego de Estatística), WTP (willingness to pay) ORG (organic), HLP (home and locally produced food), CON (conventional)

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Introduction

The objectives of organic agriculture include producing food while preserving the environment and improving sustainability (Albardíaz-Segador, 2000). European Union regulations regarding organic farming forbid the use of pesticides and greatly limit the use of chemical products (including fertilizers and allopathic treatments); they also forbid the use of genetically modified organisms (GMO), promote improved grazing and animal welfare and recommend the use and conservation of local breeds (EC, 2007; EC, 2008).

Although the organic sector is still relatively small, the demand for organic food is increasing throughout the world, with growth rates of 48% in the European Union and 28% in North America in the last years (Cottingham, 2012; Dash et al., 2014; Sharma and Singhvi, 2018). In terms of marketing, it is important to identify the characteristics of organic consumers in order to be able to design strategies to attract conventional consumers to the sector. Consumers' opinions on the strengthens and weaknesses of organic products and their perception of the difference between buying organic or conventional products influence the willingness to pay and constitute useful information (Dash et al., 2014). Moreover, identifying customer profiles and implementing market-oriented policies would allow organic farmers to become less dependent on public subsidies (Idda et al., 2008).

Studies have been carried out in numerous countries worldwide to evaluate the consumer perception of and attitudes towards organic food: in Spain (Briz and Ward, 2009), Portugal (Ventura-Lucas et al., 2008), Germany (Ventura-Lucas et al., 2008), Italy (Chinnici et al., 2002; Idda et al., 2008), Greece (Krystallis and Chryssochoidis, 2005) Romania (Oroian et al., 2017), Turkey (Marangoz et al., 2014) Brazil (Hoppe et al., 2013), Bangladesh (Ahmed and Rahman, 2015), India (Dash et al., 2014), Nepal (Aryal et al., 2009), Thailand (Ueasangkomsate and Santiteerakul, 2016) and China (Sirieix et al., 2011). Such studies must be conducted for different regions and countries as people's perceptions and attitudes vary across the world depending on cultural considerations (Ventura-Lucas et al., 2008; Dash et al., 2014). When buying organic products, consumers in different countries are mainly influenced by gender, age, income, level of education and the presence of children in the household (Sharma and Singhvi, 2018). Consumers generally value organic products for their quality and for being better for health and the environment (Hughner et al., 2007; Shafie and Rennie, 2012; Hoppe et al., 2013). However, most studies have found that price continues to be a barrier to the widespread consumption of organic products. Differences between countries have also been found in relation to frequency of consumption and willingness to pay for different products (Ventura-Lucas et al., 2008; Shafie and Rennie, 2012).

The objective of this study was to characterize organic consumers in Galicia. The specific aims were to determine the profiles of organic consumers as well as their knowledge about organic products, their reasons for consuming (or not) organic food, in addition to different attitudes and habits of consumption, their willingness to pay for organic products, the value they attach to the use of local or rustic breeds for organic production and their willingness to contribute to the conservation of these breeds.

Methodology

Sample design

Interview design. The questionnaire was specifically designed for the study and included open- and closed-ended questions. A series of coded options were provided as responses to the closed-ended questions, and the consumers were asked to choose the option that best reflected their position, opinion or behavioural pattern (Marvulli, 1985). The questionnaire included 36 items divided into 4 groups: personal data, general questions about organic food, specific questions related to traditional breeds, ecotourism and farm schools and other questions (Annex 1).

Number of samples. According to the Spanish National Classification of Economic Activities (CNAE), there were 9202 type 47.1 (retail trade not specialized) and 47.2 (food and drink retail trade) establishments in Galicia in 2015 (IGE, 2015). In order to estimate the number of establishments that should be visited, the usual method of calculating the sample size was used, applying an expected error of 7% for a proportion of a maximum degree of indeterminancy (p=q=50). This yielded a sample size of n=200 (2.17% of establishments) in this case. In addition, the target was for at least 4 people to be interviewed each establishment chosen for data collection.

Sample selection. A stratified two-stage sampling model was applied. Each sample was selected independently in each stratum in which Galicia was divided. The units for the first stage were establishments registered in CNAE in 2017 and the units for the second stage were consumers. The criteria for stratification were based on demographics according to population of the area: stratum 1 (S1): population less than 2,000 inhabitants; stratum 2 (S2): population between 2,000 and 5,000 inhabitants; stratum 3 (S3): population between 5,000 and 10,000 inhabitants; stratum 4 (S4): population between 10,000 and 20,000 inhabitants; stratum 5 (S5): population between 20,000 and 50,000 inhabitants; stratum 6 (S6) inhabitants: large council areas (the seven cities in

Galicia: A Coruña, Ferrol, Santiago de Compostela, Lugo, Ourense, Pontevedra and Vigo). In addition, councils were also divided in *substrata* by considering the degree of urbanization, following the proposal of Eurostat: densely populated areas (DPA), groups of contiguous councils, each with a demographic density of more than 500 population/km^2 and an overall population of at least 50,000); intermediately populated areas (IPA, groups of councils each with a density higher than 100 population/Km^2, but excluding those in densely populated places, the population of the entire area should be at least of 50,000 or the area must be contiguous to a densely populated place) and scarcely populated places (SPA, groups of councils not classified as densely populated or intermediate populated places) (IGE, 2017). The establishments (n=200) were selected within each stratum and substratum with a probability proportional to their population, resulting in S1 ZIP=2, S1 ZPP=8, S2 ZIP=2, S2 ZPP=22, S3 ZIP=5, S3 ZPP=23, S4 ZIP=25, S4 ZPP=12, S5 ZIP=20, S5 ZPP=11, S6 ZDP= 70. Once the number of establishments of each type was known, the addresses were randomly selected and provided by the IGE (Instituto Galego de Estatística). Within each establishment, people were also randomly selected for questioning (Lohr, 1999). When the consumer was from a different council area, the interview was assigned to the corresponding stratum.

Empirical application

Data collection

A total of 830 interviews were conducted between January and October 2017, in 200 establishments. The questionnaire was administered by interviewing consumers when they were leaving the establishments. All interviews were performed by the same interviewer (Ruth Rodríguez).

Statistical analysis

Data were analysed using SPSS (version 24). Interviews (n=830) were initially intended to be classified by organic and conventional consumers/responses. A total of 24 people responded that they do not know whether they were organic or conventional consumers or declined to answer (*do not know/no answer*) and were excluded from the analysis. Moreover, on analysing the responses given to questions 13-15 and 35-36 (see annex), we realised that 305 respondents considered that they were organic consumers when in fact they consumed home or locally produced food bought in local markets or produced at home. For this reason, the respondents were finally classified as *organic* consumers (ORG, n=288), *conventional* consumers (CON, n=213) and *home and locally produced food* consumers (HLP, n=305).

All variables were analysed by cross-tabulation, and differences were considered significant at $p<0.05$ (Chi-square test). Customer group (ORG, HLP, CON) was considered the grouping variable and all other variables were considered dependent variables (Annex 1).

Results and discussion

General data

General information about the consumers questioned in the survey is presented in Figure 1. People who thought (and stated) that they consume organic food although they actually consume “environmental friendly” home and locally produced (HLP) food were the most numerous group, accounting for 40% of responders. Organic (ORG) consumers (including people who consume at least one organic product in their diet) represented one third of responders, and the “only conventional” (CON) consumers were the least numerous group (26%). Data produced by the Spanish government indicate that 29% of people in Spain consume organic food, a figure that has increased by 3% since 2011 (MAGRAMA, 2014). Within Europe, organic consumers represent 34.1% of consumers in Italy (Chinnici et al., 2002), 27.4% in Germany (Ventura-Lucas et al., 2008), 20.1% in Portugal (Ventura-Lucas et al., 2008), while Switzerland has the highest per capita consumption of organic food worldwide (280 Euros), followed by Denmark (220 Euros) and Sweden (200 Euros) (FiBL, 2018). As in our study, other authors have indicated that consumers display a high level of confusion in identifying organic products (Hughner et al., 2007; Briz and Ward, 2009). In Europe, organic products are subject to European Union regulations and must meet certain criteria to qualify for an official EU label, which appears on the product; however, most consumers are unaware of this (Pivato et al., 2008). Furthermore, variables such as the level of market development, the use of other positively associated food terms (e.g. “cage-free” and “natural”) and the product category (e.g. farmed salmon) serve to heighten consumer confusion (Fotopoulos and Krystallis, 2002; Aarset et al., 2004; Mauleón, 2014).

Analysis of the profile of the organic consumers revealed that more women consumed organic food than men (37.3% vs 32.9%). Regarding age, most of the respondents who consume organic food were between 25 and 54 years all, with the highest proportion in the 45-54 year age group (41.3%). These data are consistent with those obtained in other studies carried out in Spain by MAGRAMA (2011, 2014) and other European countries (Krystallis and Chryssochoidis, 2005), which have shown that organic consumers tend to be women of age 34 to 54 years old and, within Spain, who usually live in Northern Spain, usually in large cities. The main organic consumers across Europe are also middle-aged women (Chinnici et al., 2002; Generalitat de Catalunya, 2015). Although younger consumers tend to have more positive attitudes towards organically grown food, older consumers are more likely to be purchasers, and the discrepancy is attributed to the higher price of organic food and lower purchasing power of younger people (Krystallis and Chryssochoidis, 2005; Hughner et al., 2007).

Considering educational levels, our results show that consumers with higher levels of education buy more organic food. Respondents with university-level education made up the highest proportion (47.1% organic consumption) and those with low levels of education constituted the lowest proportion (2.9%) of organic consumers. Consumers with lower educational levels were often not aware that they were consuming conventional food or thought they were consuming organic food rather than home and/or locally produced food. Other studies have also observed that organic consumers are more likely to be more highly educated (Chinnici et al., 2002; Padel and Foster, 2005; MAGRAMA, 2011; Hoppe et al., 2013; Generalitat de Catalunya, 2015; Oroian et al., 2017). Briz and Ward (2009) reported a negative relation between knowledge and organic purchasing, with better informed consumers having real motives for buying organic products and rely less on their own perceptions.

Organic food is more frequently consumed in towns of population 5,000-10,000 and in towns with more than 20,000 inhabitants than in other areas (although the difference is not statistically significant). These findings are consistent with those of other studies carried out in Spain showing that organic consumption is highest in towns with 10,000-50,000 inhabitants and lowest in large cities of more than 100,000 inhabitants (MAGRAMA, 2007; Generalitat de Catalunya, 2015).

Among the respondents, organic consumers included high proportions of married people (37.1%) or people living with partners (44.9%) and a relatively low proportion of divorced people (26.7%). No differences were found in relation to “number of family members”, “having children or not”, “age of the children” or “number of children”. By contrast, other studies have observed that people with children are more likely to be organic consumers (Hughner et al., 2007; MAGRAMA, 2011; Sharma and Singhvi, 2018) as having children greatly changes family eating habits and parents take great interest in diet (Hughner et al., 2007). Although no differences were found for the “number of family members working”, “family income” was a significant factor: organic consumers include a higher percentage people with a high family income. Similar results have been found in other studies (Chinnici et al., 2002; Padel and Foster, 2005; Roitner-Schobesberger et al., 2008; MAGRAMA, 2011), situating organic consumers in the high-medium class.

Considering the frequency of shopping, those consumers who always do the shopping or more frequently than other members of family tended to buy more organic products than those respondents who only occasionally go shopping.

When questioned about purchasing criteria, organic consumers focused more on “quality” and “freshness” of the food than the other groups of consumers. Our results differ from those of Krystallis and Chryssochoidis (2005), who found that in terms of the most important criteria considered when buying food, the greatest importance (>80%) was given to price, taste, certification of production method, nutritional value, environment, raw materials and origin.

Regarding the “1st place for purchase” for general food shopping, there were no differences between groups, and in all cases supermarket was the first (75%) and only choice (60%) for most respondents. Krystallis and Chryssochoidis (2005) also reported that organic consumers can also be considered typical supermarket consumers.

When organic consumers were asked where they specifically buy organic food (Figure 2), the main "1st place for purchase" option (25.4%) was the supermarket, followed by small shops (22.6%), specialized shops (16.3%) and local markets (15.3%). For general shopping, half of the respondents did have not a "2nd place for purchase" of organic food. There is no agreement in the published surveys about where organic consumers buy organic food. Thus, while in some studies report that supermarkets or hypermarkets are the main establishments where the products are bought (MAGRAMA, 2011; Sirieix et al., 2011), other studies have found that consumers mostly buy organic food in specialised shops (Mauleón, 2014; Generalitat de Catalunya, 2015) and other findings differ depending on the country considered (Ventura-Lucas et al., 2008). Long-term organic consumers appear to tend to buy in specialized and delicatessen shops, because of the higher quality of the products, or because they find more variety than in supermarkets and hypermarkets (MAGRAMA, 2007) or they even find that the organic products more reliable (Sirieix et al., 2011). Within Europe, in Scandinavia and the UK organic products are mainly sold in supermarkets, while in Germany and The Netherlands they are sold in more expensive, specialised shops (Wier and Calverley, 2002).

Knowledge about organic food

Many studies have found that consumers are not clear as to the definition of organic food, even those consumers who say that they consume organic products (Hughner et al., 2007). The responses to this question are shown in Figure 3. ORG consumers provided more accurate definitions of organic food than CON, with HLP in an intermediate position. Few people defined organic food very well (3.5, 1.6 and 1.4 % for ORG, HLP and CON respectively) or well (21.3, 24.6, 17.0%), and almost half of the respondents (particularly CON) displayed poor or very poor knowledge about organic food. These findings are very similar to those of other surveys carried out in Spain (Cobo and Gónzalez-Ruiz, 2001, Mauleón, 2014; Generalitat de Catalunya, 2015) and other countries (Bhatta et al., 2008; Aryal et al., 2009), i.e. that although most consumers (generally up 90%) state they know what organic agriculture is or have heard about it, only a very low number of respondents display very good (< 5%) or good (27-41%) knowledge about organic agriculture. These observations clearly show that more education and further information are needed to promote organic food consumption. The level of knowledge about organic farming influences the willingness of consumers to purchase the products (Cobo and Gónzalez-Ruiz, 2001; Mauleón, 2014).

