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Il benessere del suino pesante italiano: esperienze di ricerca in allevamento, durante il trasporto e nella percezione dei consumatori

Presentata da: Dott.ssa Giulia Rubini

Coordinatore Dottorato **Supervisore**

Chiar.ma Carolina Castagnetti **Chiar.ma Eleonora Nannoni**

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Introduzione

1.1 Il benessere animale

Il concetto di benessere animale è noto come si sia evoluto nel corso del tempo.
Una definizione semplicistica di benessere animale potrebbe essere "come si sente l'animale in un momento specifico".
Tale definizione permette di includere al suo interno un ampio range di parametri da rilevare.
Il concetto di benessere si esplica quindi attraverso numerose forme, sia per quanto riguarda la sua definizione, che indubbiamente ad oggi non può essere univoca, sia per quanto riguarda i metodi di valutazione.
Storicamente, il Brambell Report (1965), mettendo nero su bianco le cinque libertà ha permesso di porre le fondamenta di ciò che ha guidato nei decenni successivi la ricerca e le normative a protezione degli animali, comunitarie e nazionali, ponendo l'attenzione su aspetti fondamentali riguardo la tutela del benessere animale nelle varie fasi di allevamento, trasporto e macellazione.
È ampiamente riconosciuto da molti anni che una relazione positiva uomo-animale è benefica non solo per il benessere degli animali da allevamento ma anche per la produttività e la qualità dei prodotti animali.
La tutela del benessere viene perseguita quindi sia per fini etici che produttivi.

1.1.1 Benessere: storia ed evoluzione di una scienza

L'attuale tendenza legislativa a richiedere un sempre più stringente rispetto del "Benessere Animale" è in armonia con le richieste dei consumatori, soprattutto in considerazione del fatto che questa tendenza ha l'ulteriore obiettivo di ottenere alimenti con più elevate caratteristiche di qualità, di salubrità e di sicurezza.

Negli ultimi decenni sta aumentando la sensibilità dell'opinione pubblica nei confronti del benessere animale, e la nascita dei movimenti per i diritti degli animali nei paesi occidentali costituisce un chiaro segnale dell'accresciuta attenzione verso questa tematica.

Nonostante ciò, continuano ad essere presenti due principali problematiche riguardo il benessere animale, una riguarda la definizione maggiormente rappresentativa del concetto stesso, e la seconda concerne la ricerca di indicatori il più possibile attendibili per la sua valutazione.

Negli ultimi cinquant'anni, a seconda che venisse posta più enfasi sulla capacità dell'animale di adattarsi all'ambiente (Broom 1986; Fraser et al. 1990), la qualità della vita vissuta e valutata dall'animale (Sumner 1996) o gli stati mentali positivi e negativi [Dawkins et al. 1988; Dunkan et al. 1991; Sandøe et al. 1996), sono state proposte una varietà di definizioni del benessere animale.

La prima definizione di benessere animale risale al 1976, anno in cui Hughes lo definisce come "uno stato di salute completa, sia fisica che mentale, stato in cui l'animale è in armonia con l'ambiente circostante".

Come anticipato, nel 1965 il Brambell Report enunciava le 5 libertà necessarie all'animale per vivere in uno stato di benessere, modificate successivamente nel 1979, che da allora costituiscono la filosofia di base del Farm Animal Welfare Council (1993).

Esse infatti individuano gli elementi essenziali a determinare un buono stato di benessere e definiscono le disposizioni necessarie per promuovere tale stato.

1. Libertà dalla Fame e dalla Sete - fornendo accesso ad acqua fresca e ad una dieta che garantisca piena salute e vigore.
2. Libertà dal Disagio – fornendo un ambiente di vita appropriato, inclusi ripari e aree di riposo confortevoli.
3. Libertà da Dolore, Ferite o Malattie – attraverso la prevenzione o la rapida diagnosi e trattamento.
4. Libertà di Esprimere un Comportamento Normale – fornendo sufficiente spazio, strutture adeguate e la compagnia di altri animali della stessa specie.
5. Libertà dalla Paura e dal Distress – assicurando condizioni e trattamenti che evitino la sofferenza mentale.

Webster nel 2000 le rivede e riformula ritenendo che uno degli approcci più utili alla scienza del benessere animale sia quello di porre agli animali domande su ciò che conta per loro e quanto importa (Dawkins, 1993).

Combinando questo approccio scientifico alla valutazione dei bisogni degli animali con un corretto riconoscimento e comprensione delle buone pratiche di allevamento è stato

possibile elaborare i primi principi a tutela del benessere per gli animali sia in allevamento, durante il trasporto, o nel luogo della macellazione.

Le Cinque Libertà riguardano sia la forma fisica che la sofferenza mentale, dovrebbero pertanto essere utilizzate come una *check-list* pratica e completa per valutare i punti di forza e di debolezza di qualsiasi sistema di allevamento, e non dovrebbero al contrario essere interpretate per implicare che tutti gli animali dovrebbero essere sempre esenti dall'esposizione a qualsiasi stress.

Il loro scopo non è quello di eliminare lo stress ma di prevenire la sofferenza (e non solo la "sofferenza non necessaria").

La sofferenza può verificarsi quando un animale non riesce a far fronte (o ha difficoltà a far fronte) agli stress: perché lo stress stesso è troppo forte, troppo complesso o troppo prolungato, oppure quando all'animale è impedito di intraprendere qualsiasi azione costruttiva per poter gestire lo stress o allontanarsi dalla situazione.

Un esempio della prima condizione può essere la vacca da latte ad alta produzione, che sperimenta contemporaneamente la motivazione a mangiare per alleviare la sua fame metabolica di nutrienti per sostenere l'allattamento, il disagio di un eccessivo riempimento del rumine e il potente desiderio di sdraiarsi e riposare (Webster, 1995). Un esempio di quest'ultima condizione è anche la scrofa confinata in una gabbia da parto.

Webster svolge un'ulteriore analisi, filosofica ed etica, sul benessere e soprattutto approfondisce la reale importanza che hanno le cinque libertà. Ritiene infatti che la principale attenzione di scienziati, studiosi di benessere animale e legislatori dovrebbe essere rivolta verso quegli elementi che determinano scarso benessere attraverso la perdita della adattabilità o la sofferenza mentale, fenomeni che possono essere collegati direttamente alle caratteristiche intrinseche del sistema produttivo. (Webster Farm Animal Welfare: the Five Freedoms and the Free Market)
Questi includono:

1. Fame o malattia metabolica acuta; attraverso alimentazione e/o metodologie di allevamento impropri. Esempio: la vacca da latte ad alta produzione.
2. Disagio cronico; a causa di un cattivo alloggiamento, ecc. Esempio: maiali su pavimenti in cemento non idonei.
3. Dolore cronico o movimento limitato. Esempi: patologie podali nei broiler e nelle vacche da latte.
4. Aumento delle patologie in azienda; attraverso un'eccessiva esposizione ad agenti

patogeni, inquinanti e/o un'immunità ridotta. Esempio: diarrea post-svezzamento nei suini.

5. Ansia o frustrazione cronica; attraverso alloggi inadatti, personale scarsamente formato o contatti sociali tra animali. Esempi: morsicatura della coda nei maiali? piumaggio nel pollame?
6. Esaurimento metabolico o fisico; a causa di una produttività prolungata ed eccessiva. Esempio: “spent hens”, o galline ovaiole al termine della loro vita produttiva.

Questo elenco di potenziali problemi, elaborato da Webster nel 2000,che possono essere strettamente correlati ai sistemi di produzione si basa in gran parte sulle "Cinque libertà".

I problemi di benessere associati alla perdita della capacità di adattamento vengono ritenuti essere dall’autore più netti e probabilmente più gravi di quelli associati a comportamenti anormali. Inoltre, l’elenco presentato include un ulteriore elemento importante, non incluso nelle Cinque Libertà, ovvero il concetto di esaurimento; animali che possono soffrire non perché vengano uccisi precocemente ma perché non vengono uccisi, venendo allevati per continuare a produrre nonostante appaiano, e si sentano, fisicamente usurati.

Nel 1978 viene stipulata la Convenzione Europea per la Protezione degli animali negli allevamenti, convenzione che si applica agli animali allevati o custoditi per la produzione di prodotti alimentari, lana, pelli, pellicce o altri scopi agricoli, compresi gli animali provenienti da modificazioni genetiche o da nuove combinazioni genetiche.

Essa si rivolge in particolare agli animali che si trovano in sistemi di allevamento intensivo.

L'obiettivo è proteggerli da inutili sofferenze o lesioni, causate delle condizioni di allevamento, alimentazione o cura. Per raggiungere questo obiettivo, la convenzione impone agli Stati firmatari di rispettare determinate regole, in particolare relativamente alle caratteristiche del sito di allevamento (spazio e condizioni ambientali), all'alimentazione e la salute degli animali, e all'organizzazione delle ispezioni degli impianti tecnici nei moderni sistemi di allevamento intensivo.

Nel 1986, Broom definisce il benessere animale come il modo in cui l’organismo attua determinati meccanismi allo scopo di adattarsi all’ambiente circostante, ritenendo il benessere una caratteristica intrinseca dell’animale stesso, e valutandolo attraverso una scala che va da un buon livello di benessere ad uno scarso.

Sempre Broom sostiene che *"gli animali hanno sempre goduto della protezione dell'uomo per la tutela del loro benessere, ma sono cambiate le conoscenze che l'uomo ha acquisito sull'argomento. I concetti umani riguardo a quali azioni debbano essere considerate o meno* morali *probabilmente non sono molto cambiati nei millenni; tuttavia le convinzioni rispetto a quali* individui *meritino di ricevere tali attenzioni morali sono cambiate a seguito dell'incremento delle conoscenze sul funzionamento biologico degli umani e degli altri animali e anche grazie all'aumento delle comunicazioni a livello globale"* (Broom, 2004)

Ad oggi lo studio del benessere animale può anche essere definito come una scienza olistica che prende in considerazione la salute globale, ovvero l'insieme di tutte le condizioni fisiche e psichiche positive per la sussistenza della vita senziente (McInerney, 2004; Regione Emilia Romagna, 2006).

Fraser ha classificato gli approcci scientifici per definire il benessere animale in tre gruppi a seconda che si concentrassero sul funzionamento biologico dell'animale (oggettivo); le emozioni vissute dagli animali o lo stato affettivo (soggettivo); e, infine, se il comportamento o l'ambiente in cui vive l'animale è simile a quello dello stato naturale della specie.

Nonostante le discrepanze, comprensibili trattandosi di un concetto molto complesso e polifattoriale [49], vi sono alcuni punti di consenso. Ad esempio, il fatto che il benessere sia una caratteristica intrinseca dell'animale e non dell'ambiente (Broom et al. 2007) che possa variare nel tempo in modo continuo, e che richieda l'uso di diversi metodi scientificamente coerenti per valutarlo (Bracke et al. 1999) proprio in funzione della multidimensionalità che lo caratterizza (Botreau et al. 2007).

Il Welfare Quality Project (WQ), finanziato dalla Commissione Europea, ha schematizzato 12 criteri per la valutazione del benessere animale, che si rifanno ad una rielaborazione dell'approccio delle Cinque Libertà, che vengono però valutate basandosi, ogni volta che sia possibile, su *animal criteria*.

Infine, nella definizione "A Life Worth Living", il benessere animale viene definito come la qualità di vita negativa o positiva osservata negli animali e dipende da come si sentono in un particolare momento e luogo (Green et al. 2011).