The concept of Genetically Modified Organisms (GMOs) is important in relation to organic food as their use is forbidden in organic production (EC, 2007). We therefore considered it important to ask people about GMOs (Figure 3). The ORG consumers generally knew more about transgenic food (nearly half of respondents defined it very well) and they stated that “would buy more organic food knowing they are free of GMO” (nearly 90%). The HLP group displayed a slightly lower level of knowledge (41.3 %) about GMO, although they also expressed a wish to buy transgenic free organic food. On the contrary, the CON group knew considerably less (16.9%) about GMOs and attached little importance to them in food (54.9%). These findings may be related to consumer perception of GMOs, which are usually seen as overly manipulated and altering nature, while organic food is seen to preserve the natural qualities of the environment (Dreezens et al., 2005). Interest in production processes also leads consumers to reject certain types of technology, and the use of GMO has met with considerable consumer resistance in Europe (Grunert et al., 2000). In fact the resistance to GMO products is also common in other European countries (Almeida et al., 2006). Thus, studies comparing attitudes to genetically modified food and organic food have found that consumers have positive attitudes towards organic food (Magnusson et al., 2003; Arvola et al., 2008) while they are quite negative about GMOs (Dreezens et al., 2005).

Frequency of organic food consumption

Although we recognise that the HLP are not organic consumers, we evaluated frequency of consumption of organic products in both ORG and HLP consumers (Figure 4), as we consider HLP as potential organic consumers. ORG consumers reported that they mostly eat vegetables, tomatoes, fruit and eggs (42.4%, 38.9%, 40.2% and 39.2% respectively many times a week plus every day) while jam and wine (8% and 6.2% respectively every day or many times a week) were the least consumed products. HLP consumers stated that they preferably consume the same items (vegetables, tomatoes, fruit and eggs 55%, 49.5%, 48.5% and 52.4% respectively many times a week or every day) while the other foodstuffs are eaten in lower proportions. The significantly higher consumption of organic food within the HLP than the ORG group seems to be due to the widely held belief that all food produced at home or bought in local markets is organic. In general, our findings are consistent with those of many other studies that have found that organic consumption is mainly of vegetables and fruit followed by eggs (Chinnici et al., 2002; Krystallis and Chryssochoidis, 2005; Ventura-Lucas et al., 2008; MAGRAMA, 2014; Mauleón, 2014; Generalitat de Catalunya, 2015). Organic milk and dairy products, meat, bread and cereals and oil are less frequently consumed and very few people consume organic wine (Chinnici et al., 2002; Generalitat de Catalunya, 2015).

Reasons for consuming (or not) organic products

The reasons for organic consumption given by ORG and HLP consumers were examined (Figure 5). In general, consumers have a good opinion of organic products, awarding high scores to most of the possible reasons for consuming organic food. Few respondents consumed organic products out of curiosity. HLP consumers attached more importance than ORG to flavour, while HLP consumers placed more emphasis on health and quality aspects and to a lower degree to the environment. The positive image of organic products has also been mentioned by other authors (Ventura-Lucas et al., 2008; Marangoz et al., 2014; Mauleón, 2014), and in general researchers found that people value organic products because they perceive them as being healthier, of better quality and contributing to environment protection (Idda et al., 2008; Sirieix et al., 2011; MAGRAMA, 2014; Mauleón, 2014; Ahmed and Rahman, 2015; Ueasangkomsate and Santiteerakul, 2016). Some authors also mentioned other secondary factors such as e.g. promoting animal welfare, not containing GMOs, preservation of traditions, support for rural systems and the local economy, evocation of nostalgic feelings and traditions or curiosity (Hughner et al., 2007; Ueasangkomsate and Santiteerakul, 2016). Our findings are consistent with these results. Organic consumers appear to place more emphasis on health aspects and quality and although environmental concerns have been demonstrated to have a favourable influence on consumer attitudes, they are not a driving factor (Hughner et al., 2007).

Reasons for not consuming organic food given by CON consumers were examined (Figure 5). “Excessive Price” (mean=5.6; score: 1-10), “Lack of habit” (5.3) and “I do not trust that it is organic" (4.2) were awarded the highest scores; on the contrary "not knowing that organic exist" (1.3) and "not having an attractive appearance" (1.5) were awarded the lowest scores. Most studies indicate that people find organic products too expensive to buy or to buy frequently (Ventura-Lucas et al., 2008; Dupupet et al., 2010; Sirieix et al., 2011; MAGRAMA, 2014; Mauleón, 2014; Puelles-Gallo et al., 2014; Generalitat de Catalunya, 2015). Apart from price, other reasons for not consuming organic products are ignorance, not finding the products, not trusting that products are organic and limited variety (MAGRAMA, 2007, 2011; Aryal et al., 2009; Nielsen, 2010; Sirieix et al., 2011; Puelles-Gallo et al., 2014; Generalitat de Catalunya, 2015). The lack of trust in the authenticity of organic food deserves special attention. Consumers cannot directly judge whether organic products are authentic as "organic" is not an attribute that consumers can simply verify in a product (Pivato et al., 2008). Some European studies have found that consumers tend to distrust certification bodies, leading them to question the authenticity of organic products (Canavari et al., 2002; Aarset et al., 2004). The skepticism of consumers will diminish if they believe that producers or retailers are able and willing to monitor their organic suppliers and ensure that organic standards are respected (Perrini et al., 2010). When CON consumers were asked if they would be interested in consuming organic products in the future, 46.5% answered positively.

Perception of differences between organic and conventional food

Consumer perception about differences between organic and conventional food is shown in Figure 6. ORG and particularly HLP consumers responded similarly, perceiving that organic food is "very different" or "quite different" from conventional food. On the other hand, a higher proportion of CON consumers found no difference or little difference between both type of food, in accordance with the findings of other studies (Ventura-Lucas et al., 2008). Some studies have found that consumers perception of organic products depends on the frequency of organic consumption, with organic consumers having a more positive impression of these products (Dash et al., 2014; Mauleón, 2014). This may explain why ORG consumers interviewed in the present study have a higher opinion of the products than reported by CON consumers. In fact 75% of people who consume or have consumed organic food find differences relative to conventional food (MAGRAMA, 2007). The proportion was even higher in our study, in which less than 6% of ORG consumers said that they found no difference between both foods. However, the HLP consumers believed that they were consuming organic products even when they were not. These consumers expressed positive opinions of the products they are consuming because of taste and of being home-produced. These people are potential organic consumers because they are interested in organic products; however, they need more information to be able to distinguish organic and other types of food.

Willingness to pay (WTP) for organic food

Data on WTP for organic food is presented in Figure 6. Most ORG consumers stated that an increase in price relative to conventional food of between 10-30% would be a fair price for organic food. Most HLP consumers would be willing to pay 0 or 10-30% more than for conventional food, and in the case of CON more than 30% for all types of food responded they would not to pay extra money to purchase organic food.

Overall, the WTP for organic food shown by ORG consumers in our study is consistent with the findings of other surveys in Spain (Albardíaz-Segador, 2000; Gil et al., 2001; MAGRAMA, 2007), and other countries (Fotopoulos and Krystallis, 2002; Krystallis and Chryssochoidis, 2005; Menon, 2008; Urena et al., 2008), in which organic consumers have been found to be willing to pay more (ranging from 5 to 60 %) to buy organic food, although the amount differs significantly according to the type of product. Overall, organic fruits and vegetables (and to a lesser extent eggs and meat) are perceived as different from other products, and consumers exhibit the highest WTP extra for these products (Gil et al., 2001; Krystallis and Chryssochoidis, 2005).

The increasing number of individuals who are willing to pay more for environmentally friendly products is perhaps the most convincing evidence supporting the growth of ecologically favourable consumer attitudes (Laroche et al., 2001). However, price continues to be a barrier to consumers (Gil et al., 2001; Nielsen, 2010; Generalitat de Catalunya, 2015), and the gap between the prices must be reduced to favour increased consumption of organic food. Consumers who are well informed about what organic food is are willing to pay more to buy organic products because they attach less importance to price (Albardíaz-Segador, 2000; Nielsen, 2010; Puelles-Gallo et al., 2014). This may explain why although HLP consumers think that organic food is very different from conventional produce, it is ORG consumers who are willing to pay most of the three groups. Hence, better knowledge about organic products reduces sensitivity to the price and increases WTP (Aryal et al., 2009; Nielsen, 2010). Marketing and publicity are thus necessary to increase the level of knowledge and WTP (Albardíaz-Segador, 2000). Maxwell (2002) concluded that it is not only price that influences purchasing intention but also understanding how price is determined. Thus, justification of price affects consumers perception and WTP. Quality, security and trust usually play an important role in WTP for organic products; consumers are willing to pay more for organic products because they perceive these products as being of higher quality and as safer foods that they can trust more than their conventional equivalents. If consumers are not absolutely sure that the food products they purchase are indeed organic, they will be unwilling to pay more than standard prices (Krystallis and Chryssochoidis, 2005). In addition to price, the other main barriers to purchase of organic products are low variety, lack of availability, lack of trust and lack of information. Marketing strategies such as increased exposure and lower prices, combined with additional information about the advantages of organic products could help to overcome these barriers (Puelles-Gallo et al., 2014).

Importance of external appearance

The consumers were also questioned about the importance of external appearance and whether they would buy organic food with aesthetic defects (Figure 7). CON consumers attached more importance to appearance than ORG and HLP; moreover the CON group gave a lower percentage of positive responses about buying organic products with aesthetic defects (61.5%) than the ORG (87.9%) and HLP consumers (85.3%). This is an important point to take into consideration as organic products are more natural and sometimes have aesthetic defects, such as e.g. not being all of same size or being deformed, which do not affect the quality of the product (Albardíaz-Segador, 2000). In fact, rejection of aesthetic defects has also been mentioned by other authors who found that consumers are unwilling to accept the blemishes or imperfections often present in organic produce (Albardíaz-Segador, 2000; Bhatta et al., 2008; Ventura-Lucas et al., 2008).

Valuing local or rustic breeds for organic production and willingness to contribute for their conservation

Maintaining biodiversity, including genetic resources, for food and agriculture is another of the main key points in making organic agriculture sustainable. When consumers were asked if they would value the use of local or rustic breeds, in example "for organic dairy milk production other breeds different than Holstein-Friesian", both ORG and HLP showed great interest (ca. 54% positive responses), although CON were also interested (38% positive responses) (Figure 8). It is well known that there is increasing interest in local products (Albardíaz-Segador, 2000), a preference that is partly justified by tradition and evocation of the past. Many organic consumers associate organic products with preservation of tradition (Cicia et al., 2006), and part of this tradition involves using local or traditional breeds (Nauta et al., 2009). Following the same reasoning, the consumers in our study were very interested in "knowing which breed was used for organic dairy production" and showed "WTP for milk products produced by breeds other than Holstein-Friesian". This can be taken advantage of as a marketing tool, especially in small farm systems which transform their own products, which have gate shops or are dedicated to tourism activities. In a similar study carried out in Finland with the aim of determining whether Finnish consumers would buy beef produced from indigenous breeds (Finncattle) even if they had to pay higher prices, Tienhaara et al. (2015) found that 72% of respondents chose to support conservation of the breeds and 40% to pay extra for the meat. The reasons given for this choice were taste, support for farmers, naturalness and participation in the conservation of the breed (Tienhaara et al., 2015).

Another way of contributing to breed conservation, apart from using the animals for organic production (of e.g. milk), is to use them in cultural or leisure activities, which includes both ecotourism and farm schools. Data on ecotourism, perception of breeds used and WTP for breed conservation are presented in Figure 9. The first questions were aimed at discovering whether the attitudes of the different groups of consumers vary in relation to ecotourism. More ORG and HLP consumers have heard about ecotourism than CON, and more ORG followed by HLP have visited ecotourism establishments. The same tendency was observed in those consumers who have never visited such establishments, CON were the least interested in going in the future and if they did visit, they would do so less often. The consumers were then asked about their perception of animals and breeds used in ecotourism establishments. The responses followed a similar trend: ORG consumers valued having animals and traditional breeds more positively and were also willing to pay a greater amount of extra money than CON, with HLP in an intermediate position.

Most indigenous breeds are adapted to particular habitats or production systems and although they may not be as productive as other breeds they represent an important resource for meeting present and future breeding objectives (Medugorac et al. 2009). In our opinion, these breeds represent a genetic patrimony that should be preserved, and ecotourism establishments could play an important role in providing such protection. This was the thinking behind determining whether consumers value having different breeds available and whether they would pay for this. Cultural value may be considered a tool in adding economic value to local breeds, and diverse products can be sold at higher prices, in order to improve the profitability of local breeds and minimize the threat of extinction (Gandini and Villa, 2003).

Regarding children's activities, the percentage of ORG consumers who organize extracurricular activities was higher than in other categories, and these consumers were also more interested in sending children to visit school farms (giving marks above 8). A high percentage of ORG consumers also reported that they positively value traditional breeds, followed in lower proportions by HLP and CON. In general, most respondents (ca. 70%) in all categories would pay extra to help protect traditional breeds in school farms and to educate children about protecting them, and the percentage is higher than WTP for having traditional breeds in ecotourism establishments.

Conclusions and Policy implications

Overall, the survey findings indicate that approximately one third of respondents consume organic food, as previously found in Spain and other European countries. The typical profile of an organic consumer is a middle-aged, medium-high class, university-education woman, who lives in a large village, shops in supermarkets and preferably consumes vegetables, fruit and eggs. Interestingly, a large number of people who declared that they were organic consumers confused organic with home and locally produced food. This indicates the potential for growth of the organic sector if such consumers are provided appropriate information. Most consumers (including conventional consumers) have a favourable opinion of organic food, highlighting that it is better for health, is of better quality and does not contain pesticide residues. However, price continues to be a barrier to increased consumption; most consumers say that they would consume more organic food if the price was closer (only 10-30% higher) to that of the equivalent conventional products. Finally, organic consumers in North Spain have a positive attitude towards using local breeds in organic agriculture, for both food production and for ecotourism and educational activities, which could contribute to conserving breed biodiversity and adding value to organic farming.

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Figure 1. General data (%) regarding organic (ORG), home and locally produced (HLP) and conventional (CON) food consumers in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 2. General data about the establishments where organic consumers buy organic food. DK/NA: Don't know/not answered.