La definizione di benessere animale fornita dall'Organizzazione per la salute animale (OIE) include alcuni dei diversi punti sopra menzionati e considera "come un animale affronta le condizioni in cui vive".

Un animale è in buono stato di benessere se (come indicato da evidenze scientifiche) è sano, a suo agio, ben nutrito, sicuro, in grado di esprimere comportamenti innati e se non soffre di stati spiacevoli come dolore, paura e angoscia Attraverso l'introduzione di questa definizione nel Codice per la salute degli animali terrestri dell'OIE, viene riconosciuta l'importanza e la priorità del benessere degli animali (Cornish et al. 2016) Questo codice è la fonte principale degli standard internazionali sulla salute degli animali e delle raccomandazioni sul benessere degli animali da allevamento (Capitolo 7.1 art. 7.1.3) (Vapnek et al. 2010)

Il problema della mancanza di una definizione globalmente accettata è correlato alla presenza di tre diversi approcci con cui affrontare la valutazione del benessere e di quale sia ritenuta predominante (funzionamento biologico, stato affettivo o vita naturale) (Fraser et al. 2003)

Fraser scrive: “Sarebbe confortante pensare che la scienza potrebbe semplicemente dirimere la questione sostituendo queste diverse visioni del benessere animale con dati oggettivi su ciò che è veramente meglio per gli animali”.

Una solida base scientifica rafforzerebbe il collegamento tra benessere e salute animale e aiuterebbe a sviluppare una legislazione sul benessere animale che possa affrontare le preoccupazioni del pubblico con un approccio scientifico e non essere basata sul buonsenso o sulla tendenza a equiparare sistemi "tradizionali" o pratiche di allevamento "naturali" con il benessere degli animali. Ciò è necessario per sviluppare una relazione forte e dinamica tra mondo scientifico e legislatori.

Al fine di mantenere la legislazione in linea con gli sviluppi scientifici, le principali normative nazionali dovrebbero essere essenziali e semplici, rimandando i requisiti più dettagliati ai regolamenti di attuazione e in altre legislazioni sussidiarie che possono essere più facilmente modificate (Vapnek et al. 2010).

Rendendo ancora più complicata la situazione delle diverse definizioni di benessere animale, che a sua volta potrebbe ostacolare lo sviluppo di una misurazione e una valutazione diretta del benessere animale (Vanhonacker 2014) alcuni documenti affermano che gli standard morali ed etici della società dovrebbero essere considerati perché dei valori imposti ai suoi animali dalla società (Webb 2013).

Tuttavia, lo studio del benessere animale non può essere basato solamente sulla scienza, ma deve considerare anche le differenze nei presupposti etici e i potenziali conflitti nei punti di vista, tutti aspetti che devono essere riconosciuti e discussi Lassen et al.2006;

Sandøe et al 2003)

Il benessere animale non dovrebbe essere inteso come una semplice funzione additiva di stati negativi o positivi (Sandøe et al.2019) e l'esistenza di diversi concetti di natura legati al benessere, culturalmente e storicamente, suggerisce la necessità di ulteriori ricerche (Weary et al. 2019)

1.1.2 Sistemi di valutazione del benessere animale

Il benessere è un concetto multidimensionale e la maggior sfida ad oggi è proprio identificare un metodo di valutazione che sia il più possibile oggettivo.

Storicamente, sia la legislazione che gli schemi di garanzia hanno adottato misure di benessere basate sulle risorse, ma appaiono dei limiti quando si tratta di comprendere il vero stato di benessere dei singoli animali (Webster et al., 2004). Per questo motivo si registra una crescente tendenza all'adozione di misure basate sugli animali, a volte chiamate misure di outcome del benessere, che si basano su misurazioni effettuate direttamente sugli animali stessi.

I parametri per stabilire il livello di benessere degli animali possono essere suddivisi schematicamente in *design criteria* (basati sulla valutazione dell'ambiente in cui vive l'animale e della maniera in cui gli animali vengono allevati, che sono chiamati anche *input* o *engineering criteria*) e *animal criteria* (basati sull'osservazione diretta dell'animale, chiamati anche *output* o *performance criteria*).

Facendo riferimento agli animal criteria alcuni esempi di criteri di questo tipo estrapolati dal sistema di valutazione Welfare Quality sono:

- Assenza di fame prolungata (stato di nutrizione)
- Assenza di ferite
- Assenza di patologie
- Espressione di comportamenti sociali
- Buona relazione uomo animale
- Stato emotivo positivo

Invece i design criteria che comunemente vengono valutati sono:

- lo spazio disponibile,

- la presenza di arricchimenti ambientali,
- il numero e le dimensioni degli abbeveratoi e dei punti di alimentazione.

Dal punto di vista medico-scientifico, la “diagnosi” del livello di benessere di un animale allevato deve necessariamente basarsi sull’analisi di molti fattori connessi con le condizioni di vita dell’animale, il rispetto dei suoi fabbisogni e la sua capacità di adattamento all’ambiente. Tutte queste condizioni devono essere registrate e valutate attraverso specifici indicatori e i risultati devono essere analizzati attraverso un metodo il più possibile obiettivo e scientifico.

In definitiva, la valutazione del benessere animale è un difficile esercizio di astrazione dal consueto e quotidiano approccio sanitario, zootecnico o affettivo che ogni persona può mettere in atto quando a vario titolo si relaziona con gli animali da reddito.(Classy Farm 2021)

È stato osservato però che non sempre esiste un effettivo collegamento tra lo stato di benessere dell’animale e i *criteria*(Fraser, 1995; Blokhuis et al., 2003; de Passillé e Rushen, 2005) che perciò non devono mai essere considerati singolarmente e devono essere valutati criticamente.

Gli standard per il benessere degli animali sono stati incorporati nella legislazione dell’Unione Europea e nei programmi degli allevamenti, basati su informazioni scientifiche e volti a salvaguardare il benessere delle specie interessate. Di recente, l'accento si è spostato dai criteria basati sulle risorse (design *criteria*) alle misure basate sugli animali, che si ritiene valutino in modo più accurato lo stato di benessere. (Pandolfi et al 2017)

I *design criteria* sono più facilmente valutabili, dunque solitamente vengono presi in considerazione nel verificare le condizioni di benessere in allevamento e per stabilire parametri che garantiscano il benessere animale (ad esempio nella legislazione).

In linea teorica, rispettando *design criteria* adeguati dovrebbe essere favorito il raggiungimento di un livello soddisfacente o addirittura elevato di benessere animale. Tuttavia i *design criteria* non tengono conto delle risposte degli animali alle condizioni di allevamento in cui si trovano.

Pertanto, rimane ancora da indagare se esista una effettiva relazione proporzionale tra l’applicazione di *design criteria* rispettosi del benessere e l’effettivo raggiungimento di una condizione di benessere da parte degli animali. Peraltro la loro "oggettività" e quindi scarsa contestabilità (quando siano suffragati da un'adeguata letteratura scientifica) è certamente

un importante fattore a favore della loro utilizzazione nella pratica del controllo delle condizioni degli animali allevati.

Gli *animal criteria* invece comprendono misurazioni di tipo comportamentale, fisiologico e metabolico, nonché la valutazione dell'incidenza delle patologie e dei livelli di produzione, al fine di stabilire più direttamente e in maniera più puntuale lo stato di benessere degli animali. Sicuramente la rilevazione degli *animal criteria* permette una valutazione più accurata del benessere animale (de Passillé e Rushen, 2005).

Inoltre risulta ormai chiaro come una valutazione complessiva corretta e attendibile prenda in considerazione sia i design criteria (parametri ormai universalmente riconosciuti come aspetto fondamentale come lo spazio disponibile) sia gli animal criteria, integrandoli tra loro al fine di ottenere una valutazione il più attendibile possibile.

In generale la ricerca scientifica e l'applicazione pratica della tutela del benessere animale sono indirizzate più all'individuazione e al riscontro di condizioni, parametri, misurazioni indicanti scarso benessere o anche situazioni di malessere piuttosto che di benessere.

Spesso vengono indicati come parametri basilari per la valutazione del benessere lo stato di salute e la produttività (parametri abbastanza facilmente rilevabili, almeno come media di allevamento). Benché questo atteggiamento sia ben basato su meccanismi fisiologici e quindi scientificamente condivisibile, va considerato più valido per determinare se vi sia un grave stato di malessere che non per certificare uno stato di benessere.

Il rispetto del benessere animale, invece, prevede condizioni superiori rispetto al semplice mantenimento di uno stato di buona salute (Duncan, 1996), quindi il livello di benessere animale non può essere derivato unicamente dall'osservazione dell'incidenza delle patologie in allevamento e dallo stato di salute degli animali, perciò se è vero che il rilievo di un aumento dell' incidenza di determinate patologie può indicare uno scarso livello di benessere, al contrario un allevamento che presenta animali sani non univocamente indicherà che tali animali vivano in uno stato di benessere soddisfacente. Non è detto, quindi, che se l'incidenza di patologie è scarsa il livello di benessere degli animali sia elevato (de Passillé e Rushen, 2005).

Lo stesso ragionamento può essere applicato ai livelli di produttività: se un animale è in condizione di benessere, è altamente probabile che produca molto. Tuttavia un'elevata produttività non è di per sé indice di uno stato di pieno benessere: infatti l'animale può essere in grado di mantenere un'elevata produzione, ad esempio di latte, pur essendo al limite delle sue condizioni fisiologiche e dunque verosimilmente ben lontano dal

soddisfacimento del proprio benessere (Farm Sanctuary, 2005).

Webster analizza il problema del benessere animale rilevando come esso si basi su tre filoni distinti ma interdipendenti:

- Una valutazione scientifica dei fattori che contribuiscono allo stato di benessere degli animali da allevamento;
- Una valutazione etica di come e perché dovremmo rispettare il valore intrinseco di questi animali;
- Una valutazione economica dei fattori che determinano il valore estrinseco che effettivamente diamo a questi animali.

L'obiettivo deve essere quello di convertire questi principi in azioni giuste. Non possiamo, ovviamente, garantire il benessere di ogni animale da allevamento; la nostra responsabilità è di garantire adeguate condizioni e verifiche sugli animali affinché esso possa essere raggiunto.

Sebbene l'imperativo morale sia quello di migliorare l'allevamento nel rispetto del valore intrinseco degli animali da allevamento, è, purtroppo, il valore estrinseco dell'animale che determina la qualità dell'allevamento che l'allevatore può permettersi. Inoltre, i requisiti minimi in termini di protezione animale non sono stabiliti dall'agricoltore ma dalla società in generale. Quando la società in generale, attraverso la sua legislazione, consente (ad esempio) l'utilizzo di gabbie modificate per le galline, allora il produttore ha solo due opzioni:

- Ridurre al minimo i costi di produzione per il mercato di massa.
- Produrre (a costo aggiunto) beni di maggior valore per un mercato specializzato; in questo caso uno che attribuisce un valore (estrinseco) superiore agli animali produttori di derrate alimentari. (Webster 2000)

1.1.3 Evoluzione della percezione del benessere animale da parte del consumatore

In molti paesi si può osservare un crescente interesse pubblico per alimenti sostenibili, di alta qualità e sicuri. Per quanto riguarda la produzione animale da allevamento, molti consumatori si aspettano che i processi di produzione alimentare tengano conto di aspetti come il benessere animale e altri attributi sociali ed etici (Boogaard, Oosting, & Bock, 2006; Tonsor, Olynk, & Wolf,2009; Van Loo, Caputo, Nayga, & Verbeke, 2014).

Inoltre, la preoccupazione per i rischi per la salute e per l'ambiente causati dalla

produzione di carne è in aumento a causa degli scandali e delle crisi alimentari negli ultimi decenni (Krystallis, De Barcellos, Kügler, Verbeke e Grunert, 2009).

Ciò ha portato a un crescente interesse nel ruolo che alcune caratteristiche del prodotto (che non possono essere valutate dai consumatori, né prima né dopo l'acquisto, ma devono essere comunicate direttamente dal produttore, vedi Fernqvist & Ekelund, 2014) giocano nella scelta del consumatore, oltre a qualità organolettiche classiche come aspetto e gusto.

Ci si dovrebbe aspettare, ad esempio, che tali preoccupazioni portino i consumatori a prendere in considerazione aspetti del processo di produzione dei suini quando scelgono i prodotti suini, e a essere disposti a pagare prezzi più alti per la carne di maiale prodotta con attenzione ad aspetti etici come il benessere degli animali, gli aspetti sanitari o relativi a sistemi di produzione rispettosi dell'ambiente (Liljenstolpe, 2008).

Sino a ben oltre la metà del secolo scorso, anche quando la questione "benessere animale" aveva cominciato ad interessare il mondo scientifico, la sensibilità della cittadinanza e degli stessi operatori era assai scarsa. All'inizio del secolo attuale, il benessere animale risulta acquistare sempre maggiore importanza per i cittadini europei (Blokhuis et al., 2003). Ad ulteriore evidenza di quanto detto, nel caso delle produzioni zootecniche si assiste ad una importante preoccupazione generale per il benessere degli animali utilizzati per la produzione di carne (Bornett et al., 2003; Frewer et al., 2005).

In sostanza, aumentano i consumatori che ricercano caratteristiche non direttamente tangibili dal prodotto al momento dell'acquisto e tra queste possiamo annoverare ad esempio anche la sostenibilità e il benessere animale.

L'assunzione di una maggiore rilevanza pubblica dell'argomento "benessere animale" è stata rilevata dalle indagini statistiche svolte mediante interviste ai cittadini europei ed anche grazie a queste ricerche si è giunti alla conclusione che il benessere animale è un tema di primaria importanza per i consumatori europei, dunque in definitiva per gli stessi cittadini (EC, 2007a).

L'atteggiamento dei consumatori nei confronti del benessere degli animali differisce tra le diverse parti del mondo e persino all'interno dell'UE (Nocella et al., 2010). In generale, per la maggior parte dei cittadini dell'UE è importante proteggere il benessere degli animali d'allevamento (Commissione Europea, 2016), tuttavia, soprattutto i consumatori dei paesi membri del nord dell'UE sembrano essere più interessati ai problemi di benessere degli animali rispetto ai cittadini del sud o di quelli dei nuovi stati membri (Nocella et al., 2010).

I cittadini tedeschi, ad esempio, valutano con molta attenzione gli aspetti relativi al benessere degli animali; Il 61% dei cittadini ritiene che sia importante tutelare il benessere degli animali da allevamento, al contrario, solo il 34% dei cittadini polacchi è d'accordo con questa affermazione (Commissione europea, 2016). Con un consumo di carne suina pro capite superiore alla media nell'UE, Germania (51,81 kg/capite/anno nel 2013 e 52,4 nel 2015) e Polonia (46,19 kg/capite/anno nel 2013 e 52,3 nel 2015) sono entrambe considerate "heavy users" (FAOSTATS, 2017; Danish Agriculture and Food Council, 2016), ma i paesi differiscono nella loro percezione e valutazione del benessere animale (Commissione Europea, 2016).

Studi come l'Eurobarometro della Commissione Europea misurano atteggiamenti e opinioni e hanno quindi un significato limitato riguardo al comportamento di acquisto reale (Napolitano, Girolami, et al., 2010; Verbeke, 2009), inoltre spesso non consentono di analizzare i dati relativi ai dei diversi segmenti di consumatori.

I compromessi tra i diversi attributi favoriti possono essere analizzati utilizzando esperimenti di scelta (Tonsor et al., 2009). Gli esperimenti di scelta sono ancora una volta ipotetici, a causa del fatto che gli intervistati non devono scambiare denaro reale (Lusk, Roosen e Fox, 2003). Tuttavia, simulano situazioni di acquisto nella vita reale costringendo i consumatori a fare compromessi tra diversi attributi e quindi consentono un'analisi di come i consumatori danno priorità ai loro requisiti (Tonsor et al., 2009). In questo contesto, l'obiettivo di ricerca di questi studi è innanzitutto quello di analizzare quali attributi di produzione relativi all'ambiente, alla salute e al benessere degli animali sono classificati più in alto dai consumatori quando effettuano scelte sugli acquisti di carne suina in Germania e Polonia.

Prickett et al. (2010) hanno affermato che la maggior attenzione e talvolta preoccupazione dei consumatori nei confronti del benessere animale ha comportato un importante cambiamento nella produzione primaria e che quello del benessere è divenuto il più controverso e pubblicizzato argomento nell'ambito dell'agricoltura.

Il progressivo allontanamento dalla realtà rurale e di conseguenza il minor contatto quotidiano con gli animali ha portato a profondi cambiamenti nel rapporto uomo-animale e di conseguenza nella percezione dell'animale in sé. L'apprensione dei consumatori riguardo al benessere animale è multidimensionale, intendendo con ciò che comprende sia preoccupazioni di tipo antropocentrico sia di carattere zoocentrico: timori relativi al livello di benessere degli animali si accompagnano a paure per la salute umana (Blokhuis et al., 2003).

La prima, preoccupazione, che come accennato possiamo definire antropocentrica, trova le sue origini nella sicurezza alimentare, facendo quindi idealmente coincidere un buon livello di benessere animale con il fatto che i prodotti derivati da quegli animali siano ritenuti sicuri dal punto di vista sanitario.

Una ulteriore preoccupazione che attira l'attenzione del consumatore nei confronti di questo tema è invece relativa ad una visione, se così si può dire, zoocentrica: in questo caso il consumatore, attraverso il suo acquisto, chiede che venga salvaguardato il benessere dell'animale da cui è stato ottenuto il prodotto, attribuendo a tale caratteristica una connotazione di per sé positiva, e facendo leva su un concetto etico.

Per questo secondo aspetto, le campagne sostenute dalle associazioni votate alla protezione degli animali hanno presumibilmente veicolato al grande pubblico una maggiore quantità di informazioni circa le condizioni di allevamento, contribuendo così all'ampliamento della platea di consumatori che condividono questa seconda motivazione (Miele e Parisi, 1998).

In "*Consumer Concerns about Animal Welfare and the Impact on Food Choice, Italian Survey Report"* (Miele e Parisi, 2001) viene evidenziato che anche i consumatori italiani si riferiscono molto di rado al benessere animale come preoccupazione etica ("per l'animale") all'atto dell'acquisto o del consumo di un alimento. Quando si riferiscono al benessere o comunque affermano la sua importanza, lo fanno piuttosto come indicatore di altri attributi, come la tutela della salute umana o la qualità organolettica del cibo. A conferma di questo può essere utile citare alcune risposte fornite dagli intervistati. Essi attribuiscono maggiore importanza al fattore "alimentazione dell'animale", rispetto ad altri fattori, nel determinare il benessere ed emettono un giudizio negativo nei confronti dei sistemi di produzione della carne bovina e della carne di vitello, con probabili riferimenti allo scandalo alimentare della BSE.

Anche dalle indagini della Commissione Europea viene rilevato che i consumatori adducono come principale ragione per acquistare un prodotto *animal friendly* la maggiore salubrità e qualità del prodotto (EC, 2007a). Per contro, Martelli (2009) rileva che nonostante i consumatori europei percepiscano i prodotti *animal friendly* come più salubri, più sicuri e di maggiore qualità (EC, 2005a; EC, 2007a) un basso livello di benessere animale viene scarsamente percepito come un rischio alimentare (EC, 2006b).

Dunque analizzando le cause del cambiamento di atteggiamento dei consumatori nei confronti del benessere animale appare confermata la dicotomia tra visione zoocentrica e

antropocentrica. Non sempre però queste due visioni sono distinte: il consumatore potrebbe essere genuinamente interessato al benessere animale senza collegarlo a benefici rivolti a sé stesso, ma contemporaneamente il rispetto del benessere dell'animale potrebbe essere una caratteristica non percepita come positiva di per sé, ma essere positiva perché permette al consumatore di alleviare il suo senso di *discomfort* collegato al consumo di prodotti di origine animale.

Una conferma a questa interpretazione può venire dalla osservazione di Frewer (2005) che il consumo che più sollecita la considerazione di aspetti etici è quello di carne: forse al fine di sollevarsi dal senso di colpa?

È possibile, pertanto, che le persone attribuiscano un valore al benessere animale poiché da esso scaturisce un beneficio percepito, collegato alla consapevolezza che l'animale sia stato trattato in modo adeguato. In caso contrario i consumatori potrebbero percepire un senso di disagio e di *discomfort*.

Questo rende plausibile che il benessere animale sia in realtà un presupposto per il benessere dell'uomo: in sintesi, che il benessere animale sia importante solo perché lo è per il consumatore (McInerney, 2004).

In definitiva, nell'ambito della percezione dei prodotti di origine animale da parte dei consumatori, spesso si potrebbe verificare il fenomeno psicologico della dissonanza cognitiva, fenomeno che si verifica quando un individuo elabora idee antitetiche tra loro o mette in pratica comportamenti contradditori.

All'atto pratico, è verosimile che un consumatore possa essere interessato o preoccupato riguardo al benessere degli animali in allevamento, ma contemporaneamente voglia acquistare dei prodotti di origine animale; nonostante sappia che per ottenere questi prodotti l'animale è stato tenuto in allevamento, in condizioni di vita che egli può ritenere non soddisfacenti.

Ciononostante, alcune persone rispondono alle loro crescenti preoccupazioni per il benessere degli animali mangiando meno carne o diventando vegetariani o addirittura vegani (Vanhonacker et al. 2010). Inoltre, il numero di consumatori che si riforniscono di carne da sistemi di produzione più rispettosi degli animali è aumentato costantemente (Lusk e Norwood 2012, Schulze et al. 2008).

I consumatori chiedono non solo alimenti sicuri e di qualità, ma anche una certificazione che gli animali siano stati allevati e macellati in modo etico (Salamano et al. 2013).

In uno studio del 2007 della Commissione Europea, ai consumatori è stato chiesto di valutare l'importanza della protezione degli animali da allevamento su una scala da 0 a 10, ottenendo un punteggio medio di risposte pari a 7,8. Ciò dimostra che il giudizio sulla qualità degli alimenti è stabilito, oltre che dalla natura e dalla sicurezza del prodotto finale, anche dal benessere degli animali coinvolti (Blokhuis et al. 2008, Napolitano et al. 2007). BOZZO

Il concetto di benessere animale infatti è fortemente influenzato da questioni scientifiche, etiche, economiche, culturali e religiose in continua evoluzione (Fraser 2009, Green e Mellor 2011). La conoscenza della comprensione del benessere degli animali da allevamento da parte del pubblico dovrebbe essere aumentata incoraggiando il dialogo scientifico tra i cittadini e le parti interessate lungo la catena di approvvigionamento alimentare e sviluppando programmi per il benessere degli animali, premiando gli attori della catena alimentare che decidono di investire in tal senso, dall'allevatore alla grande distribuzione fino al consumatore.