Figure 3. Level of knowledge about organic food and Genetically Modified Organisms in organic (ORG), home and locally produced (HLP) and conventional (CON) food consumers in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 4. Frequency of consumption of organic (ORG) and home and locally (HLP) produced food in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 5. (A) Reasons given by organic (ORG) and home and locally produced (HLP) consumers in Galicia for consuming organic food and (B) reasons given by conventional (CON) consumers in Galicia for not consuming organic food. *P* denotes a statistically significant difference between ORG and HLP consumers. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 6. Perceived differences between organic and conventional food and willingness to pay in consumers of organic (ORG), home and locally produced (HLP) and conventional (CON) food in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 7. Importance given to external appearance of organic food in consumers of organic (ORG), home and locally produced (HLP) and conventional (CON) food in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 8. Valuing local breeds for organic production by consumers of organic (ORG), home and locally produced (HLP) and conventional (CON) food in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

Figure 9. Valuing local breeds for ecotourism and farm schools by consumers of organic (ORG), home and locally produced (HLP) and conventional (CON) food in Galicia. N: number of samples; DK/NA: Don't know/not answered. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; NS: not significant.

	N	ORG	HLP	CON	*p*
N		288	305	213	
Gender					*
Female	520	37,3	39,2	23,5	
Male	286	32,9	35,3	31,8	
Age					*
<25 years	90	23,3	40,0	36,7	
25-34 years	146	38,4	34,2	27,4	
35-44 years	187	40,6	42,3	17,1	
45-54 years	138	41,3	35,5	23,2	
55-64 years	140	37,1	35,0	27,9	
> 65 years	102	24,5	40,2	35,3	
NA	3	33,3	33,3	33,3	
Educational level					***
University degree	293	47,1	38,6	14,3	
Advanced level secondary education	113	41,6	34,5	23,9	
Vocational traiting	151	27,8	39,7	32,5	
Compulsory Secondary Education	84	31,0	38,0	31,0	
Primary Studies	127	26,0	37,0	37,0	
No studies	35	2,9	40,0	57,1	
NA	3	33,3	0,0	66,7	
Population					NS
Less than 5,000 inhabitants	141	27,0	46,8	26,2	
Between 5,000 and 10,000 inhabitants	121	41,4	32,2	26,4	
Between 10,000 and 15,000 inhabitants	78	28,2	50,0	21,8	
Between 15,000 and 20,000 inhabitants	68	32,4	39,7	27,9	
More than 20,000 inhabitants	121	38,0	33,9	28,1	
A Coruña	70	35,7	44,3	20,0	
Ferrol	17	53,0	23,5	23,5	
Lugo	33	60,6	33,3	6,1	
Ourense	28	21,4	35,7	42,9	
Pontevedra	21	66,7	14,3	19,0	
Santiago	37	35,1	43,3	21,6	
Vigo	71	32,4	25,4	42,2	
Civil status					NS
Married	350	37,1	36,3	26,6	
Single	282	33,3	37,6	29,1	
Living with partner	80	44,9	41,3	13,8	
Widower	48	33,3	37,5	29,2	
Divorced	45	26,7	44,4	28,9	
NA	1	0,0	100,0	0,0	
Family members					NS
1 member	137	33,6	42,3	24,1	
2-3 members	386	38,3	33,7	28,0	
4-5 members	259	32,8	42,9	24,3	
More than 5 members	23	34,8	26,1	39,1	
Children					NS
Yes	453	37,8	37,3	24,9	
No	351	33,3	38,2	28,5	
NA	2	0,0	0,0	100,0	
Age of children					NS
Less than 18 years	194	40,8	37,6	21,6	
Between 18 and 39 years	193	36,8	36,8	26,4	
40 years on	105	29,5	40,0	30,5	
Number of children					NS
1 child	177	39,0	33,9	27,1	
2-3 children	255	37,3	40,0	22,7	
4-5 children	6	0,0	50,0	50,0	
Number of family members working					NS
1 member working	261	33,7	39,1	27,2	
2-3 members working	388	40,0	37,6	22,4	
More than 4 members working	19	42,1	31,6	26,3	

	N	ORG	HLP	CON	*p*
		288	305	213	
Family income					**
0-400	14	28,6	42,8	28,6	
400-600	40	20,0	37,5	42,5	
600-1000	95	27,4	35,8	36,8	
1000-1500	103	30,1	37,9	32,0	
1500-2000	131	39,0	30,5	30,5	
2000-2500	107	43,0	37,4	19,6	
2500-3000	78	41,1	39,7	19,2	
3000-4000	78	48,7	38,5	12,8	
>4000	29	44,8	48,3	6,9	
DK/NA	131	29,8	42,7	27,5	
Frequency of shopping					*
Always	374	37,4	38,3	24,3	
Frequently	286	39,5	36,4	24,1	
Occasionally	124	25,0	39,5	35,5	
Never	21	19,0	38,1	42,9	
DK/NA	1	0,0	100,0	0,0	
1st Purchase criteria					***
Quality	375	45,1	36,0	18,9	
Price	139	15,1	40,3	44,6	
Freshness	137	38,0	32,8	29,2	
Naturalness	55	38,2	54,5	7,3	
Origin	32	34,4	37,5	28,1	
None	17	17,6	29,4	53,0	
DK/NA	16	31,3	50,0	18,7	
Establishment	14	14,3	57,1	28,6	
Brand	11	36,4	9,1	54,5	
Other	10	20,0	50,0	30,0	
2nd Purchase criteria					***
Price	209	35,9	36,8	27,3	
Freshness	194	42,7	35,1	22,2	
Quality	138	28,3	44,2	27,5	
DK/NA	108	17,6	37,0	45,4	
Naturalness	50	52,0	42,0	6,0	
Origin	53	49,0	45,3	5,7	
Brand	27	37,0	26,0	37,0	
Establishment	24	37,5	20,8	41,7	
Other	3	33,3	66,7	0,0	
None	0	0,0	0,0	0,0	
1st place for purchase					NS
Supermarket	608	33,9	39,6	26,5	
Hypermarkets	82	41,5	25,6	32,9	
Small shops	51	41,2	39,2	19,6	
Local markets	41	51,2	31,7	17,1	
DK/NA	16	18,9	37,6	43,5	
Producers	3	33,3	66,7	0,0	
Other	3	33,3	33,3	33,3	
Consmer groups	1	0,0	100,0	0,0	
Specialized shops	1	100,0	0,0	0,0	
2nd place for purchase					***
DK/NA	488	32,4	34,6	33,0	
Small shops	115	40,0	44,3	15,7	
Local markets	96	43,8	41,6	14,6	
Supermarket	55	43,7	32,7	23,6	
Hypermarkets	28	28,6	53,5	17,9	
Producers	7	28,6	42,8	28,6	
Other	6	16,7	83,3	0,0	
Specialized shops	6	50,0	50,0	0,0	
Consumer groups	5	80,0	20,0	0,0	

1st place for purchase	N	%
Hypermarkets	17	5,9
Consumer groups	4	1,4
Producers	32	11,1
Local markets	44	15,3
Small shops	65	22,6
Specialized shops	47	16,3
Supermarket	73	25,4
Other	3	1,0
DK/NA	3	1,0
Total	288	100
2nd place for purchase		
Hypermarkets	8	2,8
Consumer groups	9	3,1
Producers	18	6,3
Local markets	25	8,7
Small shops	42	14,6
Specialized shops	17	5,9
Supermarket	28	9,7
Other	1	0,3
DK/NA	140	48,6
Total	288	100

	ORG	HLP	CON	*p*
N	288	305	213	
Organic food definition				***
Very well	3,5	1,6	1,4	
Well	21,3	24,6	17,0	
Medium	30,0	24,9	21,2	
Bad	28,5	30,2	16,0	
Very bad	16,7	18,7	44,4	
Total	100	100	100	
Do you know transgenic food?				***
Yes	87,5	70,2	44,6	
No	10,4	24,9	45,1	
DK/NA	2,1	4,9	10,3	
Total	100	100	100	
Transgenic definition				***
Very well	49,4	41,3	16,9	
Well	0,3	1,0	0,9	
Medium	14,9	10,2	5,6	
Bad	9,0	7,2	5,6	
Very bad	26,4	40,3	71,0	
Total	100	100	100	
Would you buy organic food knowing they are transgenic free?				***
Yes	88,2	83,6	54,9	
No	4,5	5,9	17,4	
DK/NA	7,3	10,5	27,7	
Total	100	100	100	

		Cereals	Cheese	Eggs	Fruit	Jam	Meat	Milk	Oil	Tomatoes	Vegetables	Wine	Yoghurt
Frecuency of consumption													
ORG (n=288)	Every day	6,9	4,2	7,6	14,9	4,2	2,1	8,0	10,4	8,0	10,8	1,0	6,6
	Many times a week	9,4	12,5	31,6	25,3	3,8	15,3	6,9	10,8	30,9	31,6	5,2	13,2
	Many times a month	12,2	14,9	24,0	32,7	11,1	16,7	10,1	9,7	31,3	32,0	7,6	17,0
	Less than once a month	16,7	21,9	11,1	16,3	20,5	19,8	16,0	14,2	14,2	12,8	14,2	18,4
	Never	54,8	46,5	25,7	10,8	60,4	46,1	59,0	54,9	15,6	12,8	72,0	44,8
	DK/NA	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Total	100	100	100	100	100	100	100	100	100	100	100	100
HLP (n=305)	Every day	6,2	4,3	12,8	21,3	3,9	4,3	8,9	8,9	17,7	22,0	2,0	4,9
	Many times a week	4,9	8,5	39,6	27,2	6,9	18,7	5,2	6,9	31,8	33,0	3,6	7,9
	Many times a month	10,5	13,1	20,7	23,3	9,8	15,1	5,2	5,9	21,3	22,0	8,9	12,1
	Less than once a month	11,1	15,7	5,9	17,7	15,1	13,4	10,5	10,2	14,8	12,5	11,8	13,4
	Never	65,0	65,1	18,7	8,2	62,0	46,2	67,9	65,8	12,1	8,2	71,4	59,4
	DK/NA	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
	Total	100	100	100	100	100	100	100	100	100	100	100	100
	p	**	*	**	**	**	*	**	**	***	***	NS	**

		p	0	1	2	3	4	5	6	7	8	9	10	Mean
A	**ORG (n=288)**													
	Score		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
	Animal welfare	**	9,5	0,4	3,9	3,5	1,8	13,7	5,6	10,2	14,6	8,1	28,7	6,8
	Better flavour	NS	7,7	0,7	1,1	2,1	1,8	11,2	4,2	9,1	14,4	12,3	35,4	7,4
	Curiosity	NS	45,9	5,3	4,9	3,9	1,8	9,5	2,8	4,2	4,2	3,9	13,6	3,3
	Environment care	*	6,7	0,0	1,1	1,8	2,1	8,5	6,7	11,3	15,7	8,5	37,6	7,6
	Food safety	NS	9,8	0,7	3,5	2,5	1,1	12,3	4,9	9,8	16,8	8,4	30,2	6,9
	Health, dietary and nutritional aspects	NS	5,3	0,0	0,4	0,4	1,4	6,0	1,4	4,6	11,9	9,1	59,5	8,5
	Quality	NS	4,9	0,4	0,4	0,7	0,4	7,4	1,4	5,6	16,5	13,3	49,0	8,3
	To consume local products	*	20,1	1,1	3,5	2,8	1,8	12,3	2,8	5,6	10,6	11,3	28,1	6,1
	To avoid intake of chemical wastes	*	5,3	0,4	0,4	2,1	2,5	5,6	3,9	7,0	14,6	8,8	49,4	8,1
	To avoid intake of genetically modified organisms	NS	15,4	1,8	2,8	3,2	1,4	9,8	5,3	8,4	11,2	8,1	32,6	6,5
	HLP (n=305)													
	Score		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
	Animal welfare		19,0	1,0	1,7	2,0	4,4	12,2	5,8	12,6	9,9	6,5	24,9	6,0
	Better flavour		11,9	0,0	0,3	0,3	0,3	7,8	5,4	9,3	11,9	7,5	45,3	7,5
	Curiosity		53,1	4,4	3,4	2,4	2,4	11,6	1,0	3,7	4,1	2,0	11,9	2,9
	Environment care		16,7	0,3	0,7	1,4	1,7	8,9	5,5	8,9	14,7	10,2	31,0	6,7
	Food safety		21,9	1,0	3,7	3,1	1,7	12,9	4,4	8,8	12,9	8,2	21,4	5,7
	Health, dietary and nutritional aspects		10,5	0,0	0,0	1,4	0,3	8,8	3,7	5,4	11,0	8,5	50,4	7,8
	Quality		11,6	0,0	0,3	0,0	0,3	8,8	1,7	8,5	15,3	11,6	41,9	7,6
	To consume local products		23,1	0,0	1,4	1,7	1,0	12,2	6,5	6,1	10,9	4,8	32,3	6,1
	To avoid intake of chemical wastes		13,6	0,0	1,4	0,7	0,7	6,8	1,7	8,2	10,5	9,9	46,5	7,5
	To avoid intake of genetically modified organisms		26,5	1,0	3,7	2,7	1,4	10,3	4,8	8,2	7,1	7,8	26,5	5,5
B	**CON (n=213)**													
	Score		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
	Appearancenot attractive		73,5	2,4	2,9	0,5	2,9	4,8	1,9	2,9	2,9	1,4	3,9	1,5
	There is little variety available		70,1	0,0	2,9	1,9	2,9	7,3	1,9	4,3	4,8	1,0	2,9	1,8
	Lack of habit		41,1	0,5	1,0	0,0	0,5	2,4	1,9	2,4	2,9	7,7	39,6	5,3
	I did not know that organic food exists		79,6	1,4	1,9	2,4	1,0	3,9	1,0	1,0	0,5	0,5	6,8	1,3
	I have no interest in organic products		74,0	1,0	1,5	1,5	1,0	7,3	2,0	2,4	1,0	1,0	7,3	1,7
	I do not trust the authenticity of organic products		44,4	1,0	1,4	1,0	3,9	7,2	4,3	5,8	4,8	1,4	24,8	4,2
	I cannot find organic products easily *		59,3	0,0	0,5	1,0	0,5	3,9	3,9	5,3	6,8	3,4	15,4	3,3
	No information about organic food, ignorance		57,6	0,0	1,0	1,9	3,4	7,2	2,4	2,4	5,3	2,9	15,9	3,2
	I do not think there are differences between organic and conventional produts		65,3	1,4	2,4	3,9	2,9	6,3	2,4	1,9	2,4	0,5	10,6	2,2
	Excessive price		36,7	0,0	0,0	1,0	0,0	2,9	4,3	5,8	6,3	5,3	37,7	5,6
	I have an orchard		62,7	0,5	1,0	1,0	1,0	1,0	0,5	1,0	2,4	2,4	26,5	3,3

* establishments where I go shopping do not have organic products

		Cereals	Cheese	Eggs	Fruit	Jam	Meat	Milk	Oil	Tomatoes	Vegetables	Wine	Yoghurt
Differences between organic and conventional food													
ORG (n=288)	A lot of diference	26,7	29,1	44,8	42,0	28,5	36,6	31,3	9,9	42,0	39,9	26,4	29,5
	Quite different	41,0	43,0	39,2	45,9	39,9	41,8	42,6	23,0	44,5	46,9	35,8	42,4
	Few differences	13,5	12,2	6,9	5,9	13,2	9,7	9,7	13,6	6,9	7,3	14,6	14,2
	Very few differences	8,0	5,9	4,2	3,8	5,2	4,2	5,6	4,7	3,5	3,5	6,9	5,2
	No difference	5,2	3,5	0,7	0,7	5,6	2,8	4,5	11,7	1,4	0,7	10,8	2,4
	DK/NA	5,6	6,3	4,2	1,7	7,6	4,9	6,3	37,1	1,7	1,7	5,6	6,3
	Total	100	100	100	100	100	100	100	100	100	100	100	100
HLP (n=305)	A lot of diference	32,5	41,7	54,4	45,6	37,0	48,2	45,8	38,9	51,8	46,5	36,1	41,7
	Quite different	38,6	35,7	29,5	38,7	34,4	33,1	31,5	34,8	34,1	38,7	34,8	37,1
	Few differences	10,2	8,5	5,6	6,2	10,5	8,2	7,9	9,2	4,9	5,6	9,5	8,5
	Very few differences	4,9	3,9	2,6	3,3	5,6	3,0	3,9	4,6	3,0	3,0	5,2	3,9
	No difference	5,9	2,3	1,3	1,3	3,6	1,3	3,0	3,0	1,3	1,3	5,6	2,6
	DK/NA	7,9	7,9	6,6	4,9	8,9	6,2	7,9	9,5	4,9	4,9	8,9	6,2
	Total	100	100	100	100	100	100	100	100	100	100	100	100
CON (n=213)	A lot of diference	8,0	11,3	14,6	9,4	8,9	11,3	11,3	9,9	10,8	9,4	10,3	11,7
	Quite different	24,9	24,9	23,5	30,0	22,5	26,3	24,4	23,0	27,7	28,6	24,0	24,4
	Few differences	14,6	14,6	11,7	11,3	14,6	3,3	13,6	13,6	11,3	12,2	13,1	14,1
	Very few differences	6,6	3,3	2,8	3,3	6,1	12,7	4,7	4,7	3,3	2,8	4,2	3,8
	No difference	9,4	9,4	10,8	9,4	10,8	9,9	9,4	11,7	10,3	10,3	11,3	9,4
	DK/NA	36,5	36,5	36,6	36,6	37,1	36,5	36,6	37,1	36,6	36,7	37,1	36,6
	Total	100	100	100	100	100	100	100	100	100	100	100	100
	p	***	***	***	***	***	***	***	***	***	***	***	***
Organic food payment													
ORG (n=288)	More than 50%	2,4	3,5	5,2	4,5	2,1	4,9	5,2	5,2	3,1	3,5	2,8	3,5
	31-50%	9,4	11,8	14,6	11,5	10,1	14,2	11,8	9,4	12,8	11,8	9,4	13,9
	10-30%	50,0	51,7	51,7	57,9	47,5	51,7	48,6	50,6	55,3	57,3	45,5	48,5
	Less than 10%	21,5	20,8	18,1	17,4	21,9	17,0	20,8	18,8	19,1	19,1	19,4	21,9
	Nothing	12,2	7,3	5,9	5,6	13,2	7,3	8,7	11,1	6,6	5,2	17,7	7,3
	DK/NA	4,5	4,9	4,5	3,1	5,2	4,9	4,9	4,9	3,1	3,1	5,2	4,9
	Total	100	100	100	100	100	100	100	100	100	100	100	100
HLP (n=305)	More than 50%	1,6	2,3	5,6	2,3	1,6	3,6	2,6	3,3	3,0	2,3	2,3	2,0
	31-50%	4,9	6,6	11,5	7,9	5,2	10,8	6,6	7,5	11,1	8,5	4,3	7,9
	10-30%	40,0	42,0	39,0	45,2	36,5	40,6	39,0	38,4	42,0	44,6	36,7	40,6
	Less than 10%	24,6	22,5	20,0	21,3	26,2	20,7	24,6	23,3	20,3	21,6	23,9	23,0
	Nothing	18,4	16,4	14,4	14,1	20,3	15,1	17,0	18,0	14,4	13,8	23,3	16,7
	DK/NA	10,5	10,2	9,5	9,2	10,2	9,2	10,2	9,5	9,2	9,2	9,5	9,8
	Total	100	100	100	100	100	100	100	100	100	100	100	100
CON (n=213)	More than 50%	0,5	0,0	0,9	0,0	0,0	0,0	0,0	0,5	0,5	0,9	0,5	0,5
	31-50%	0,9	1,4	1,9	1,9	0,5	1,9	1,9	1,4	2,3	1,9	0,9	0,9
	10-30%	16,9	17,4	19,7	21,1	17,8	18,8	19,2	19,2	21,1	21,1	16,9	17,8
	Less than 10%	23,0	24,9	21,1	22,1	22,5	23,9	23,5	23,0	21,1	21,1	20,2	24,9
	Nothing	34,3	31,9	32,0	30,5	34,8	31,0	31,0	31,5	30,6	30,6	37,1	31,5
	DK/NA	24,4	24,4	24,4	24,4	24,4	24,4	24,4	24,4	24,4	24,4	24,4	24,4
	Total	100	100	100	100	100	100	100	100	100	100	100	100
	p	***	***	***	***	***	***	***	***	***	***	***	***

	ORG	HLP	CON	*p*
N	288	305	213	
Importance of external appearence				***
Very important	16,0	11,8	20,7	
Quite important	32,3	26,6	26,3	
Few important	24,3	23,6	13,6	
Very few important	8,3	10,8	6,1	
Not important	18,4	24,6	27,7	
DK/NA	0,7	2,6	5,6	
Total	100	100	100	
Would you buy organic food with aesthetic defects?				***
Yes	87,9	85,3	61,5	
No	9,7	8,5	22,1	
DK/NA	2,4	6,2	16,4	
Total	100	100	100	

Would you like breed to be specified in organic products?				*p*
N	288	305	213	***
Yes	65,2	64,6	42,7	
No	16,0	15,7	24,9	
DK/NA	18,8	19,7	32,4	
Total	100	100	100	
Would you positively value the use of traditional breeds?				
N	288	305	213	***
Yes	54,5	54,1	38,0	
No	14,9	14,4	24,0	
DK/NA	30,6	31,5	38,0	
Total	100	100	100	
Would you pay extra money for the use of traditional breeds?				
N	157	165	81	NS
Yes	81,5	81,2	74,1	
No	14,0	12,7	21,0	
DK/NA	4,5	6,1	4,9	
Total	100	100	100	

		ORG	HLP	CON	*p*
Do you know anything about ecoturism?					***
	N	288	305	213	
	Yes	76,8	76,3	51,2	
	No	20,8	20,7	40,8	
	DK/NA	2,4	3,0	8,0	
	Total	100	100	100	
Have you been an ecotourism customer?					***
	N	288	305	213	
	Yes	30,9	26,6	21,6	
	No	67,4	69,8	69,9	
	DK/NA	1,7	3,6	8,5	
	Total	100	100	100	
If so, how often?					NS
	N	89	81	45	
	Once a month	5,6	3,7	6,7	
	Twice a year	15,7	9,9	13,3	
	Once a year	16,9	11,1	4,4	
	Other	60,7	72,8	75,6	
	DK/NA	1,1	2,5	0,0	
	Total	100	100	100	
If you have not participated, would you be interested in future?					***
	N	199	224	168	
	Yes	64,3	50,4	31,0	
	No	16,6	22,8	34,5	
	DK/NA	19,1	26,8	34,5	
	Total	100	100	100	
If so, how often?					**
	N	130	113	51	
	Once a month	17,7	12,4	9,8	
	Twice a year	20,0	13,3	2,0	
	Once a year	28,5	35,4	25,5	
	Other	20,0	23,0	43,1	
	DK/NA	13,8	15,9	19,6	
	Total	100	100	100	
Do you positively value the presence of animals in ecotourism establishments?					***
	N	288	305	213	
	Yes	68,0	66,8	48,3	
	No	10,1	10,2	15,5	
	DK/NA	21,9	23,0	36,2	
	Total	100	100	100	
Would you positively value the presence of traditional breeds?					***
	N	288	305	213	
	Yes	75,7	72,5	50,7	
	No	6,9	10,5	17,8	
	DK/NA	17,4	17,0	31,5	
	Total	100	100	100	

		ORG	HLP	CON	*p*
If you positively value the use of local breeds, would you pay extra money for this?					*
	N	218	221	108	
	Yes	66,6	63,7	52,7	
	No	18,3	24,0	34,3	
	DK/NA	15,1	12,3	13,0	
	Total	100	100	100	
Do you organize extracurricular activities for children?					**
	N	288	305	213	
	Yes	27,8	21,6	15,0	
	No	70,5	75,4	80,3	
	DK/NA	1,7	3,0	4,7	
	Total	100	100	100	
How likely would you be to send children to a farm school?					***
	N	203	211	126	
	0	1,0	2,4	8,7	
	1	0,5	0,0	0,8	
	2	1,0	1,9	1,6	
	3	2,5	1,9	0,8	
	4	0,5	0,9	1,6	
	5	6,4	8,5	9,5	
	6	1,5	3,8	3,2	
	7	8,9	8,1	7,1	
	8	16,7	15,2	15,1	
	9	11,3	6,2	2,4	
	10	49,8	51,2	49,2	
	Total	100	100	100	
Would you positively value the use of traditional breeds in school farm?					***
	N	288	305	213	
	Yes	84,0	77,0	57,3	
	No	3,5	5,6	15,0	
	DK/NA	12,5	17,4	27,7	
	Total	100	100	100	
If you positively value the use of traditional breeds in school farm, would you pay extra money for this?					NS
	N	242	235	122	
	Yes	74,0	72,4	69,6	
	No	16,5	19,1	23,8	
	DK/NA	9,5	8,5	6,6	
	Total	100	100	100	

QUESTIONNAIRE ABOUT CONSUMPTION OF ORGANIC FOOD PRODUCTS IN GALICIA

Personal data:

1. Gender:

   ☐ Male ☐ Female ☐ NA

   (Go to question 2)

2. Age:

   ☐ <25 years ☐ 45-54 years ☐ NA

   ☐ 25-34 years ☐ 55-64 years

   ☐ 35-44 years ☐ >65 years

   (Go to question 3)

3. Educational level:

   ☐ No studies

   ☐ Primary Studies

   ☐ Compulsory Secondary Education

   ☐ Vocational training

   ☐ Advanced level secondary education

   ☐ University degree

   ☐ NA

   (Go to question 4)

4. Where do you live (council area)? ______________________________
   a. Where do you live within the council area (name of village, parish, other)? ____
   b. Approximately how many people live in the area? ____________________

   (Go to question 5)

5. Civil status:

   ☐ Single ☐ Widower

   ☐ Married ☐ Divorced

   ☐ Living with partner ☐ NA

   (Go to question 6)

6. Family members: _______

   (Go to question 7)

7. Do you have children?

☐ Yes (Go to question 7.1) ☐ No (Go to question 8)

☐ NA (Go to question 8)

7.1. If you have children, how many children do you have? How old are they? (Go to question 8)

8. Number of family members working:
(Go to question 9)

9. Family income in the last 3 months (combined income of all family members in work and different types of benefits etc.)?

☐ Up to 400,00 euros

☐ Between 400,01 and 600,00 euros

☐ Between 600,01 and 1000,00 euros

☐ Between 1000,01 and 1500,00 euros

☐ Between 1500,01 and 2000,00 euros

☐ Between 2000,01 and 2500,00 euros

☐ Between 2500,01 and 3000,00 euros

☐ Between 3000,01 and 4000,00 euros

☐ More than 4000,00 euro

☐ DK/NA

(Go to question 10)

10. How often do you go shopping relative to other members of your family?

☐ Always

☐ Frequently

☐ Occasionally

☐ Never

☐ DK/NA

(Go to question 11)

11. Indicate first and second criteria for purchasing food products:

___ Quality

___ Freshness

___ Price

___ Brand

___ Origin

___ Establishment

___ Naturalness

___ Other_________________

___ None

___ DK/NA

(Go to question 12)

12. Where/from whom do you usually buy your food?

☐ Hypermarkets ☐ Local markets

☐ Supermarkets

☐ Small shops

☐ Consumer groups

☐ Specialized shops

☐ Producers

☐ Other

☐ DK/NA

(Go to question 13)

General questions about organic food:

13. Do you know what organic food is?

☐ Yes ☐ No ☐ DK/NA

(Go to question 14)

14. How do you define organic food?

(Go to question 15)

15. Have you ever eaten organic food?

☐ Yes (Go to question 18) ☐ No (Go to question 16)

☐ DK/NA (Go to question 20)

16. If you have not eaten organic products, why not? Score from 0 to 10, where 0 is totally in disagreement and 10 totally in agreement, you can repeat marks as times as you need to.

___ Excessive price

___ No information about organic food, ignorance

___ I cannot find organic products easily; the establishments where I go shopping do not stock organic products

___ I do not think there are any differences between organic and conventional products

___ I do not trust the authenticity of organic products; they do not offer sufficient guarantees

___ Lack of habit

___ I have an orchard/vegetable garden

___ There is little variety available

___ Appearance not attractive

___ I did not know that organic food exists

___ I have no interest in organic products

___ Other ____________________

___ DK/NA

(Go to question 17)

17. If you have not eaten organic food, would you be interested in consuming it in future?

☐ Yes ☐ No ☐ DK/NA

(Go to question 20)

18. If you have eaten organic food, why? Score from 0 to 10, where 0 is totally disagreement and 10 totally agreement, you can repeat marks as times as you need to.