Come sopra esposto, al fine di valutare il benessere degli animali a livello di allevamento, è essenziale sviluppare strumenti basati direttamente su valutazioni svolte sugli animali e sviluppate con l'obiettivo di valutare l'effettivo stato di benessere degli animali in termini di comportamento, salute e fisiologia (Blokhuis et al. 2003). La ricerca di indicatori validi e affidabili è un obiettivo chiave di diversi programmi di ricerca, in particolare per la valutazione del benessere a livello aziendale, e gli strumenti possono includere indagini effettuate tramite questionari e rivolte ai vari attori della filiera; in questo caso è determinante prestare attenzione alla metodologia utilizzata per condurre le interviste.

Gli studi condotti da Heise e Theuvsen (Heise e Theuvsen 2015) e Heise e colleghi (Heise et al. 2015) hanno indicato chiaramente che diversi approcci metodologici (domande aperte o domande chiuse) possono portare a differenze sostanziali nelle risposte in merito alla percezione del benessere degli animali da allevamento (FAW) da parte di allevatori e veterinari.

Le differenze di approccio complicano lo sviluppo di un quadro di valutazione comune per il benessere degli animali, che sarebbe accettato all'unanimità dalle varie parti interessate. La maggior parte dei concetti scientifici che definiscono FAW sono in realtà stati criticati per non affrontare adeguatamente le concezioni pubbliche di FAW (Fraser 2008, Vanhonacker e Verbeke 2014).

Studi precedenti (De Greef et al. 2006, Lassen et al. 2006, Marie 2006) avevano mostrato

che i consumatori associano fortemente il FAW con l'accesso all'aperto, requisiti di spazio adeguati e la capacità degli animali di poter manifestare comportamenti naturali.

Uno dei primi problemi che affrontiamo quando confrontiamo studi e pubblicazioni scientifiche sulle prospettive e le preoccupazioni dei cittadini e dei consumatori è la mancanza di una definizione globalmente accettata di benessere degli animali; questo termine è usato con significati diversi (Hemsworth et al. 2015) e le diverse parti interessate ne danno definizioni e hanno conseguentemente percezioni diverse del benessere degli animali (Fisher et al. 2009; Vanhonacker et al. 2008)

Differenziare i ruoli dei consumatori e dei cittadini in relazione alle implicazioni morali sul benessere degli animali da allevamento aiuta ad ottenere una maggiore comprensione delle loro azioni. I cittadini partecipano al processo di formazione dell'opinione pubblica (Grunert et al. 2006), guidano la legislazione e influenzano le decisioni politiche prese dai governi esprimendo le loro preoccupazioni pubbliche per il benessere degli animali da allevamento (Cornish et al. 2006; Clarck et al. 2017; de Graaf et al. 2016). Votare, scrivere lettere a politici e media e partecipare ad associazioni sono alcuni dei comportamenti comuni dei cittadini (Broom et al. 2007, Grunert et al. 2006)]. Il cambiamento di atteggiamenti, comportamenti e opinioni potrebbe costituire un'importante forza trainante per il miglioramento dello status etico degli animali da allevamento nella società (Kupsala et al. 2015) I consumatori, d'altra parte, hanno un'influenza sul mercato perché possono modificare il loro comportamento di acquisto o rifiutare di acquistare prodotti derivanti da sistemi di allevamento con aspetti che vengono considerati non graditi o poco rispettosi del benssere animale (Broom et al. 1990). I consumatori hanno anche un ruolo come cittadini, e durante l'inizio del ventunesimo secolo, la canalizzazione delle preoccupazioni su alcuni prodotti animali avveniva principalmente attraverso il ruolo di cittadino (Grunert et al. 2006).

Alonso (2020) inoltre evidenzia che tutti coloro che sono direttamente interessati agli animali da allevamento abbiano la responsabilità di promuovere il loro benessere. Questo include, ovviamente, gli allevatori ei veterinari. Comprende anche in una certa misura tutti gli altri, certamente tutti coloro che consumano prodotti derivanti dagli animali di allevamento, ma anche quelli che non lo fanno. La semplice decisione di indossare la lana ma non mangiare agnello può ridurre il numero di agnelli macellati per la carne ma non avrà alcun beneficio diretto sul benessere degli animali vivi. In effetti, può peggiorare le cose poiché riduce il valore in denaro di ogni individuo, quindi riduce il denaro a disposizione dell'allevatore per la cura degli animali.

Ne consegue che possiamo promuovere al meglio il benessere degli animali da allevamento aumentando il valore che diamo al loro benessere.

Il primo passo, secondo Webster, necessario sarebbe garantire che la nostra percezione del benessere degli animali da allevamento sia allineata alle effettive esigenze degli animali.

Per la grande maggioranza della popolazione del Regno Unito e del mondo sviluppato e urbanizzato, il benessere degli animali da allevamento implica un comportamento "naturale" in un ambiente "naturale". Questo desiderio è compassionevole ma raramente ben informato, poiché pochi consumatori hanno un'esperienza pratica diretta dell'agricoltura, antica o moderna.

Questa ignoranza rende il consumatore altamente vulnerabile a slogan di marketing comodi ma semplicistici come "naturale" o "pulito e verde". La percezione del benessere degli animali da parte degli allevatori dovrebbe essere più informata, meno sentimentale, anche se non necessariamente meno compassionevole. La stragrande maggioranza degli allevatori si prende cura dei propri animali in maniera adeguata e rispettosa, risultano spesso non economicamente soddisfacente rispetto ai sacrifici che vengono svolti da questi. Tuttavia, molti allevatori considerano ancora il benessere degli animali semplicemente come un problema creato *ad hoc* derivante da una percezione errata da parte di un pubblico che ignora la materia e alimentato da immagini distorte dai media.

Anche questa è una visione pericolosamente ristretta poiché ignora ciò che deve, per qualsiasi criterio morale o pratico, essere la questione più importante di tutte, vale a dire il benessere come percepito dagli animali stessi.

Il benessere di un animale senziente è di buon livello se esso può mantenersi in salute ed evitare la sofferenza.

Questa definizione più breve di tutte richiede alcune spiegazioni.

L'espressione “evitare la sofferenza” si riferisce al benessere mentale. Per un animale senziente devono essere soddisfatti entrambi i criteri, sia fisico che mentale.

La senzienza implica una consapevolezza della natura delle emozioni associate al piacere e alla sofferenza. Molte di queste emozioni sono associate a sensazioni primitive come fame, dolore e ansia. Alcune specie possono anche provare "sentimenti più elevati" come l'amicizia e il dolore, ma sarebbe un errore antropomorfico enfatizzare eccessivamente la loro importanza. Sarebbe ugualmente fallace sottovalutare il disagio emotivo causato agli animali da allevamento dalla fame, dal dolore e dall'ansia.

I lavori fin qui presentati trattano in ambiti diversi tematiche riguardanti il benessere in varie specie, analizzando gli aspetti fondamentali legati alla definizione e alla tutela del benessere in allevamento , anche in relazione alla percezione da parte del consumatore.

All'interno di tale tema si colloca una delle ricerche che verranno presentate all'interno di questa tesi (capitolo 3); si tratta infatti di una survey condotta sul territorio italiano che interroga i consumatori riguardo la loro percezione del benessere animale, il peso che tale tematica ha per loro al momento dell'acquisto.

Nel suo complesso, il seguito di questo elaborato si concentrerà su alcune delle principali problematiche di benessere del suino pesante italiano nelle sue attuali condizioni di allevamento (disponibilità di spazio), trasporto (gestione pre-macellazione e suoi effetti sulla qualità delle carni) e sulla percezione da parte dei consumatori (del benessere in generale e della pratica della castrazione/immunocastrazione in particolare). Pertanto si procederà, nei prossimi paragrafi, ad una introduzione sulla normativa in generale e poi su queste tre macro-tematiche, prima di addentrarci nelle singole ricerche.

1.1.4 Cosa dice la normativa

Una pietra miliare per la tutela degli animali è rappresentata dal testo dell'articolo 13 del Trattato di Lisbona del 2009, che riconosce che gli animali sono esseri senzienti e stabilisce che le loro esigenze siano considerate durante la formulazione e l'applicazione delle politiche comunitarie: gli animali dunque, in quanto esseri viventi, acquisiscono nella giurisprudenza europea una serie di diritti (Barbieri ed al., 2017).
Quindi nella normativa europea il benessere animale trova spazio ormai da quasi quarant'anni dettando sia norme di tipo orizzontale (ovvero norme generali riguardo alla protezione dei diversi animali da reddito, a prescindere dalla specie), sia norme verticali(cioè che si occupano delle singole specie animali) (D'Aronco 2018).
La protezione degli animali destinati alla produzione di alimenti (e non) deve avvenire ed essere garantita attraverso tutte le fasi produttive includendo in queste, ovviamente, anche quelle deltrasporto e della macellazione.
A tal riguardo quindi il legislatore ha provveduto sia a livello comunitario che nazionale a promulgare norme che ne regolino la gestione, in particolar modo abbiamo:

- Direttiva 98/58 CE del Consiglio che definisce norme minime per la protezione di tutti gli animali negli allevamenti (recepita in Italia con Dlgs.146/2001).

- Regolamento 1/2005 CE del Consiglio riguardante la protezione degli animali durante il trasporto e le operazioni correlate.
- Regolamento 1099/2009 CE del Consiglio riguardante la protezione degli animali durante l'abbattimento.

All'interno del quadro normativo nazionale sono presenti inoltre norme verticali che si applicano direttamente a specifiche categorie zootecniche ritenute particolarmente "a rischio", sia per i metodi di allevamento utilizzati sia per le caratteristiche fisiologiche e comportamentali di tali animali.
Ad oggi infatti sono vigenti sul territorio nazionale:

DLgs. 26 marzo 2001, n. 146 (attuazione della direttiva 98/58/CE) protezione degli animali negli allevamenti

D.Lgs 267/2003 "Attuazione della direttiva 2002/4/CE per la protezione delle galline ovaiole e la registrazione dei relativi stabilimenti di allevamento"

DLgs. 29 luglio 2003, n. 267 (attuazione delle direttive 1999/74/CE e 2002/4/CE) per la protezione delle galline ovaiole e la registrazione dei relativi stabilimenti di allevamento

Regolamento (CE) n. 882/2004 del Parlamento europeo e del Consiglio del 29 aprile 2004 relativo ai controlli ufficiali intesi a verificare la conformità alla normativa in materia di mangimi e di alimenti e alle norme sulla salute e sul benessere degli animali;

Decreto Legislativo n. 122 del 7 luglio 2011, "Attuazione della direttiva 2008/120/CE che stabilisce le norme minime per la protezione dei suini", pubblicato nella Gazzetta Ufficiale Serie Generale n.178 del 02 agosto 2011.

1.2 Il benessere del suino: normativa, aspetti generali e particolari

I sistemi di allevamento intensivo spesso sono fonte di stress e possono mettere a rischio il benessere degli animali allevati.

In questi sistemi, i suini sono spesso alloggiati in ambienti piccoli e non confortevoli, che impediscono loro di svolgere i loro comportamenti naturali. Questo ha un ruolo importante causando un aumento della frequenza di comportamenti anormali e stereotipie (Cronin, 1985).

Altri fattori di stress frequenti nella zootecnia industriale sono la fame cronica, le mutilazioni dolorose, lo svezzamento precoce, l'elevata densità di allevamento e gli stress sociali causati dalla formazione di gruppi di animali non stabili (Pedersen, 2018; Read et al., 2020).