___ Health, dietary and nutritional aspects

___ Quality

___ Environment care

___ Animal welfare

___ Food Safety (Bovine Spongiform Encephalopathy, Avian Influenza, ...)

___ To avoid intake of genetically modified organisms

___ To avoid intake of chemical wastes (pesticides, insecticides, fertilizers, drugs, ...)

___ Better flavour

___ Curiosity

___ To consume local products

___ Other___________________

___ DK/NA

(Go to question 19)

19. If you eat organic food, how frequently do you consume it?

	Never	Less than once a month	Many times a month	Many times a week	Every day
Fruit					
Vegetables					
Tomatoes					
Cereals					
Milk					
Cheese					
Yoghurt					
Eggs					
Meat					
Jam					
Oil					
Wine					

(Go to question 20)

20. Do you think there are differences between these organic and conventional food products ?

	No difference	Very few differences	Few differences	Quite different	A lot of difference
Fruit					
Vegetables					
Tomatoes					
Cereals					
Milk					
Cheese					
Yoghurt					
Eggs					
Meat					
Jam					
Oil					
Wine					

(Go to question 21)

21. What extra price would you be willing to pay for organic produce, relative to the conventionally produced equivalent?

	Nothing	Less than 10%	Between 10 and 30%	Between 31 and 50%	More than 50%
Fruit					
Vegetables					
Tomatoes					
Cereals					
Milk					
Cheese					
Yoghurt					
Eggs					
Meat					
Jam					
Oil					
Wine					

(organic buying go to question 22, conventional and DK/NA go to question 23)

22. If you buy organic food, where/from whom do you buy it?

- ☐ Hypermarkets
- ☐ Supermarket
- ☐ Small shops
- ☐ Consumer groups
- ☐ Specialized shops
- ☐ Local markets
- ☐ Producers
- ☐ Other
- ☐ DK/NA

(Go to question 23)

23. In your opinion how important is the external appearance of organic food?

☐ Not important ☐ Quite important

☐ Very few important ☐ Very important

☐ Few important ☐ DK/NA

(Go to question 24)

24. Would you buy organic food with aesthetic defects: e.g. fruit or eggs that are not of uniform size?

☐ Yes ☐ No ☐ DK/NA

(Go to question 25)

Valuing traditional breeds: Specific questions related to products

25. Would you like breed to be specified in organic products?

☐ Yes ☐ No ☐ DK/NA

(Go to question 26)

26. Would you positively value the use of traditional breeds?

☐ Yes ☐ No ☐ DK/NA

(Go to question 27)

27. Would you pay extra money for the use of traditional breeds?

☐ Yes ☐ No ☐ DK/NA

(Go to question 28)

Valuing traditional breeds: Specific questions related to ecotourism and farm schools

28. Do you know anything about ecotourism?

☐ Yes ☐ No ☐ DK/NA

(Go to question 29)

29. Have you been an ecotourism customer?

☐ Yes (Go to question 29a) ☐ No (Go to question 29b)

☐ DK/NA (Go to question 30)

a. If so, how often?

☐ Once a month ☐ Other ____________

☐ Once a year ☐ DK/NA

☐ Twice a year

(Go to question 30)

b. If you have not participated in ecotourism, would you be interested in doing so in the future? ☐ Yes (Go to question 29bi) ☐ No (Go to question 30)

☐ DK/NA (Go to question 30)

i. If so, how often?

☐ Once a month ☐ Other ____________

☐ Once a year ☐ DK/NA

☐ Twice a year

(Go to question 30)

30. Do you positively value the presence of animals in ecotourism establishments?

☐ Yes ☐ No ☐ DK/NA

(Go to question 31)

31. If you visited an ecotourism establishment with animals, would you positively value the presence of traditional breeds?

☐ Yes (Go to question 31a) ☐ No (Go to question 32)

☐ DK/NA (Go to question 32)

a. If you positively value the use of traditional breeds, would you pay extra money for this?

☐ Yes ☐ No ☐ DK/NA

(Go to question 32)

32. Do you organize extracurricular activities for children?

☐ Yes ☐ No ☐ NA

(Go to question 33)

33. If you had to organize activities for children, how likely would you be to send them to a farm school? Score from 0 to 10 (with 0 the least likely and 10 the most likely): ________

(Go to question 34)

34. If you sent children to a farm school, would you positively value the use of traditional breeds?

☐ Yes (Go to question 34a) ☐ No (Go to question 35)

☐ DK/NA (Go to question 35)

a. If you value positively the use of traditional breeds, would you pay extra money for this?

☐ Yes ☐ No ☐ DK/NA

(Go to question 35)

Other questions:

35. Do you think there are differences between traditional food (e.g. free-range chicken, local market tomatoes, eggs produced at home) and organic food?

☐ Yes ☐ No ☐ DK/NA

(Go to question 36)

36. Do you think there are differences between organic food and food with geographical origin of denomination?

☐ Yes ☐ No ☐ DK/NA

(Go to question 37)

37. Do you know what genetically modified organisms are?

☐ Yes ☐ No ☐ DK/NA

(Go to question 38)

38. How would you define genetically modified organism?

(Go to question 39)

39. Organic products are free of genetically modified organisms. Would this information make you be more interested in consuming these products?

☐ Yes ☐ No ☐ DK/NA

CAPÍTULO VI

CAPÍTULO VI

Rodríguez-Bermúdez R, López-Alonso M, Miranda M, Fouz R, Orjales I, Herrero-Latorre C. 2018. Chemometric authentication of the organic status of milk on the basis of trace element content. *Food Chemistry.* 240: 686-693.

http://dx.doi.org/10.1016/j.foodchem.2017.08.011

CAPÍTULO VII

CAPÍTULO VII

Rodríguez-Bermúdez R, Herrero-Latorre C, López-Alonso M, Losada DE, Iglesias R, Miranda M. 2018. Organic cattle products: Authenticating production origin by analysis of serum mineral content. *Food Chemistry,* 264: 210-217.

https://doi.org/10.1016/j.foodchem.2018.05.044

DISCUSIÓN XERAL

DISCUSIÓN XERAL

Comportamento racial a nivel produtivo, reprodutivo e funcional

A gandería ecolóxica é un sector en crecemento a nivel mundial (Díez et al., 2012) que demanda máis información en múltiples aspectos produtivos, e nos últimos tempos fixo especial énfase no coñecemento produtivo das razas. Na actualidade a maior parte dos gandeiros europeos en produción ecolóxica adaptáronse desde os sistemas convencionais e manteñen a mesma xenética vacúa que antes da adaptación (Ahlman, 2010; Nauta, 2010; Zollitsch et al., 2014). Porén, existe a percepción de que estas razas altamente produtivas seleccionadas en convencional non son as mellor adaptadas á produción leiteira en ecolóxico, e que polo tanto, conviría buscar razas ou cruces que se adapten mellor ás condicións e enfermidades locais (Diepen et al., 2007). As análises produtivas, reprodutivas e funcionais das diferentes razas realizáronse dentro do Proxecto VALECO (Goberno de España, AGL2010-21026), incluíndo un total de 56 granxas ecolóxicas e 10 granxas convencionais distribuídas ao longo do norte de España.

A produción animal é o resultado da interacción do xenotipo co ambiente, do inglés Genotype by Environment Interaction (GxE) (Diepen et al., 2007), de tal xeito que os animais que están xeneticamente adaptados a unhas condicións específicas son máis produtivos e teñen menores custos de produción (Simm et al., 2004). De feito, algúns Frisóns están mellor adaptados ca outros ás condicións ecolóxicas, o que supón unha ordenación diferente en canto a mérito xenético para o seu uso en sistemas ecolóxicos (Nauta et al., 2006d; Ahlman, 2010; Horn et al., 2013). No desenvolvemento desta Tese de Doutoramento viuse que as vacas en ecolóxico producen arredor dun 55% menos leite que en convencional intensivo, esta diferenza débese principalmente á nutrición, debido ao maior uso de concentrado en convencional (Horan et al., 2005; Orjales et al., 2018a). En canto ás diferenzas raciais observadas na produción ecolóxica, as diferenzas ao comparar leite diario producido non son tan evidentes como ao usar lactacións estandarizadas, onde se ve que a Holstein produce máis leite que os seus cruces e outras razas puras (Parda Alpina), tendo xeralmente os cruces producións intermedias; estes resultados son comparables aos encontrados noutros sistemas ecolóxicos (Sundberg et al., 2009; Mullen et al., 2015). O estudo máis completo é o realizado por Haas et al. (2013) onde compara vacas Holstein, Jersey, Meuse-Rhine-Yssel, Montbeliarde, Fleckvieh, Parda Alpina, Groningen White Headed, Frisoas holandesas e os seus cruces; observando que as vacas con 100% de xenes de Holstein son as máis produtivas e as vacas con 100% de xenes de Groningen White Headed as menos produtivas.

No campo da investigación sobre a produción leiteira é ben coñecido que certas razas producen maiores contidos de sólidos (Haas et al., 2013), porén aínda non está claro ata que punto o contido de sólidos depende dos litros de leite producidos (efecto de dilución) ou dunha diferente capacidade das razas para producir graxa e proteína. Na presente Tese de Doutoramento ao analizar a composición nutricional, como % de graxa e % de proteína non se observaron diferenzas en canto aos sistemas produtivos (ecolóxico, convencional pastoreo e convencional intensivo). As diferenzas en composición nutricional son moi dependentes da alimentación, dependendo non só da cantidade de forraxe e concentrado senón tamén da súa composición nutricional (Palmquist et al., 1993; Walker et al., 2004). Nun estudo desenvolvido en Suecia, Ahlman (2010) encontrou menor produción de sólidos nas granxas ecolóxicas que nas convencionais; porén nun estudo en Canadá os resultados foron os opostos (Rozzi et al., 2007). Ao comparar as diferenzas entre razas en ecolóxico observouse que tanto as razas diferentes da Holstein como os seus cruces producían maiores porcentaxes de proteína, e no caso da Parda Alpina tamén de graxa. Posteriormente, analizáronse as producións estandarizadas a 305 días de lactación de graxa e proteína encontrando que os cruces producían maiores cantidades de ambos sólidos, posiblemente debido a unha combinación das maiores porcentaxes de graxa e proteína encontradas no estudo previo e unha produción intermedia de litros de leite. En canto á produción de graxa e proteína en ecolóxico existen resultados variados, algúns autores encontran peores producións nas Holstein, achacando a boa produción dos cruces ao efecto da heterose (Haas et al., 2013); mentres que outros afirman obter mellores resultados na Holstein (Sundberg et al., 2009; Mullen et al., 2015).

De cara a estudar o estatus sanitario das granxas utilizouse como medida da saúde do ubre o Reconto de Células Somáticas (RCS), non observando diferenzas entre os sistemas analizados. Como cabía esperar, atopouse un incremento do RCS ao aumentar o número de lactación (Reneau, 1986). Existe numerosa bibliografía acerca das diferenzas no RCS entre ecolóxico e convencional, se ben non se encontrou consenso posible, existindo estudos que indican un menor RCS en ecolóxico (Busato et al., 2000; Hamilton et al., 2006), aínda que a maior parte manifestan o contrario (Zwald et al., 2004; Roesch et al., 2007; Rozzi et al., 2007; Sundberg et al., 2009) ou simplemente encontran poucas diferenzas (Vaarst et al., 2006; Fall et al., 2008a; Haskell et al., 2009; Orjales et al., 2016). Nun primeiro estudo non se encontraron diferenzas no RCS para as razas, se ben ao marcar un punto de corte por enriba de 200.000 células somáticas, momento no que comeza a mamite subclínica e ao analizar a Puntuación Lineal (PL) como marcador da saúde do ubre si se encontraron diferenzas. Os cruces teñen menores PL e RCS que as Holstein e as Pardas Alpinas, este fenómeno podería explicarse como unha combinación do efecto de dilución cunha maior resistencia dos cruces á mamite debido á heterose. O feito de presentar as vacas Holstein maiores incrementos no RCS ao aumentar as lactacións pode suxerir unha maior predisposición desta raza a sufrir de infeccións do ubre (Busato et al., 2000). No caso das Pardas Alpinas, os maiores RCS poden ser debidos, polo menos en parte, a un menor efecto de dilución debido á menor produción leiteira. En xeral os estudos realizados acerca das diferenzas raciais en canto a saúde do ubre obtiveron resultados moi variados, desde os que non encontraron diferenzas entre a Holstein e outras razas (Prendiville et al., 2010; Horn et al., 2012, 2013; Mullen et al., 2015) ata os que encontraron que as Holstein tiñan maiores (Sundberg et al., 2009; Coffey et al., 2016) ou menores (Swalve, 2007) RCS que outras razas ou cruces.

A reprodución é un aspecto de vital importancia nas granxas ecolóxicas debido á imposibilidade de utilizar tratamentos hormonais (EC, 2007). Ademais, recentemente apareceu en ecolóxico un interese pola agrupación de partos cun criterio estacional, de cara a garantir que se produzan de acordo cos ciclos de crecemento da herba para realizar un aproveitamento eficiente dos recursos locais, e para iso é imprescindible que a reprodución sexa o máis eficaz posible (Auldist et al., 2007). As vacas (*Bos taurus*) son unha especie unípara (Çobanoglu, 2010), na que ademais non son desexables os partos de xemelgos xa que producen un impacto negativo na economía das granxas (Silva-Del Río et al., 2007; EFSA, 2009). A raza Holstein asóciase en sistemas convencionais a altas taxas de partos de xemelgos, porén fronte ao que cabía esperar, no estudo desenvolvido para elaborar a presente Tese de Doutoramento non se encontraron diferenzas entre razas, feito que se relacionou coa baixa produción das Holstein en ecolóxico, xa que a taxa de partos de xemelgos amosou ter relación coas altas producións leiteiras (Çobanoglu, 2010; Hossein-Zadeh, 2010). Convén ter en conta que os partos de xemelgos tamén están relacionados co uso sistemático de tratamentos para a mellora da fertilidade amplamente usados en convencional (Lucy et al., 2004), que como xa se mencionou están restrinxidos nos sistemas ecolóxicos.

A facilidade de parto tamén ten impacto económico nas granxas de leite debido á mortalidade dos xatos (Lombard et al., 2007; Dhakal et al., 2013), ao impacto sobre a saúde da vaca e a redución da produción leiteira (Heins et al., 2006a; b). Algúns estudos apuntan á posibilidade dunha redución da dificultade de parto nos cruces (Heins et al., 2006a; b; Sorensen et al., 2008), aínda que existen poucos estudos que analicen este aspecto en ecolóxico, en xeral encontran resultados similares (Aksakal and Bayram, 2009) aos da presente Tese de Doutoramento, onde os cruces presentan menor dificultade de parto. Convén ter en conta que na área onde se desenvolveu o estudo, os gandeiros tenden a asistir os partos aínda cando non é estritamente necesario, sobre todo en granxas pequenas. Ao analizar os datos en función do tamaño da granxa as diferenzas raciais só se manteñen nas granxas pequenas e medianas, mentres que nas grandes máis do 97% das vacas de calquera das razas analizadas paren sen asistencia. En estudos desenvolvidos en pastoreo tampouco encontraron diferenzas entre razas para a dificultade de parto (Dhakal et al., 2013; Mullen et al., 2015).

Respecto á reprodución tamén se analizaron certos parámetros (número de servizos por xestación, intervalo entre partos, intervalo parto-primeira inseminación, intervalo parto-inseminación fecundante, idade á primeira inseminación, idade á inseminación fecundante e idade ao primeiro parto) que se utilizaron como indicadores da eficiencia reprodutiva. A eficiencia reprodutiva das Holstein foi lixeiramente mellor en ecolóxico que nos sistemas convencionais de pastoreo, pero non se observaron diferenzas con respecto ao sistema convencional intensivo. A explicación destes resultados ten que ver co manexo, mentres nas explotacións ecolóxicas e intensivas a detección de celos se realiza correctamente, nas granxas en pastoreo non se dedica nin o tempo suficiente nin en exclusividade, aproveitando para realizar a detección de celos ao mesmo tempo que outras actividades. Por outro lado as vacas en sistemas intensivos reciben tratamentos para aumentar a súa fertilidade, estando estes prohibidos nos sistemas ecolóxicos. As diferenzas na produción leiteira poden explicar que as vacas en ecolóxico mostren mellor reprodución, de feito, outros autores encontraron resultados similares ao comparar os sistemas ecolóxicos cos convencionais (Reksen et al., 1999; Valle et al., 2007; Fall et al., 2008b; Sundberg et al., 2009; Ahlman, 2010), aínda que debemos ter en conta que non comparaban Holstein en exclusiva, senón os animais presentes independentemente da raza. Na maior parte dos estudos asimilaron as diferenzas observadas á produción de leite, pois existe unha relación entre os litros de leite producidos e a eficiencia reprodutiva, as vacas máis produtivas mostran peor o celo dificultando as súa detección (Garmo et al., 2009).

Por outro lado analizáronse os mesmos parámetros reprodutivos en sistemas ecolóxicos para observar o comportamento das razas. Os cruces son os máis eficientes a nivel reprodutivo e as Holstein as que mostran peor reprodución. Os resultados de ambos estudos mostran que os cruces se comportan mellor a nivel reprodutivo, porén os resultados difiren entre si debido a que a composición racial de ambos estudos non é a mesma. Estes resultados concordan con outros autores que atribúen o mellor comportamento dos cruces á heterose, sendo polo tanto explicado polo vigor híbrido (Lopez-Villalobos et al., 2000; Pyman et al., 2005; Auldist et al., 2007; Begley et al., 2009; Prendiville et al., 2011a; Buckley et al., 2014). Os cruzamentos poden eliminar de forma efectiva os efectos negativos sobre a reprodución dos programas de selección baseados no aumento da produción láctea (Buckley et al., 2014). Para unha eficiente xestión da reprodución é fundamental detectar os celos adecuadamente, neste sentido convén ter en conta que a vaca Holstein mostra peor o estro pois é máis curto que o das Vermellas Noruegas ou as Normandas, o que fai que os gandeiros que desexen manter o gando Holstein teñan que facer un esforzo na detección dos celos (Cutullic et al., 2009; Sveberg et al., 2015). A peor eficiencia das vacas Holstein en comparación con outras razas puras e cruces en sistemas ecolóxicos foi probado anteriormente por outros autores (Swalve, 2007; Sundberg et al., 2009; Haas et al., 2013), porén cando as Holstein se seleccionan en función da lonxevidade e fertilidade teñen unha mellor reprodución incluso que vacas rústicas coma a Parda Alpina (Horn et al., 2012, 2013). A baixa eficiencia reprodutiva das Holstein pódese asociar co fenómeno coñecido como *Holsteinización* (Lindhe and Philipsson, 1998; Royal et al., 2000; Buaban et al., 2015), este termo fai referencia á presenza de xenes de Holstein ou Frisón norteamericano (Dillon et al., 2003a; EFSA, 2009); seleccionado principalmente cara á produción de leite (Pryce et al., 2004; Dillon et al., 2006), coas consecuencias que como se comentou ten sobre a fertilidade (Mackey et al., 2007). No caso dos sistemas ecolóxicos sería interesante a utilización de Frisoas rústicas que como se comentou aínda que son menos produtivas teñen mellor eficiencia reprodutiva (Horn et al., 2012, 2013), pois como apuntaron Sundberg et al. (2009) ao incrementar a produción leiteira, incluso unha raza rústica como a Vermella Sueca chega un momento en que ten peores índices reprodutivos que as Holstein.

Dado que os resultados produtivos e reprodutivos non eran determinantes para decantarse por unha raza ou outra nos sistemas ecolóxicos no norte de España, decidiuse estudar a influencia da raza nas causas de eliminación e a lonxevidade. As causas de eliminación clasifícanse habitualmente como voluntarias e involuntarias, sendo estas últimas necesarias para reducir o sufrimento animal porén as altas proporcións das mesmas teñen un impacto económico importante (Ahlman et al., 2011; Fouz et al., 2014). A variable "outras" foi a principal causa de eliminación nas Holstein, motivo que xa comentaban os gandeiros nun estudo previo (Rodríguez-Bermúdez et al., 2016) ao manifestar que as vacas se eliminaban a causa da idade avanzada, o que suxire que non se eliminan por un único motivo senón por múltiples pequenas causas. De feito, as vacas eliminadas debido a outras causas aumentan co número de lactación en todas as razas, efecto que tamén foi observado por Fouz et al. (2014) na raza Holstein en sistemas convencionais. Ao aumentar a idade a causa de eliminación obedece a razóns múltiples (mamite crónica, laminite, infertilidade, baixa produción) que fan que o animal xa non sexa rendible e polo tanto os gandeiros proceden á súa eliminación ao finalizar a lactación. Os resultados parecen indicar que a Holstein sofre de múltiples patoloxías aínda que o feito de manter unha boa produción de leite fai que permaneza no rabaño. Ademais, a Holstein elimínase en maior porcentaxe que outras razas por morte ou o sacrificio urxente, isto soe correlacionar con enfermidades agudas asociadas a un balance enerxético negativo no postparto, ao que as Holstein son particularmente susceptibles (Friggens et al., 2007). Cómpre salientar que os cruces manifestan unha reducida incidencia de eliminación por laminite, unha baixa incidencia da mesma é fundamental para os sistemas de pastoreo, esta resistencia dos cruces á laminite xa fora reportada en Nova Zelandia (Chawala, 2011). Finalmente, as Pardas Alpinas son eliminadas con maior frecuencia debido á baixa produtividade, de feito, como se viu ao analizar os datos produtivos esta raza produce manifestamente menos volume de leite. A nivel ecolóxico a bibliografía acerca das causas de eliminación é moi escasa, en xeral encontran resultados similares aos nosos, sendo a fertilidade e a mamite os motivos máis frecuentes de eliminación de animais (Rozzi et al., 2007; Ahlman et al., 2011).

A lonxevidade é unha característica moi apreciada nos sistemas ecolóxicos (Ahlman, 2010) que se define habitualmente coma a capacidade dunha vaca para evitar ser eliminada (Vollema and Groen, 1996). Os resultados obtidos amosan unha maior lonxevidade das vacas Holstein, sendo contrarios tanto a estudos en ecolóxico coma en convencional (Dillon et al., 2003a; Swalve, 2007; Ahlman, 2010; Bjelland et al., 2011), porén isto pode ser debido á selección que se está realizando no gando Holstein para prolongar a duración das lactacións.

Percepción do consumidor sobre os alimentos ecolóxicos

A alimentación en ecolóxico está medrando nos últimos tempos, con todo existen poucos estudos que caractericen a percepción que o consumidor ten sobre estes produtos, de cara a establecer estratexias de mercado (Idda et al., 2008). Coñecer os motivos do consumidor, tanto para mercar, como para non facelo é esencial, e desde o punto de vista da gandería de leite abre a posibilidade de coñecer ata que punto valora o emprego de diferentes razas. Isto pode ser especialmente útil para as granxas que non se dedican á produción de leite en exclusiva senón que teñen múltiples obxectivos (leite, derivados lácteos, carne, turismo) e que denominamos como granxas multifuncionais. Para a elaboración deste estudo realizáronse enquisas ao consumidor en vilas e cidades da Comunidade Autónoma de Galicia.

Os produtos ecolóxicos en Europa están suxeitos a unha serie de normativas de etiquetado (EC, 2007), aínda así resulta curioso que a maioría de consumidores pensa que consome produtos ecolóxicos cando en realidade está a consumir produtos locais ou amigables co medio ambiente, isto ten que ver coa confusión respecto aos produtos ecolóxicos que xa relataran anteriormente outros autores (Briz and Ward, 2009). Moitos destes consumidores confunden a etiquetaxe ecolóxica coa de produtos de orixe local (caseiro, mercados locais) ou amigables co medio ambiente (natural, denominación de orixe) (Hughner et al., 2007; Mauleón, 2014).

Cando se fai unha análise do perfil de consumidor de produtos ecolóxicos obsérvase que normalmente se trata dunha muller de mediana idade, con estudos universitarios e renda elevada. A maior parte dos estudos realizados co fin de obter un perfil do consumidor ecolóxico observa estes mesmos resultados (Chinnici et al., 2002; Krystallis and Chryssochoidis, 2005; Padel and Foster, 2005; Roitner-Schobesberger et al., 2008; MAGRAMA, 2014; Generalitat de Catalunya, 2015). Respecto á idade cabe sinalar que aínda que os consumidores máis xoves mostran actitudes positivas cara aos alimentos ecolóxicos o seu poder adquisitivo actúa como factor limitante (Hughner et al., 2007). En canto ao nivel de estudos, as persoas con menor nivel de estudos son máis propensos a confundir os produtos locais e amigables co medio ambiente con ecolóxicos. Aínda que non se observaron diferenzas estatisticamente significativas, si que se viu unha tendencia numérica a que os consumidores de ecolóxico vivan en vilas de 5.000-10.000 habitantes ou máis de 20.000, concordado con outros estudos españois (MAGRAMA, 2007; Generalitat de Catalunya, 2015). Por último, existen estudos (Hughner et al., 2007; MAGRAMA, 2014) que atopan que as persoas casadas e con fillos consomen máis produtos ecolóxicos, xa que a chegada dun bebé á familia muda os hábitos alimenticios, no noso caso non foi significativo pero tamén existe esa tendencia.

Coñecer os motivos para mercar ou non un produto ecolóxico serve para establecer estratexias de mercado adecuadas. En xeral os consumidores teñen unha boa opinión sobre os alimentos ecolóxicos, facendo especial énfase na saúde e na calidade dos alimentos, e secundariamente na protección do medio ambiente; a maior parte dos autores consultados atopan resultados similares (Idda et al., 2008; Sirieix et al., 2011; Marangoz et al., 2014; Mauleón, 2014; Generalitat de Catalunya, 2015; Ueasangkomsate and Santiteerakul, 2016; Baer-nawrocka and Szalaty, 2017). En canto ás razóns para non consumir ecolóxico destaca o elevado prezo destes produtos, seguido da falta de hábito e a desconfianza cara a etiquetaxe; estudos previos mostran tamén resultados similares (Dupupet et al., 2010; Sirieix et al., 2011; Mauleón, 2014; Puelles-Gallo et al., 2014; Generalitat de Catalunya, 2015). Pivato et al. (2008) tamén fixeron mención á falta de confianza dos consumidores na etiquetaxe, este escepticismo desaparece cando aos consumidores se lles aportan probas que lles permitan monitorizar a orixe e verificar que se cumpriron os estándares requiridos (Perrini et al., 2010). A desconfianza dos consumidores cara aos produtos vendidos como ecolóxicos fai necesario o desenvolvemento de sistemas de autenticación coma os elaborados nos derradeiros capítulos da presente Tese de Doutoramento.

O concepto de alimento ecolóxico aínda leva a confusións entre os consumidores que non teñen claros os requisitos que estes alimentos deben cumprir (Hughner et al., 2007; Briz and Ward, 2009; Generalitat de Catalunya, 2015). Son os consumidores de produtos ecolóxicos quen mellor definen o concepto de alimentos ecolóxicos e aínda así só o fai moi ben un 3,5%. Á vista destes resultados sería interesante levar a cabo programas de formación e educación sobre o sistema ecolóxico, pois o grao de coñecemento influencia a vontade de mercar (Mauleón, 2014). En Galiza, os consumidores de ecolóxico mercan en maior porcentaxe vexetais, tomates, froita e ovos, de feito estudos realizados anteriormente en Europa manifestan que é habitual que os consumidores comecen a consumir ecolóxico comprando vexetais e froita e a continuación ovos (Chinnici et al., 2002; Krystallis and Chryssochoidis, 2005; MAGRAMA, 2014; Mauleón, 2014; Generalitat de Catalunya, 2015).