Il sistema immunitario dei suini spesso è compromesso anche dalla presenza di stimoli stressanti, rendendoli quindi più suscettibili alle infezioni (Filipe et al., 2020).

Nel tentativo di garantire la produttività e al tempo stesso prevenire focolai di infezione, gli allevamenti intensivi di suini si affidano all'utilizzo di antimicrobici a scopo profilattico e metafilattico al fine di mantenere dal punto di vista infettivo in salute il gruppo fino alla macellazione (Sjölund et al., 2016).

Tale uso di antimicrobici negli animali destinati alla produzione alimentare contribuisce in modo significativo al problema globale della antibiotico-resistenza, e questo problema ha portato di recente a una maggiore regolamentazione dell'uso degli antimicrobici nel settore veterinario (Van Boeckel et al., 2015 e 2019).

Le politiche che mirano a controllare la diffusione dell'antibiotico-resistenza richiedono il monitoraggio/riduzione dell'uso di antibiotici e la promozione di buone pratiche di allevamento, compreso il miglioramento del benessere degli animali (Magnusson et al., 2019).

Ciò si aggiunge alla crescente pressione pubblica affinché i settori degli animali da produzione alimentare agiscano in modo più coerente con gli obiettivi di sostenibilità e benessere degli animali (Pedersen, 2018).

La produzione commerciale di suini nei paesi industrializzati ha, dagli anni '60, intrapreso un drammatico cambiamento in cui si è passati da piccole aziende agricole a conduzione familiare a una più grande produzione industrializzata, con proprietari privati e diversi dipendenti. Questi cambiamenti hanno portato anche a un cambiamento da aziende con spazi ampi destinati agli animali (basso grado di confinamento) che però richiedevano un intenso lavoro da parte degli operatori, ad una tipologia di allevamento con spazio limitato, alto grado di confinamento e utilizzo di sistemi con pavimento fessurato e ambiente spoglio.

Anche la gestione è cambiata adottando sistemi di alimentazione e climatizzazione automatizzati, meno sorveglianza degli animali da parte degli operatori, e pratiche come lo svezzamento precoce e l'inseminazione artificiale.

Insieme a questi cambiamenti c'è stata una crescente consapevolezza delle questioni relative al benessere degli animali legate al uso di metodi di produzione industrializzati tra consumatori, mondo politico e commercianti.

Pertanto, la suinicoltura nell'UE, che nel 2014 (FAO 2015), ha prodotto circa il 25% della popolazione suina mondiale, è regolamentata dalla legislazione comunitaria sulla protezione dei suini, che stabilisce standard minimi per garantire un livello di benessere accettabile. Norme di welfare simili stanno ora emergendo in altri paesi produttori di suini, tra cui Stati Uniti, Canada e Australia.

Nonostante la presenza di una specifica legislazione sul benessere, l'industria suinicola deve tuttavia ancora affrontare importanti sfide in materia di benessere.

Queste non sono problematiche facili da risolvere in una produzione economicamente limitata e con una crescente domanda sociale per ridurre l'impatto ambientale da parte dell'industria zootecnica.

Per poter migliorare il benessere dei suini in queste condizioni, c'è urgente bisogno di una mentalità aperta a nuove visioni e di una collaborazione tra i vari ambiti del mondo scientifico, zootecnico e ambientale.

1.2.1 Aspetti normativi e sfide della suinicoltura moderna

La direttiva 2008/120/CE stabilisce norme minime per i suini, tra cui i requisiti generali per l'alloggiamento, le attrezzature, la sorveglianza, l'alimentazione e l'acqua, e lo spazio disponibile.

I singoli Paesi UE possono stabilire standard legislativi più elevati di quelli della Direttiva. All'interno di tale direttiva sono stati inclusi particolari miglioramenti specifici del benessere per le scrofe, come gli standard minimi per la disponibilità di spazio, requisiti specifici per l'alloggiamento in gruppo delle scrofe durante il periodo di gestazione, oltre ad una particolare cura per quanto riguarda la quota fibrosa nella dieta delle scrofe e scrofette.

Inoltre, già in precedenza la Direttiva del Consiglio UE 2001/93/CE poneva attenzione nei confronti dell'importanza dell'arricchimento ambientale per i suini, al fine di limitare comportamenti patologici come il cannibalismo e di disporre norme specifiche in materia di mutilazioni (spuntatura degli incisivi, taglio della coda e castrazione).

1.2.1.1 I problemi di benessere nel settore svezzamento e ingrasso

L'uso dello svezzamento precoce è uno dei maggiori problemi di benessere. In condizioni naturali le scrofe svezzano la loro cucciolata gradualmente già iniziando dalla seconda settimana (Jensen e Recen, 1989; Damm et al., 2003b).
A seconda della disponibilità di risorse ambientali, il processo di svezzamento si completa mediamente intorno alla diciasettesima settimana di lattazione (Jensen e Recen, 1989).
Al contrario, quando i suinetti vengono svezzati bruscamente già a 3-4 settimane di età, essi non sono né fisiologicamente, nè immunologicamente, né comportamentalmente pronti a consumare maggiori quantità di mangimi solidi (Heo et al., 2013). Ciò si traduce in un drastico calo dell'assunzione di energia metabolizzabile il primo giorno di svezzamento a circa il 20% della normale assunzione.
Nei lattonzoli, l'assunzione di mangime solido aumenta gradualmente intorno alla quarta settimana di vita (Boe, 1991), sebbene con notevoli differenze individuali.
Al momento dello svezzamento quindi i suinetti sono soggetti a una grande varietà di cause di stress tra cui la separazione dalla scrofa, il brusco cambiamento sia nel mangime che nella fonte d'acqua, lo stress da trasporto e movimentazione, lo stress sociale a causa della composizione di nuovi gruppi, il diverso ambiente fisico e la maggiore esposizione ad agenti patogeni e antigeni ambientali (come da revisione della letteratura di Campbell et al., 2013).
Quando il carico di fattori di stress diventa eccessivo, non solo porta a scarso benessere ma anche a scarso rendimento, alto rischio di diarrea da svezzamento e morte.
Il rischio di diarrea da svezzamento induce spesso la maggior parte degli allevatori a trattare regolarmente tutti gli animali con antibiotici a scopo profilattico, somministrato attraverso mangimi o acqua, per evitare la ridotta produttività causata da diarrea e altre malattie.
Un possibile approccio per ridurre significativamente lo stress da svezzamento sarebbe evitare lo svezzamento prima della quarta o quinta settimana di vita, ed attuarlo in combinazione con una procedura in cui i suini svezzati rimangono nel settore parto almeno fino a quando non si saranno ripresi dallo stress nutrizionale dello svezzamento, al fine di limitare possibili concause di stress.
Altri importanti rischi per il benessere sia per i suini svezzati che per i suini da ingrasso sono la mancanza di arricchimenti ambientali e la mancanza di spazio.
Si stima che oltre l'80 % dei suini nell'UE sia alloggiato in box senza alcun stimolo biologicamente rilevante. La mancanza di sufficienti materiali di arricchimento ambientale rilevanti è un importante fattore di rischio per lo sviluppo, tra l'altro, di episodi di

morsicatura della coda, oltre a costituire un rischio di benessere in sé dovuto al mancato soddisfacimento del bisogno comportamentale di esplorazione.
Pedersen et al. (2014) e Jensen et al. (2015a) hanno riscontrato una riduzione lineare del tempo speso per comportamenti anormali e un aumento del tempo dedicato al comportamento diretto verso la paglia con l'aumento della quantità di paglia fino a circa 300-400 g per suino al giorno, a seconda dell'età dei suini. Inoltre, la frequenza di ulcere gastriche era ridotta (Herskin et al., 2016) e il tasso di crescita aumentato (Pedersen et al., 2015) aumentando anche solo la quantità di paglia.
La formazione di gruppi sociali nuovi costituisce di per sé un rischio per il benessere. I gruppi sono frequentemente mischiati, allo scopo di mantenere la taglia dei suini all'interno di un gruppo più uniforme possibile, per rendere il più efficiente possibile il processo di consegna di un "prodotto" il più standardizzato possibile alla macellazione, con i vari risvolti pratici legati ad esempio al trasporto e allo stordimento.
La restrizione di spazio è particolarmente problematica al momento del raggruppamento o all'introduzione di individui sconosciuti in un gruppo già noto. I suini infatti hanno bisogno di spazio per stabilire nuovi rapporti sociali e conseguentemente creare una nuova gerarchia.

Per ridurre o superare i problemi sopra menzionati, lo spazio disponibile deve essere riconsiderato. Gli effetti positivi dell'aumento dello spazio, sia in generale che per il fronte mangiatoia, dovrebbero essere considerati sia dal punto di vista economico sia per il benessere.
Infatti, nonostante una maggiore attenzione al benessere degli animali da parte dei consumatori e degli altri attori della filiera, sono ancora presenti importanti sfide di benessere legate a ciascuna delle diverse fasi del ciclo di vita dei suini.
La maggior parte dei problemi sono legati al confinamento o alla mancanza di spazio, alla mancanza di arricchimenti ambientali, e alle caratteristiche produttive dei sistemi di allevamento intensivi.
I problemi di welfare sono spesso intrinsecamente legati all'alloggio e alla gestione correlata. Di conseguenza, i limiti per il miglioramento del benessere sono spesso correlati anche ai limiti architettonici del singolo edificio, al design del box, al sistema di alimentazione.
Questi fattori non sono facilmente modificabili e raramente senza costi, quindi spesso le modifiche vengono applicate lentamente e nel corso di molti anni, con notevoli resistenze da parte dell'industria.

I miglioramenti futuri suggeriti potrebbero essere ritenuti irrealistici, e quindi non ulteriormente indagati, in quanto non incrementano il profitto in maniera diretta. Tuttavia, i cambiamenti che migliorano il benessere possono rivelarsi redditizi nel lungo periodo poiché i costi da sostenere al fine di costruire nuove strutture idonee o correlati aumento dello spazio pro capite possono essere mitigati da una migliore salute, aumento della longevità e produttività dei suini.

1.1.2.2 La normativa a tutela del benessere del suino

Il decreto legislativo 122 del 2011 sancisce che le aziende devono soddisfare i seguenti requisit minimi:

a) le superfici libere a disposizione di ciascun suinetto o suino all'ingrasso allevato in gruppo, escluse le scrofette dopo la fecondazione e le scrofe, devono corrispondere ad almeno:

- 0,15 m^2 per i suini di peso vivo pari o inferiore a 10 kg;
- 0,20 m^2 per i suini di peso vivo compreso tra 10 e 20 kg;
- 0,30 m^2 per i suini di peso vivo compreso tra 20 e 30 kg;
- 0,40 m^2 per i suini di peso vivo compreso tra 30 e 50 kg;
- 0,55 m^2 per i suini di peso vivo compreso tra 50 e 85 kg;
- 0,65 m^2 per i suini di peso vivo compreso tra 85 e 110 kg;
- 1,00 m^2 per i suini di peso vivo superiore a 110 kg;

Risulta già evidente come tale normativa nazionale, attuativa della direttiva comunitaria, risulti inadeguata rispetto alle caratteristiche del suino pesante allevato in Italia per l'industria salumiera, che arriva alla macellazione con un peso medio di circa 160 kg. Tale norma invece lo equipara, per quanto riguarda i requisiti di spazio disponibile, ad un suino destinato alla macelleria e quindi alla produzione di carne fresca che raggiunge alla macellazione un peso di circa 110 kg.

le pavimentazioni invece devono essere conformi ai seguenti requisiti:

qualora si utilizzano pavimenti fessurati in calcestruzzo per suini allevati in gruppo l'ampiezza massima delle aperture deve essere di:

- 11 mm per i lattonzoli;
- 14 mm per i suinetti;
- 18 mm per i suini all'ingrasso;
- 20 mm per le scrofette dopo la fecondazione e le scrofe;

l'ampiezza minima dei travetti deve essere di:

- 50 mm per i lattonzoli e i suinetti;
- 80 mm per i suini all'ingrasso, le scrofette dopo la fecondazione e le scrofe.