Respecto á percepción que os consumidores teñen sobre as diferenzas entre os alimentos ecolóxicos e convencionais, observouse que tanto as persoas que consomen ecolóxico como aquelas que consomen alimentos amigables co medio ambiente teñen percepcións similares, e encontran que ambos alimentos son bastante diferentes entre si. Polo contrario, as persoas que consomen alimentos convencionais manifestan non encontrar diferenzas nunha proporción máis elevada. Mauleón (2014) achaca que a percepción que as persoas teñen dos alimentos ecolóxicos depende en grande medida da frecuencia con que consomen estes alimentos, sendo os consumidores de ecolóxico os que teñen unha opinión máis positiva. Aínda cando as persoas podan percibir a diferenza entre ambos produtos o poder adquisitivo das mesmas pode condicionar a vontade de compra, por iso é interesante estudar ata que punto están dispostos a pagar a diferenza de prezo que soe existir entre ecolóxico e convencional (Nielsen, 2010). A maior parte dos consumidores de ecolóxico manifestan que estarían dispostos a pagar entre un 10 e un 30% de diferenza por consumir produtos ecolóxicos, mentres que os consumidores de produtos amigables co medio ambiente están entre nada e o 30% e máis dun 30% dos convencionais manifestan non estar dispostos a pagar ningún tipo de incremento. A maioría dos estudos sobre vontade do consumidor a pagar polos alimentos ecolóxicos concordan cos nosos resultados, observando unha maior vontade a pagar por vexetais e froitas ecolóxicas (Krystallis and Chryssochoidis, 2005; MAGRAMA, 2007; Menon, 2008; Urena et al., 2008; Asadi et al., 2009). Destes resultados despréndese que o prezo continua a ser unha barreira (Nielsen, 2010; Generalitat de Catalunya, 2015), polo que debería tentar reducirse a grande franxa de diferenza existente de cara a atraer máis consumidores a mercar alimentos ecolóxicos. Por outro lado, cómpre remarcar unha vez máis que canta máis información se lle proporcione ao consumidor máis diñeiro está disposto a gastar xa que o feito de saber o motivo do incremento de prezo réstalle importancia ao mesmo (Nielsen, 2010; Puelles-Gallo et al., 2014). Outro aspecto que pode influír na intención de compra é a aparencia externa dos produtos, que no caso de ecolóxico tenden a presentar pequenos defectos ou falta de uniformidade que non afectan á calidade pero poden ser motivo de rexeitamento (Albardíaz-Segador, 2000). As persoas que mercan produtos convencionais danlle máis importancia ao aspecto externo dos alimentos e polo tanto responden con máis frecuencia que non comprarían produtos con defectos estéticos que os consumidores de ecolóxico e amigable co medio ambiente, o rexeitamento por problemas estéticos xa foi estudado por outros autores (Albardíaz-Segador, 2000; Bhatta et al., 2008) que encontraron resultados similares.

O ecoturismo pode aportar un beneficio engadido na gandería ecolóxica, sobre todo nas granxas máis pequenas, os gandeiros que rexentan este tipo de negocio están preocupados polo valor que o consumidor poda darlle ao emprego das razas tradicionais. Por iso para finalizar estudouse a opinión e a vontade de pagar dos consumidores, pola utilización de razas tradicionais en establecementos de ecoturismo e granxas escola. Tanto os consumidores de produtos ecolóxicos como de produtos amigables co medio ambiente mostraron un importante interese pola protección das razas. Este interese polas razas locais xa fora mencionado con anterioridade por outros autores (Albardíaz-Segador, 2000; Weinrich et al., 2014), estando xustificado por razóns culturais como unha evocación do pasado e unha protección das tradicións (Cicia et al., 2006). Actualmente, moitas razas locais atópanse en perigo de extinción (Tienhaara et al., 2015), estas razas menos produtivas representan un importante recurso de material xenético (Medugorac et al., 2009), o feito de que moitos consumidores valoren positivamente a seu uso e estean dispostos a pagar un incremento de prezo fai que os establecementos de ecoturismo se podan converter en lugares de preservación do patrimonio xenético das razas. Convén salientar que todos os tipos de consumidor valoran moi positivamente o uso de razas tradicionais en granxas escolas estando dispostos a pagar para que os nenos adquiran coñecemento sobre as mesmas.

Autenticación dos produtos ecolóxicos

En relación coa falta de confianza dos consumidores cos produtos que se venden baixo a etiquetaxe ecolóxica realizáronse dous estudos sobre autenticación do sistema ecolóxico e os seus produtos, utilizando mostras de sangue (soro) e leite, respectivamente. As mostras proceden de granxas ecolóxicas e convencionais do norte de España.

Para que o consumidor confíe na autenticidade dos produtos convén aportarlle ferramentas que permitan manter a trazabilidade do produto e determinar que foi producido baixo os estándares de ecolóxico. A autenticación das mostras de leite e sangue realizouse medindo a concentración elementos esenciais e tóxicos. No caso do leite as concentración de cobalto, cobre, selenio, zinc, e particularmente iodo e cromo foron máis altas nas mostras dos sistemas convencionais que nos ecolóxicos. En xeral a información acerca dos minerais traza no leite é escasa, aínda que certos autores (Rey-Crespo et al., 2013; Schwendel et al., 2015; Bath and Rayman, 2016; Srednicka-Tober et al., 2016) teñen manifestado que o leite ecolóxico contén menores cantidades de selenio e iodo que o convencional. Na mesma rexión onde se desenvolveron os estudos incluídos nesta Tese de Doutoramento, Rey-Crespo et al. (2013) encontraron tamén menores concentracións de cobre e zinc no leite ecolóxico, de feito un estudo quimiométrico recente nesta mesma zona mostra que as maiores concentracións de selenio e iodo en convencional están asociadas ao manexo mentres que o cromo, cobre e zinc se deben ao mineral aportado no concentrado (López-Alonso et al., 2017). Para comprender porque o selenio e o iodo son máis altos no leite convencional, convén saber que o selenio se utiliza habitualmente nas explotacións intensivas para previr alteracións reprodutivas (López-Alonso et al., 2016) e o iodo como desinfectante do ubre (Rey-Crespo etal., 2013). Polo contrario, no leite ecolóxico encóntranse maiores concentracións de ferro e metais como o arsénico (Rey-Crespo et al., 2013), o estudo quimiométrico asocia a súa orixe ao consumo de solo durante o pastoreo (López-Alonso et al., 2017). A pesar das diferenzas no contido mineral entre ambos tipos de leite, os modelos construídos (diagramas de caixa) para cada variable individual mostraron unha superposición para todos os elementos. Polo tanto ningunha variable foi capaz de discriminar entre leite ecolóxico e convencional, polo que se usou unha análise multivariante para avaliar se o conxunto de todas as variables contiña suficiente información para desenvolver un sistema de clasificación do leite.

Realizouse un estudo quimiométrico: análise de compoñentes principais (PCA) e análise de cluster (HCA) cunha matriz X_{98x11}. A PCA é unha técnica quimiométrica que se usa a modo de avaliación multidimensional preliminar da base de datos, reducindo a base de datos á mínima dimensión sen perder información útil. A avaliación das puntuacións no espazo tridimensional mostra unha separación natural entre as mostras de ecolóxico e convencional, porén existe unha pequena superposición entre ambas categorías. A segunda técnica quimiométrica utilizada foi a HCA que normalmente se usa para buscar grupos naturais de mostras ou variables en base á súa distancia no espazo multidimensional, o gráfico resultante presentouse en forma de dendrograma. Identificáronse dous clusters principais: A e B; a maioría das mostras ecolóxicas incluíronse no cluster B, mentres que a maioría das mostras convencionais se incluíron no cluster A. Isto confirma a conclusión obtida pola técnica PCA, as mostras ecolóxicas e convencionais atópanse en áreas separadas no espazo multidimensional. Porén, o cluster que inclúe as mostras de leite ecolóxico tamén incluíu algunha mostra de leite convencional, isto revela un certo grao de superposición das dúas clases. Neste estudo obtívose un resultado similar ao encontrado ao comparar o estatus mineral das vacas de leite dos sistemas ecolóxicos e convencionais no norte de España (López-Alonso et al., 2017). O contido mineral está moi influenciado polas prácticas de manexo, isto pode explicar a superposición encontrada polo modelo, xa que as mostras convencionais incluídas dentro do cluster ecolóxico correspóndense con animais alimentados con dietas de baixos insumos (elevado pastoreo e baixa suplementación de concentrados). Os resultados son similares aos encontrados ao utilizar os contidos de ácidos graxos para diferenciar o leite ecolóxico do convencional (Schewendel et al., 2015).

En relación aos clusters do HCA, o primeiro componse dos elementos traza esenciais que forman parte dos suplementos minerais do concentrado. O segundo grupo inclúe os elementos asociados ao solo, inxeridos durante o pastoreo. A asociación cos elementos relacionados coa suplementación mineral foi máis forte nas mostras convencionais que nas ecolóxicas, isto é un resultado esperado porque a suplementación mineral é unha práctica habitual na gandería convencional mentres que só unha pequena proporción de granxas ecolóxicas usan suplementos minerais. Por outro lado, as asociacións cos minerais presentes no solo foi máis forte en ecolóxico como era esperado xa que a intensidade de pastoreo é maior nas granxas ecolóxicas. Tendo en conta estes resultados o seguinte paso foi desenvolver un modelo matemático de clasificación por recoñecemento de patróns para autenticar a orixe de mostras de leite de orixe descoñecida. Neste estudo aplicáronse tres técnicas de clasificación diferentes: unha análise de discriminación lineal (LDA), un modelo independente por analoxía de clase (SIMCA) e unha rede neuronal prealimentada (MLF-ANN). O LDA actúa buscando os límites lineais óptimos entre as clases nun espazo n-dimensional (Varmuza and Filzmoser, 2009), as mostras clasificáronse en función da súa posición en relación coa función discriminante. O modelo establecido para o LDA predixo correctamente máis do 97% das mostras ecolóxicas; porén o éxito foi moito menor para as mostras convencionais (78%). Polo tanto aínda que o procedemento pode verificar a autenticidade das mostras ecolóxicas algunhas mostras convencionais tamén se identifican como ecolóxicas. Estes resultados concordan co encontrado no HCA, só un pequeno número de mostras ecolóxicas se clasifican dentro do cluster convencional mentres que un número maior de mostras convencionais se clasifican erroneamente como ecolóxicas, estas mostras proceden de sistemas de baixos insumos, e polo tanto teñen un perfil de elementos traza máis similar ás granxas ecolóxicas que ás convencionais que reciben grandes cantidades de suplemento mineral no concentrado, de xeito que as vacas procedentes de granxas convencionais en pastoreo están máis influídas polos elementos procedentes do solo que polos do suplemento mineral.

A técnica SIMCA establece modelos para cada clase en base a un número de compoñentes principais seleccionadas, de tal xeito que as mostras coñecidas incluiranse nunha clase particular se están dentro do modelo desa clase, o funcionamento de cada modelo construído avalíase en termos de sensibilidade e especificidade. A sensibilidade do modelo para a clase ecolóxica representa a proporción de mostras ecolóxicas auténticas que o modelo recoñeceu como pertencentes a esa clase. A especificidade do modelo para a categoría ecolóxica representa a proporción de mostras convencionais que o modelo non clasifica como ecolóxicas. O SIMCA construíu un modelo moi sensible (97,34%) para a clase ecolóxica, pero menos específico (71,19%), porque o modelo para mostras ecolóxicas tamén inclúe algunhas mostras convencionais.

A técnica MLF-ANN é un patrón de recoñecemento con moita potencia. A predición que fixo esta técnica é consecuente coa categoría da mostra, predicindo correctamente o 94,87% e 93,22% para as categorías ecolóxico e convencional, respectivamente. Esta técnica obtivo máis éxito que as outras debido á súa capacidade para dilucidar a complexa distribución das mostras nun espazo multidimensional onde forman grupos e subgrupos. Polo tanto estes resultados poden usarse para establecer un sistema de clasificación que distinga as mostras de leite ecolóxico e convencional en base ao seu contido mineral medido utilizando técnicas de espectroscopia de emisión. Este método permite a clasificación das mostras dun xeito correcto cun erro dun 5%.

Noutros casos non é suficiente con acreditar a pertenza ecolóxica do leite senón que se fai necesario autenticar o sistema de produción dos animais seguindo os estándares da normativa ecolóxica. O ideal sería poder facelo a partir dunha mostra non letal, de fácil recollida no animal vivo e que nos permitira facer unha trazabilidade do sistema de produción e polo tanto, indirectamente dos produtos derivados deses animais. Polo tanto, propoñemos a posibilidade de facelo a partir dunha mostra de sangue (soro).

Nun estudo previo no que se avaliou o perfil mineral do sangue en animais procedentes de granxas ecolóxicas e convencionais observouse que a matriz de datos revelaba unha separación natural entre animais criados en ecolóxico e animais de granxas convencionais (López-Alonso et al., 2017). A partir de aquí planeamos desenvolver un modelo matemático de clasificación por recoñecemento de patróns para estudar a posibilidade de distinguir entre ambos tipos de mostras en base ao contido mineral (esenciais e tóxicos) no sangue nunha ampla matriz de datos $X_{522\times14}$. A primeira técnica utilizada foi o SIMCA, que para a categoría ecolóxica inclúe a maioría das mostras ecolóxicas pero tamén un amplo número de convencionais. Aínda que presenta unha sensibilidade do 90%, o feito de que a especificidade sexa do 25% limita o seu uso.

Á vista de que a técnica SIMCA non funcionou decidiuse probar outro tipo de patróns. En todos os procedementos de clasificación aplicados se observou que a porcentaxe de predicións correctas foi lixeiramente mellor para a categoría ecolóxica que para a convencional. Isto pódese explicar polo feito de que algúns gandeiros convencionais aplican o mesmo manexo nutricional que os ecolóxicos, realizando fundamentalmente pastoreo con baixo nivel de suplementación de minerais na dieta (Orjales et al., 2018b).