Inoltre è vietato costruire o convertire impianti in cui le scrofe e le scrofette sono tenute all'attacco, nonchè il relativo utilizzo.

Inoltre in tale norma si fa riferimento alla necessità della presenza di materiale manipolabile a disposizione dei suini al fine di limitare gli episodi di cannibalismo e di aggressività.

I suini che devono essere allevati in gruppo, che risultano particolarmente aggressivi, che sono stati attaccati da altri suini o che sono malati o feriti, devono essere temporaneamente ricoverati in un recinto individuale, che deve permettere all'animale di girarsi facilmente se ciò non è in contraddizione con specifici pareri veterinari.

In aggiunta alle disposizioni pertinenti di cui all'allegato del decreto legislativo 26 marzo 2001, n. 146, relativo alla protezione degli animali negli allevamenti, si applicano inoltre i seguenti requisiti specifici per la protezione dei suini:

- nella parte del fabbricato dove sono stabulati i suini vanno evitati i rumori continui di intensità pari a 85 dBA nonchè i rumori costanti o improvvisi;
- i suini devono essere tenuti alla luce di un'intensità di almeno 40 lux per un periodo minimo di 8 ore al giorno;

i locali di stabulazione dei suini devono essere costruiti in modo da permettere agli animali di:

- avere accesso ad una zona in cui coricarsi confortevole dal punto di vista fisico e termico e adeguatamente prosciugata e pulita, che consenta a tutti gli animali di stare distesi contemporaneamente;
- riposare e alzarsi con movimenti normali;
- vedere altri suini; tuttavia, nella settimana precedente al momento previsto del parto e nel corso del medesimo, scrofe e scrofette possono essere tenute fuori dalla vista degli animali della stessa specie;
- i suini devono avere accesso permanente a una quantità sufficiente di materiali che consentano loro adeguate attività di esplorazione e manipolazione, quali ad esempio paglia, fieno, legno, segatura, composti di funghi, torba o un miscuglio di questi, salvo che il loro uso possa comprometterne la salute e il benessere;

- i pavimenti devono essere non sdrucciolevoli e senza asperità per evitare lesioni ai suini e progettati, costruiti e mantenuti in modo da non arrecare lesioni o sofferenze ai suini. Essi devono essere adeguati alle dimensioni e al peso dei suini e, se non è prevista una lettiera, costituire una superficie rigida, piana e stabile;
- tutti suini devono essere nutriti almeno una volta al giorno. Se i suini sono alimentati in gruppo e non «ad libitum» o mediante un sistema automatico di alimentazione individuale, ciascun suino deve avere accesso agli alimenti contemporaneamente agli altri suini del gruppo;
- a partire dalla seconda settimana di età, ogni suino deve poter disporre in permanenza di acqua fresca sufficiente;
- sono vietate tutte le operazioni effettuate per scopi diversi da quelli terapeutici o diagnostici o per l'identificazione dei suini e che possono provocare un danno o la perdita di una parte sensibile del corpo o un'alterazione della struttura ossea, ad eccezione:
  - di una riduzione uniforme degli incisivi dei lattonzoli mediante levigatura o troncatura, entro i primi sette giorni di vita, che lasci una superficie liscia intatta;
  - delle zanne dei verri che possono essere ridotte, se necessario, per evitare lesioni agli altri animali o per motivi di sicurezza;
  - del mozzamento di una parte della coda;
  - della castrazione di suini di sesso maschile con mezzi diversi dalla lacerazione dei tessuti; dell'apposizione di un anello al naso, che è ammessa soltanto quando gli animali sono detenuti in allevamenti all'aperto e nel rispetto della normativa nazionale.

Tuttavia il mozzamento della coda e la riduzione degli incisivi dei lattonzoli non devono costituire operazioni di routine, ma devono essere praticati soltanto ove sia comprovata la presenza di ferite ai capezzoli delle scrofe o agli orecchi o alle code di altri suini. Prima di effettuare tali operazioni si devono adottare misure intese ad evitare le morsicature delle code e altri comportamenti anormali tenendo conto delle condizioni ambientali e della densità degli animali. E' pertanto necessario modificare condizioni ambientali o sistemi di gestione inadeguati.

Tutte le operazioni sopra descritte devono essere praticate da un veterinario o da altra persona formata che disponga di esperienza nell'eseguire le tecniche applicate con mezzi idonei e in condizioni igieniche. Qualora la castrazione o il mozzamento della coda siano praticati dopo il settimo giorno di vita, essi devono essere effettuati unicamente da parte di un veterinario sotto anestesia e con somministrazione prolungata di analgesici.

Alla luce delle disposizioni indicate nell'allegato è chiaro come anche i legislatori abbiano voluto stabilire norme accurate e specifiche che regolamentino le fasi maggiormente complesse e critiche del ciclo produttivo dei suini.

Viene posta particolare attenzione infatti agli spazi disponibili, alle caratteristiche dei locali di stabulazione e alle mutilazioni, ad oggi chiaramente i punti critici che rischiano di minare maggiormente il benessere del suino e su cui è necessario apportare attenzione e miglioramenti al fine di ottenere una filiera che tuteli al meglio tale specie.

1.2.1 Spazio, trasporto e mutilazioni tre punti critici nell'allevamento suino

- **Spazio**

Numerosi studi hanno dimostrato che maggior arricchimenti, maggior spazio (bassa densità di allevamento), gruppi sociali stabili e una migliore gestione possono contribuire in modo significativo ad allevare suini a code integre e quindi ad incrementare in maniera diretta ed efficace il benessere dei suini (EFSA 2007; Petherick et al. 1987; Zonderland et al. 2010).

L'arricchimento è stato identificato come il principale fattore di rischio, ma anche i pavimenti completamente e parzialmente fessurati, più di cinque animali per spazio di alimentazione e meno di 1 mq per animale possono aumentare il rischio di morsicatura della coda. uno studio condotto in Olanda, presso l'allevamento della catena di suini sostenibile olandese "De Hoeve" ha dimostrato che L'obiettivo prossimo di questo progetto era ridurre le ferite da morso sulla pelle e sulla coda fornendo periodicamente piccole quantità di cibo sul pavimento come arricchimento ambientale. L'obiettivo era quello di produrre suini da macello senza mordere la coda con la coda ancorata, la pelle senza lesioni e le gambe sane, comprese buone prestazioni come passo verso il divieto di taglio della coda.

Uno studio finlandese mirava a stabilire le correlazioni eventuali tra l'ambiente e le misure di benessere rilevate sugli animali raccolte in 158 allevamenti finlandesi.
I dati consistevano in 95 valutazioni del benessere nei suini da ingrasso e 103 nelle scrofe, compresi i suinetti.
I fattori ambientali maggiormente impattanti sul benessere dei suini erano lo spazio disponibile per i suini da ingrasso, la dimensione del gruppo per le scrofe in gestazione e l'uso della lettiera sia per i suini da ingrasso che per le scrofe in gestazione.
Un incremento di spazio risultava vantaggioso per i maiali da ingrasso, sebbene i segni di combattimento aumentassero in recinti molto spaziosi. Gli effetti positivi dello spazio,

inclusa una diminuzione delle lesioni della coda e un umore più positivo, sono continuati almeno fino a 1,5 mq per suino da ingrasso.

Lo spazio a disposizione influenza il benessere e alcuni parametri produttivi dei suini (Kornegay et al. 1984; Weng et al. 1998; Spoolder et al. 2000; EFSA 2005).
La legislazione Europea stabilisce un minimo di $1m^2$ di superficie a capo per suini sopra i 110 kg (EC 2008) ma non dà indicazioni ulteriori per animali di peso superiore, come per esempio i suini Italiani pesanti (i quali alla fine del ciclo produttivo raggiungono e spesso superano i 160 kg) (Consorzio del Prosciutto di Parma 1992).

Lo spazio minimo consentito dalla legge sopracitato (A) è stato calcolato tramite l'equazione $A=0.030\times BW^{0.67}$, dove il coefficiente dell'equazione (k) è impostato a 0.030 e BW rappresenta il peso dell'animale (Spoolder et al. 2000).
In accordo con le raccomandazioni EFSA, dovrebbero essere usati coefficienti più alti (k=0.036 per suini fino a 110 kg e k=0.047 sopra i 110 kg) in modo tale da permettere a tutti i suini di poter coricarsi a terra separatamente gli uni dagli altri e nello stesso momento (Petherick et al. 1981).
E' interessante notare che queste richieste minime di spazio, che si basano sul comportamento adottato dal suino nel momento del riposo, non prendono in considerazione lo spazio necessario per espletare altri comportamenti naturali (alimentarsi, abbeverarsi, comportamenti eliminatori, esplorativi, etc. (Vermeer et al. 2014) comportamenti che se espletati correttamente porteranno all'assenza o alla riduzione di comportamenti patologici, come ad esempio la morsicatura della coda.
Per quanto disponibile in legteratura, solo Pastorelli et al. (2006) hanno condotto uno studio con l'obiettivo di calcolare i requisiti di spazio necessari per i suini pesanti, nonostante i consumatori italiani percepiscano la disponibilità di spazio come il principale fattore che influenza il benessere animale (Di Pasquale 2014).
Per quanto riguarda gli studi che valutano l'impatto della disponibilità di spazio sulle carcasse e la qualità delle carni, Serrano et al. (2013) hanno trovato un calo di MUFA a livello di lardo dorsale (Acidi Grassi Monoinsaturi) all'aumento dello spazio disponibile. Rossi et al. (2008) non hanno trovato differenze nella qualità delle carni, ma hanno trovato un un aumento dello spessore del grasso dorsale in suini pesanti allevati con una superficie disponile di 1,4 m^2/capo, a confronto con suini allevati ad $1m^2$/capo.
Al contrario, gli effetti delle diverse disponibilità di spazio sulla qualità dei prosciutti crudi non sono mai stati indagati. L'obiettivo del terzo studio presentato in questo elaborato (Capitolo 5) era quindi quello di investigare gli effetti di due differenti soluzioni riguardanti

lo spazio disponibile (lo spazio minimo stabilito dalla normativa vs. vo spazio calcolato in accordo alle raccomandazioni EFSA) sul comportamento, sui parametri di accrescimento, sulla qualità della carne e dei prosciutti in suini pesanti, e in particolare modo destinati alla produzione di Prosciutto di Parma.
La finalità aggiuntiva di questo studio era anche quella di contribuire a migliorare la conoscenza riguardo le diverse necessità dei suini pesanti, fornendo un background scientifico a supporto di una legislazione che possa essere maggiormente inclusiva.