Realizáronse trece modelos matemáticos ou redes neuronais artificiais de clasificación por recoñecemento de patróns, e identificáronse tres grupos, o primeiro grupo de técnicas inclúe técnicas simples (Naive Bayes, PLR (Penalized Logistic Regression) e KNN (k-nearest Neighbours)) que debido á complexidade da clasificación non aportaron resultados satisfactorios (75-85%). O segundo grupo de algoritmos (ELM (Extreme Learning Machine), PLS (Partial Least Squares), SVM (Support Vector Machines), MARS (Multivariate Adaptative Regression Splines), LDA (Linear Discriminant Analysis), SDA (Shrinkage Discrimant Analysis), FDA (Flexible Discriminant Analysis)) melloraron as taxas de clasificación correcta (80-86%). Por último o terceiro grupo (Random Forest, Adaboost e C5.0) conseguiu os mellores resultados (90%). Random Forest e Adaboost son procedementos baseados en estratexias conxuntas, usando algoritmos múltiples que aportan unha mellor eficiencia preditiva (Rokach, 2010). Estes algoritmos empregan unhas árbores decisivas como aprendices de base, e demostraron unha habilidade excelente para desenvolver unha boa clasificación e unhas regras ben adaptadas con aceptables taxas de predición. A C5.0 emprega árbores de decisión cunha estratexia similar ao Random Forest e AdaBoost e aportou tamén moi bos resultados. Dentro destes sistemas o modelo desenvolto usando AdaBoost é capaz de asignar cada vaca á súa categoría cunha precisión do 90%, este algoritmo parece ser o máis apropiado para usar como base do modelo para desenvolver unha clasificación mellorada.

Finalmente, fíxose unha análise ROC (do inglés Receiver Operating Characteristic, ou Característica Operativa do Receptor) para explorar a importancia relativa das variables orixinais (Beyene et al., 2009). A análise foi feita cos modelos que funcionaron mellor: Random Forest, C5.0 e AdaBoost. Os tres modelos obtiveron resultados similares para a maioría das variables. O cadmio é a variable con maior influencia nos tres modelos, seguido do molibdeno e o selenio. De feito, o cadmio é o metal tóxico máis relevante en gandería ecolóxica (Lindén et al., 2001) e o selenio é o elemento traza que se usa con maior frecuencia nos tratamentos veterinarios en convencional para manter a eficiencia reprodutiva (Tufarelli and Laudadio, 2011). Por último, o metabolismo do molibdeno é extremadamente importante nos ruminantes porque as concentracións de molibdeno na dieta determinan o grao de requirimentos de cobre (Suttle, 2010). No norte de España, as altas concentracións de molibdeno nas forraxes, xunto coa falta de suplementación de cobre no concentrado asociáronse con deficiencias de cobre en ecolóxico (Orjales et al., 2018b).

CONCLUSIONS

CONCLUSIONS

I. Organic dairy farming is very heterogeneous, and there is no single type of cow that will be suitable for all scenarios. Because of the legislation associated with organic farming and the high dependence on the environment, organic farmers generally demand robust cows. Analysis of the available data indicates that (i) there is no single alternative breed as there are advantages and disadvantages associated with all, and (ii) the strong genotype x environment interactions demand different strategies to deal with very diverse situations. For example, farms producing milk for payment systems that recompense volume would obtain benefits from high milk yielding cows, i.e. rustic Holstein-Friesian could be best option. On the other hand, farms producing milk either for systems that recompense milk solids or for transformation into dairy products would benefit from using pure-bred cows other than Holstein-Friesian or cross-breeds. Finally, organic farmers who focus on rural tourism, farm schools, or other businesses where marketing strategies must be taken into account, could benefit from using local breeds (when possible) or any other rustic breed valued by costumers.

II. Milk performance of organic dairy farms in North Spain, by comparing Holstein-Friesian cows from different production systems and, within the same organic farm, with other breeds and their crosses, did not show a lack of adaptation of Holstein-Friesian cows to the organic conditions. In organic farms Holstein-Friesian cows produce slightly less milk than in pasture-based conventional farms, but milk was similar in nutritional composition and for somatic cell counts. The data from organic farms indicate that Holstein-Friesian cows produce more milk than other breeds and crosses but with statistically lower protein content. Considering that in Spain organic milk production is mostly applied to liquid milk consumption and that the payment system is only based on milk volume, Holstein-Friesian cows would better fit the farmer interests than other breeds or crosses. Other advantages of using Holstein-Friesian in organic dairy farming are more available information and fewer difficulties to find replacement heifers compared with other breeds.

III. Comparison of the reproductive performance of organically reared Hosltein-Friesian cows with that of their counterparts in pasture-based and zero-grazing conventional systems and of other organically reared breeds and crosses allows us to demonstrate that it is not the organic system that constrains the Holstein-Friesian reproductive performance, but that the breed itself has less marked estrus expression than other breeds. Comparison of the reproductive performance of organically reared Holstein-Friesian cows with that of their counterparts in pasture-based and zero-grazing conventional systems and of other organically reared breeds and crosses allows us to demonstrate that it is not the organic system that constrains the Holstein-Friesian reproductive performance, but that the breed itself has less marked estrus expression than other breeds. If farmers are satisfied with the other aspects of the dairy production of their Holstein-Friesian cows the less obvious estrus manifestation could be counteracted by including reproductive performance traits both in the breeding goal and in the selection criteria, as well as with improved estrus detection management. However, not all farmers may be interested in the effort involved in estrus detection of the Holstein-Friesian cow. In this case, the use of more rustic breeds may be a good solution, particularly when the milk yield is not the main objective.

IV. According to analysis of the traits considered in this study, the Holstein-Friesian breed seems to suit the organic production system in Northern Spain. Although the reproductive performance of the cross-breeds and Brown Swiss was, the Holstein-Friesian cows produced more milk and lived longer. Calving type and calving ease did not differ between the breed groups. The higher milk fat and protein yields in the cross-breeds may be useful traits for farmers interested in milk transformation. The advantage of continuing to use Holstein-Friesian cattle is that it is the predominant breed worldwide and the genealogy is well documented. The priority is now to search for well adapted bulls and to elaborate a genetic merit index for organic and pasture-based systems with the aim of predicting and minimizing genotype x environment interactions.

V. The survey findings indicate that approximately one third of respondents consume organic food. The typical profile of an organic consumer is a middle-aged, medium-high class, university-education woman, who lives in a large village, shops in supermarkets and preferably consumes vegetables, fruit and eggs. Interestingly, a large number of people who declared that they were organic consumers confused organic with home and locally produced food. This indicates the potential for growth of the organic sector if such consumers are provided appropriate information. Most consumers have a favourable opinion of organic food, highlighting that it is better for health, is of better quality and does not contain pesticide residues. However, price continues to be a barrier to increased consumption; most consumers say that they would consume more organic food if the price was closer (only 10-30% higher) to that of the equivalent conventional products. Finally, organic consumers in North Spain have a positive attitude towards using local breeds in organic agriculture, for both food production and for ecotourism and educational activities, which could contribute to conserving breed biodiversity and adding value to organic farming.

VI. The concentration of 11 selected mineral elements in milk samples from organic and conventional farms were successfully used to develop a system for distinguishing the two types of milk in northern Spain. The classification model developed using and optimized multilayer feed forward artificial neural network correctly assigned the samples to the type of production system with an error of around 5%; the results of the different chemometric techniques used in this study seem to indicate that misclassified milk samples correspond mainly to conventional milk samples from low input conventional farms (high grazing with low level of supplemented feed) that have a nutritional management closer to the organic farms than the intensively managed conventional. Our findings are very important for the organic dairy sector as no analytical method is yet available for distinguishing organic from conventionally produced milk and authenticating the product status. However, it must be considered that the trace element composition of milk, particularly in organic farming, is highly dependent on the geographical conditions and management.

VII. A chemometric authentication system that uses serum mineral concentrations to verify, at the farm level, that organically reared animals have been fed following the standards of organic production was developed. The combination of the chemical information obtained from multi-element ICP analysis of single serum samples and a supervised pattern recognition classification model, developed using ensemble strategies (such as AdaBoost), yielded a predictive hit rate close to 90% for both the organic and non-organic classes. To our knowledge, this is the first study in which organic and non-organic cattle have been differentiated through 'in vivo' analysis. This approach could help producers, consumers and regulatory bodies to verify that organically reared animals have been fed following organic standards at the farm level and also to evaluate the provenance of the product, to comply with current European legislation.

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ANEXOS

ANEXOS

Tras o desenvolvemento dun proxecto de investigación é fundamental que os resultados do mesmo teñan unha repercusión no sector que se estudou. É por iso, que unha vez obtidos os resultados finais do Proxecto VALECO se realizaron novamente visitas ás granxas mostreadas coa finalidade de entregar os resultados obtidos en cada unha delas, así como, discutir os resultados e asesorar os gandeiros na introdución de cambios e medidas de manexo coa finalidade de mellorar neste caso o sector da gandería de leite en ecolóxico e permitir un avance no sector. A maiores das visitas ás granxas, tamén se realizaron xornadas informativas ás que se convidou a asistir aos gandeiros participantes, ademais de membros do sector e especialistas. Durante estas xornadas mostráronse os resultados finais do proxecto VALECO e creouse un foro de debate sobre os avances, os problemas fundamentais, as posibles solucións e as tendencias de futuro no sector ecolóxico.

Neste apartado introdúcense a modo de exemplo algunhas fichas técnicas individualizadas que se realizaron para cada unha das granxas.

FICHA TÉCNICA RAZAS

GRANXA 11

AS RAZAS NOS SISTEMAS DE LEITE ECOLÓXICO DO NORTE DE ESPAÑA

A **selección de animais** é un punto importante no vacún de leite que ten unha maior relevancia nas granxas ecolóxicas debido ás condicións especiais deste tipo de produción. Por este motivo a elección dunha **raza adecuada** nos sistemas ecolóxicos ten especial interese. No Norte de España a **diversidade racial é limitada**, máis do 82% das vacas son de raza Frisoa.

EXISTEN DIFERENZAS PRODUTIVAS ENTRE RAZAS?

O gando vacún compórtase dunha forma diferente en función da raza e do sistema produtivo. No caso das vacas en ecolóxico no norte de España, as Frisoas tenderon a producir máis leite que o resto de razas puras europeas e cruces destas con Frisón, pero cun menor contido en proteína. Só as Pardas Alpinas e os seus cruces destacaron na produción de graxa. En canto aos recontos de células somáticas non se observaron diferenzas entre razas.

QUE COMPOSICIÓN RACIAL TEN A SÚA GRANXA?

A súa granxa, como se pode observar na táboa, presenta unha composición racial semellante á da media das granxas ecolóxicas do Norte de España, cun claro predominio da raza Frisoa.

	Frisón	Cruces	*Razas puras europeas*	*Razas puras españolas*
GRANXA 11	82,5%	17,5%	0%	0%
NORTE DE ESPAÑA	82,3%	11,0%	5,9%	0,8%

Unha vez analizados os datos do control leiteiro para a súa granxa observamos que os cruces de Frisón con outras razas producían sempre máis proteína que os animais Frisóns puros. Non observamos diferenzas significativas para a produción de graxa, o reconto de células somáticas e a produción de leite, aínda que as Frisoas tenderon a producir máis leite.

COMO POIDO MELLORAR?

Tendo en conta que dentro das granxas ecolóxicas, Granxa 11 se dedica á **venda directa** de leite sen facer transformación, e que actualmente o **pago de leite** se realiza fundamentalmente en función do **volume** vendido e non tanto da composición do leite entregado, recomendámoslle que continúe producindo con gando Frisón. Porén, sería recomendable que dentro do **Frisón** elixa unha **liña rústica** que se adapte ben ás condicións da gandería ecolóxica.

No caso de que nalgún momento decida transformar o leite para a venda de derivados lácteos (queixo, iogur, ...) sería recomendable a introdución de razas rústicas ou cruces de Frisón coas mesmas.

FICHA TÉCNICA RAZAS

GRANXA 20

AS RAZAS NOS SISTEMAS DE LEITE ECOLÓXICO DO NORTE DE ESPAÑA

A **selección de animais** é un punto importante no vacún de leite que ten unha maior relevancia nas granxas ecolóxicas debido ás condicións especiais deste tipo de produción. Por este motivo a elección dunha **raza adecuada** nos sistemas ecolóxicos ten especial interese. No Norte de España a **diversidade racial é limitada**, máis do 82% das vacas son de raza Frisoa.

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O gando vacún compórtase dunha forma diferente en función da raza e do sistema produtivo. No caso das vacas en ecolóxico no norte de España, as Frisoas tenderon a producir máis leite que o resto de razas puras europeas e cruces destas con Frisón, pero cun menor contido en proteína. Só as Pardas Alpinas e os seus cruces destacaron na produción de graxa. En canto aos recontos de células somáticas non se observaron diferenzas entre razas.

QUE COMPOSICIÓN RACIAL TEN A SÚA GRANXA?

A súa granxa, como se pode observar na táboa, presenta unha composición racial moi diferente á habitual nas granxas ecolóxicas do norte de España, cun maior predominio dos animais cruzados e de raza pura Parda Alpina.

	Frisón	Cruces	*Razas puras europeas*	*Razas puras españolas*
GRANXA 20	1,9%	44,4%	53,7%	0%
NORTE DE ESPAÑA	82,3%	11,0%	5,9%	0,8%

Unha vez analizados os datos do control leiteiro para a súa granxa observamos que as vacas de raza Parda Alpina e os seus cruces estaban a producir unha menor cantidade de leite, porén o contido en proteína e graxa é sempre maior nos cruces e vacas Pardas Alpinas que nas Frisoas. Non atopamos diferenzas significativas para os recontos de células somáticas.

COMO POIDO MELLORAR?

Dentro das granxas ecolóxicas poderíamos clasificar Granxa 20 como unha **granxa multifuncional**, pois non só está destinada á produción de leite senón que parte dese leite se transforma noutro tipo de produtos para a súa venda. Granxa 20 tamén está dedicada ao sector turístico co valor engadido que pode aportar neste aspecto a produción con razas rústicas. No seu caso, recomendámoslle **continuar producindo con animais de raza Parda Alpina e os seus cruces**.

Na actualidade a gandería ecolóxica é un sistema de produción en crecemento onde os gandeiros continúan a usar os animais herdados de convencional aínda que non están satisfeitos. Por iso convén estudar a eficiencia produtiva e reprodutiva e as características funcionais de diferentes razas puras e cruces de cara a buscar cal se adapta mellor aos sistemas ecolóxicos. A opinión do consumidor tamén é fundamental no mercado ecolóxico, por iso é importante tanto coñecer a fondo o perfil de consumidor como ter en conta as súas demandas para seguir a trazabilidade dos alimentos ecolóxicos. A quimiometría en base ás diferenzas na composición mineral entre ecolóxico e convencional pode ser de axuda para autenticar a orixe ecolóxica.