- **Trasporto**

Ogni giorno milioni di animali vengono trasportati in tutto il mondo per diversi motivi, dall'allevamento alla produzione di carne (Rioja-Lang et. al 2019).
Inoltre, il ridotto numero di piccoli macelli e l'istituzione di grandi macelli hanno determinato un aumento della durata dei viaggi per gli animali (Consortium for Parma Ham *Prosciutto di Parma* 1992.) È noto che il trasporto di animali a lunga distanza è un problema di benessere animale perché è considerato un evento stressante che può portare a problemi di salute e sofferenza prolungata (Brandt et al. 2015).
Diversi fattori di stress possono influenzare negativamente il benessere degli animali durante il trasporto su strada (Faucitano et al. 2018). Potrebbero essere legati all'esperienza e alle condizioni degli animali (digiuno da cibo e acqua, condizioni termiche e fisiche all'interno del veicolo, sovraffollamento, assenza di tramezzi, mescolanza di animali) o al viaggio (stile di guida, rumore , vibrazioni, qualità della strada e durata del viaggio) (Siegel et al 2014; Broom et al 2014). Pertanto, il trasporto su strada è un problema multifattoriale caratterizzato da una combinazione di fattori stressanti che nel complesso determinano effetti sul benessere degli animali, sulla sicurezza alimentare, sulla qualità della carne e delle carcasse [Brandt et al. 2015; Anderson et al. 2010). L'Organizzazione mondiale per la salute animale (OIE) ha identificato il trasporto come una delle più importanti variabili pre-macellazione in grado di avere ripercussioni sulla qualità della carne e, di conseguenza, è stata evidenziata ulteriormente l'importanza di mantenere un buon benessere animale durante il trasporto [Adenkola et al. 2010; Averos et al. 2007; Kanda et al. 2014]. L'OIE ha emanato una serie di raccomandazioni su come gestire il trasporto degli animali, invitando ogni Paese a emanare una legge specifica sulla protezione degli animali durante il trasporto. Il regolamento (CE) n. 1/2005 del Consiglio (Addis et al. 1974) disciplina il trasporto di animali in Europa e contiene requisiti speciali per i viaggi superiori a otto ore, compresa la durata massima del viaggio, le soste ai posti di controllo e le ispezioni su strada.

Le specie trasportate hanno esigenze e fabbisogni fisiologici differenti a seconda delle condizioni di trasporto, dei mezzi di trasporto utilizzati e delle zone climatiche (Weschenfelder et al. 2013)
Dal punto di vista dell'animale, il trasporto è un evento molto complesso e stressante (Grandin 1997; Perremans et al. 1998).

Il trasporto, la relativa manipolazione durante il trasporto e la stabulazione possono avere effetti negativi sul benessere dei suini (Van Putten et al. 1982; Bottaccini et al. 2018; Dalla Costa et al. 2016).Il trasporto dei suini da ingrasso, cioè dal carico fino alla macellazione, può causare perdite economiche a causa della mortalità, danni alla cute e deterioramento generale della qualità della carne (Tarrant 1989; Guàrdia et al. 2009).

Il benessere dei suini durante il trasporto dipende da molti fattori interagenti, come le condizioni dell'animale al momento del carico, la temperatura ambientale, la densità del carico, il tempo di transito, lo stress sociale (ad es. mescolarsi con suini sconosciuti), la manipolazione, i rumori e i odori, vibrazioni e sbalzi di velocità (Bench et al. 2008; Lambooij et al. 2014).
Questi fattori sono potenzialmente stressanti e, in combinazione, possono anche avere un impatto significativo sulla fisiologia dei suini, determinando difetti di qualità della carne al macello. Il termine stress è usato frequentemente in questa rassegna come un modo per suggerire implicazioni negative (definite come stress acuto o cronico) sul benessere dei suini durante il trasporto.

Di conseguenza, il Regolamento CE 1/2005 prevede requisiti per ciascuna specie, in particolare per quanto riguarda la progettazione del veicolo e la durata massima del viaggio. (Zappaterra, 2020)

Uno studio dettagliato dell'associazione tra le operazioni pre-macellazione e la risposta allo stress potrebbe apportare benefici sia al settore zootecnico sia agli animali, riducendo le perdite in seguito al trasporto e promuovendo il benessere animale e la qualità delle carni.
La quarta ricerca presentata in questo elaborato (Capitolo 6) si concentra sul benessere durante le operazioni precedenti alla macellazione, di suini pesanti italiani (trasportati e macellati ad un minimo di età di 9 mesi e ad un peso medio di 160 kg ± 10% (Consortium for Parma Ham *Prosciutto di Parma 1992)*.
Le operazioni precedenti alla macellazione "consistono in numerosi passaggi, iniziando da quando i suini lasciano il loro box e includendo il trasporto, lo scarico, lo stordimento e il dissanguamento (Brandt et al. 2015). Tutte queste pratiche possono indurre stress.

Complessivamente, lo stress provato dai suini in queste fasi è il risultato di una serie di condizioni che interagiscono tra loro e che riguardano l'allevamento (sistema di alloggiamento, gestione del mangime, movimentazione da parte degli operatoti, etc), il trasporto (struttura del veicolo, durata del trasporto, spazio disponibile, microclima, etc) e il carico/scarico (durata, strutture, operatori, etc). Tutti questo fattori e le loro interazioni possono portare a perdite di animali, a risposte fisiologiche e comportamentali intense prima della macellazione , e ad eventuali variazioni della qualità delle carni e delle carcasse (Faucitano et al. 2018).

La risposta fisiologica allo stress può essere studiata prendendo in esame vari parametri ematici. In particolare, nonostante i suoi valori possano variare frequentemente in letteratura e il confronto tra diversi studi non sia sempre facile da realizzare, il cortisolo viene frequentemente usato come parametro di stress acuto come conseguenza al carico, al trasporto e allo scarico. (Siegel et al. 2014)].

In maniera analoga, la creatinchinasi (o CK) nel sangue aumenta quando gli animali sono sottoposti ad una intensa attività fisica (come quella svolta durante le operazioni di carico e scarico) o a danno muscolare; inoltre questo enzima può essere usato, insieme ad altri parametri, come indicatore a lungo termine di benessere/malessere durante il trasporto (Broom et al. 2014) poiché la sua concentrazione raggiunge il picco a 6 ore e ritorna ai livelli basali tra 8 e 48 ore dopo il danno muscolare (Anderson et al. 2010; Adenkola et al. 2010)]. La CK ematica aumenta durante il trasporto (viene rilasciata nel flusso sanguigno a causa della rottura delle membrane delle cellule muscolari causata da un vigoroso sforzo muscolare) e diminuisce durante la permanenza in stalla di sosta (Averos et al. 2007)

Sebbene meno comune in letteratura, un altro possibile indicatore di stress è l'aldolasi ematica. Analogamente alla CK, l'aldolasi è un enzima che fuoriesce in circolo dal muscolo danneggiato e i cui valori aumentano lentamente nel tempo (con un picco dopo almeno 48-72 h) (Kanda et al. 2014). Uno studio ha mostrato che l'attività dell'aldolasi è correlata ad alcuni parametri di qualità della carne, come il pH e la solubilità delle proteine sarcoplasmatiche e miofibrillari (Addis et al. 1974) tutti indicatori di scarsa capacità di trattenere l'acqua. Inoltre, in medicina umana, l'aldolasi è stata indicata da uno studio come un indicatore più accurato e obiettivo del danno muscolare rispetto alla CK, a causa della sua minore variabilità interindividuale (Kanda 2014)

Per questi motivi, nel presente lavoro è stata valutata anche l'aldolasi come possibile indicatore a lungo termine di danno muscolare.

Diversi studi hanno studiato le relazioni tra i parametri di stress sanguigno (e altri indici fisiologici) e la qualità della carne, ma i loro risultati sono stati non sempre in accordo.

Inoltre, le correlazioni osservate variavano da deboli a moderate, indicando che i parametri di stress sanguigno possono essere utilizzati solo come misura complementare nella valutazione della risposta dei suini allo stress da trasporto (Sommavilla et al. 2017; Weschenfelder et al. 2013; Rocha et al. 2015) e non come indicatore complessivo. Una recente revisione della letteratura ha anche evidenziato che l'attuale letteratura disponibile sul trasporto dei suini si concentra principalmente sui suini con un peso medio di mercato (100-135 kg) (Rioja-Lang et al. 2019).Pertanto, vi è una notevole mancanza di conoscenza sulla gestione dei suini di peso inferiore e superiore, che possono reagire in modo diverso ai fattori di stress pre-macellazione. Per quanto riguarda lo stress da calore, i suini più leggeri sono più suscettibili specialmente durante trasporti di lunga durata (tra le 8 e le 24 ore), (Rioja-Lang et al. 2019), mentre quelli più pesanti lo sono soprattutto durante i trasporti di breve durata, 90 minuti (Nannoni et al. 2017), . L'obiettivo generale di questa ricerca è stato quello di identificare (e possibilmente validare) indicatori di benessere nelle fasi del trasporto e della macellazione , da utilizzare per prevedere la risposta allo stress e la variazione della qualità della carne nei suini pesanti. In particolare, lo scopo di questo lavoro era duplice: (1) valutare, sulla base di misure oggettive (parametri ematici), l'impatto degli eventi pre-macellazione (carico, trasporto, scarico, permanenza in stalla di sosta e stordimento), come singoli fattori o in combinazione, sulla risposta allo stress dei suini pesanti; (2) identificare i parametri di qualità delle carni che mostrano la maggiore variazione in risposta alle variazioni dei parametri del sangue.

- **Castrazione e Immunocastrazione**

Come appena descritto, un punto critico, dal punto di vista del benessere, nella produzione suinicola, risultano essere ancora oggi le mutilazioni, in particolare modo la castrazione dei suinetti maschi.

Fin dal 3000-4000 Ac i suinetti venivano castrati per numerose ragioni : prima tra tutte ridurre l'eventuale odore sessuale, uno sgradevole odore che presentano le carni derivanti da maschi interi. L'odore sessuale è associato alla presenza di androstenone (uno steroide sessuale prodotto a livello testicolare) e scatolo (una sostanza prodotta dalla flora batterica, derivante dalla degradazione del triptofano a livello intestinale) (Brunius et al. 2011)

La seconda ragione per cui i suinetti vengono castrati è ridurre l'aggressività e limitare I comportamenti sessuali (Rydmher et al. 2011).

Inoltre la castrazione favorisce l'accumulo e il deposito di tessuto adiposo (Poulsen Nautrup et al. 2018) il quale è particolarmente apprezzato in alcune produzioni.

Ad oggi il metodo di castrazione maggiormente praticato è la castrazione chirurgica (Vanhonacker et al. 2009)

In accordo con la Direttiva Europea 2008/120, e il decreto legislativo 122 del 2011, questa procedura viene svolta entro i primi sette giorni di vita, con un minimo, o più spesso nessun tipo di trattamento del dolore, nè analgesico nè anestetico; la castrazione chirurgica è infatti causa per il suinetto di dolore e stress che intacca il suo benessere mettendo a rischio la sua crescita, il suo sistema immunitario e quindi più in generale la sua salute (AHAW 2004).

Nel 2010 la Dichiarazione Europea sui metodi di castrazione alternativi nel suino (European Declaration on alternatives to surgical castration of pigs 2019) raccomandava di passare a metodi alternativi (come castrazione con l'utilizzo di anestetici e/o analgesici, allevamento di maschi interi, sessaggio del seme e immunocastrazione), con l'obiettivo di abbandonare la castrazione chirurgica entro il 2018, con l'eccezione dei prodotti suini che rientrano nelle produzioni "Traditional Speciality Guaranteed -TSG", "Protected Geographical Indication PGI" or "Protected Designation of Origin -PDO", per le quali la castrazione appare necessaria al fine di garantire i requisiti organolettici richiesti per tali prodotti (European Declaration on alternatives to surgical castration of pigs 2019) Sebbene ad oggi l'obiettivo fissato dalla Dichiarazione non sia stato raggiunto dalla maggior parte dei paesi europei, l'uso dell'anestesia locale durante la castrazione chirurgica è obbligatorio in Norvegia dal 2002, e in Svizzera lo è l'utilizzo dell'anestesia generale (Vanhonacker et al. 2009)

L'immunocastrazione è una interessante alternativa alla castrazione chirurgica.

Consiste infatti in una vaccinazione nei confronti del GnRH (Gonadotropin Releasing Hormone), attraverso la somministrazione di un coniugato proteico analogo al GnRH che porta ad una produzione di anticorpi nei confronti del GnRH prodotto dall'animale stesso. Questo porta successivamente alla soppressione della sintesi di LH (Luteinizing Hormone) e FSH (Follicle Stimulating Hormone), il che causa regressione testicolare, riduzione della produzione e del deposito di ormoni sessuali, tra cui l'andostenone, responsabile dell'odore sessuale delle carni (Pinna et al. 2015).

L'immunocastrazione dà modo di controllare quindi sia l'odore di verro che il comportamento sessuale (Rydmher et al. 2010; Karaconji et al 2015). Tale tecnica molto poco invasiva consente infatti numerosi vantaggi rispetto alla castrazione chirurgica: assenza di dolore acuto, minor stress (Martins et al. 2013) e manualità più semplici (consiste in una iniezione sottocutanea sul collo, dietro l'orecchio). Alcuni studi hanno anche evidenziato che l'immunocastrazione permette un miglior indice di conversione e le loro carcasse hanno una più alta percentuale di carne magra rispetto agli animali castrati

chirurgicamente.[Poulsen Nautrup et al. 2018, Vanhonacker et al. 2008; Aluwé et al. 2015).

Ciò potrebbe essere causato dal fatto che sono necessarie due somministrazioni di vaccino per una risposta completa: il primo ha lo scopo di attivare il sistema immunitario dell'animale e il secondo viene somministrato nel periodo del raggiungimento della maturità sessuale (Pinna et al. 2015).

Fino alla seconda somministrazione i maschi trattati dal punto di vista fisiologico sono più simili ai maschi interi che ai maschi castrati chirurgicamente, conseguentemente henno una più alta percentuale di massa magra, un impatto ambientale potenzialmente inferiore e una maggiore efficienza dei costi alimentari (Brunius et al. 2015; EC et al. 2019; Fabrega et al. 2010; Pauly et al. 2009). Altri studi non evidenziano differenze in termini di peso e qualità della carne (Zamaratskaia et al. 2015)

In accordo con le indicazioni per la somministrazione del vaccino, la prima iniezione dovrebbe essere fatta a circa 17-18 settimane se non anche prima, mentre la seconda dovrebbe essere somministrata a 22-23 settimane di età se i suini vengono macellati ad un'età di 26 settimane (EC 2015).

Per I suini macellati ad una età maggiore o ad un peso superiore ai 160 kg (come i suini pesanti italiani destinati ai prosciutti crudi DOP), una terza dose diventerebbe necessaria per evitare l'odore sessuale (Pinna et al. 2008)

Gli inconvenienti dell'immunocastrazione sono da riferire ai costi a cui gli allevatori vanno incontro con questo metodo (acquisto del prodotto e manodopera per la sua somministrazione), al rischio di autoiniezione accidentale da parte degli operatori dell'allevamento, e all'atteggiamento incerto del consumatore nei confronti della carne di animali castrati farmacologicamente. Dal punto di vista economico, la castrazione chirurgica con anestesia locale sarebbe invece l'opzione meno costosa.

D'altro canto l'immunocastrazione sembrerebbe consentire una miglior conversione alimentare la quale compenserebbe i costi della vaccinazione, in particolare modo in Italia dove i suini vengono macellati al raggiungimento di un peso molto alto (attorno ai 170 kg) (De Roest et al. 2009) Per quanto riguarda i rischi per gli operatori dell'allevamento, l'autoiniezione accidentale potrebbe indurre effetti a quelli indotti neisuini(una temporanea riduzione degli ormoni sessuali maschili e una riduzione delle funzioni riproduttive sia negli uomini che nelle donne, effetti avversi in gravidanza), con aumento dei rischi in seguito ad una seconda o successive iniezione. In accordo con le indicazioni per la somministrazione, il vaccino deve essere somministrato solo tramite un sistema di sicurezza che abbia sia una sicura per l'ago sia un meccanismo atto a prevenire l'iniezione accidentale (EC 2009).

Uno dei temi più discussi del settore primario riguarda l'accettabilità di questa pratica da parte del consumatore. Alcuni studi hanno indagato l'atteggiamento dei consumatori nei confronti dell'immunocastrazione. Questi studi indagavano due aspetti fondamentali: da un lato la sicurezza alimentare e dall'altro la sensibilità nei confronti del benessere animale. Sulla base del loro atteggiamento su questi argomenti, i consumatori europei possono essere suddivisi in due gruppi principali: uno profondamente a favore e l'altro profondamente contrario all'immunocastrazione (Mancini et al. 2018)

All'interno dei summenzionati studi, i partecipanti esprimevano principalmente atteggiamenti favorevoli nei confronti dell'abbandono della castrazione senza analgesia e/o anestesia e la sua sostituzione con metodi alternativi, nonostante in alcuni casi esprimessero alcuni timori nei confronti dell'immunocastrazione [Fredriksen et al. 2011;Heid et al. 2012). In uno studio norvegese, nonostante la forte fiducia nei confronti delle autorità competenti, gli intervistati erano scettici riguardo l'immunocastrazione a causa di possibili residui nelle carni e ipotetici e imprevedibili conseguenze a lungo termine sulla salute dei consumatori. D'altro canto, I consumatori rifiutavano categoricamente la castrazione chirurgica senza anestesia (Fredriksen et al. 2011) similarmente, uno studio condotto in Italia conferma lo scetticismo dei consumatori riguardo l'uso dell'immunocastrazione nei suini relativa alla produzione di prodotti tradizionali (PDO e IGP) con dubbi simili a quelli indicate dai consumatori norvegesi (Mancini et al. 2018) Solo alcuni studi si focalizzano il ruolo che l'informazione esercita sull'accettazione da parte del consumatore della pratica dell'immunocastrazione. Il campo dell'informazione è un tema di estrema importanza nel settore primario. La via e il tipo di informazione somministrata al consumatore possono portare all'accettazione o al rifiuto di questa partica innovativa.

Lo studio condotto da Vanhonacker et al. (2005) conclude invece che le informazioni riguardanti i potenziali benefici e/o rischi riguardo l'immunocastrazione non influenzano le attitudini dei consumatori.

Tuyttens et al. (2011) hanno messo alla prova il tipo di informazione: informazioni audio visive rivelavano un effetto maggiormente marcato rispetto a informazioni basiche e scritte: in questo studio gli studenti erano maggiormente a favore dell'immunocastrazione dopo la visione di video che mostravano i diversi metodi di castrazione. L'atteggiamento dei consumatori nei confronti dell'immunocastrazione cambia nei diversi paesi, differendo tra cittadini e allevatori, e all'interno della categoria degli allevatori (singoli vs. associazioni) e fra diverse professioni. Per esempio gli scienziati tendono a considerare l'immunocastrazione in maniera più favorevole rispetto ai produttori, i quali tendono invece ad esprimere preoccupazioni nei confronti della sicurezza degli operatori e la risposta da parte dei consumatori (Mancini et al. 2017) quest'ultimo in particolare quando è coinvolta

la filiera DOP/IGP (Mancini et al. 2018) Un elenco esaustivo riguardo le preoccupazioni espresse dalle parti interessate coinvolte nelle filiere suine in tutta Europa è dettagliato nel rapporto finale del progetto CASTRUM (Castrum 2016).

In accordo con gli studi sulla accettazione da parte dei consumatori, una limitazione comune è la ristretta o nulla conoscenza riguardo l'odore di verro, la castrazione dei suinetti maschi o le strategie alternative per ridurre tale odore (Tuyttens 2016). Perciò, per studiare l'atteggiamento e la percezione del consumatore devono essere prese in considerazione molte variabili come l'istruzione, il background sociale, il sesso e l'età dell'intervistato.

Nonostante la crescente attenzione al benessere animale, gli studi condotti sui consumatori hanno portato a risultati contrastanti sulla loro WTP (disponibilità a pagare, o Willingness To Pay) per carni provenienti da suini sottoposti ad immunocastrazione: uno studio condotto in 10 paesi nel 2013 (FCEC- Food Chain Evaluation Consortium 2013) ha stimato la WTP in 0,04€/kg. Vanhonacker et al. hanno esaminato i consumatori belgi e hanno riscontrato una WTP del 5%, nonostante un atteggiamento molto positivo nei confronti dell'immunocastrazione. Heid e Hamm (2013) hanno riscontrato tra i consumatori tedeschi una WTP negativa per la carne di maiale immunocastrata rispetto sia alla castrazione con antidolorifici/anestetici che all'ingrasso di maschi interi, ma una WTP positiva (+12%) per la carne di suini sottoposti a immunocastrazione rispetto alla castrazione senza l'utilizzo di analgesici e anestetici, come risultato del fatto che tutte le alternative presentano (percepiti) inconvenienti che costringono i consumatori a scendere a compromessi tra i diversi aspetti.

Lagerkvist et al. (2006) hanno riscontrato che la WTP per l'immunocastrazione è del 21% superiore a quella per la castrazione chirurgica tra i consumatori svedesi, che percepivano l'immunocastrazione come un'alternativa socialmente praticabile e accettabile. Dato lo scenario italiano (in cui la castrazione è necessaria perché i suini vengono macellati ad un peso corporeo ed età molto elevati, cioè dopo la maturità sessuale, e sono destinati a prodotti DOP -Denominazione di Origine Protetta-), e considerando i vantaggi dell'immunocastrazione in termini di benessere animale, lo scopo della seconda ricerca presentata in questo elaborato (Capitolo 4) è stato valutare l'atteggiamento dei consumatori italiani nei confronti dell'immunocastrazione, e come questo atteggiamento sia influenzato dal dettaglio delle informazioni e dall'ordine in cui le informazioni vengono fornite.

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Capitolo 2: Finalità della tesi

Questo elaborato racchiude studi riguardanti il benessere del suino pesante italiano e in particolar modo si concentra su alcuni aspetti che, se opportunamente modificati, potrebbero portare ad un miglioramento sensibile delle condizioni di benessere di questa categoria produttiva.

Come già indicato, gli aspetti oggetto delle ricerche che seguono hanno riguardato in primo luogo la percezione da parte del consumatore italiano del benessere in allevamento (e in particolare la sua disponibilità a consumare prodotti derivanti da suini immunocastrati); inoltre sono stati indagati gli effetti sul benessere (e sulla qualità delle carni e dei prodotti da esse derivati) di alcune caratteristiche dell'allevamento (disponibilità di spazio) e delle caratteristiche multifattoriali che intercorrono durante il trasporto verso la sede di macellazione.

La scelta di un ventaglio così ampio di tematiche e punti di vista ha avuto lo scopo, partendo dall'indagine su alcuni aspetti attualmente critici della filiera suinicola, di rappresentare la complessità delle relazioni fra i diversi stakeholders che la compongono, complessità che si traduce nella necessità di un approccio integrato volto al più ampio coordinamento possibile. Anche alla luce della attesa revisione della normativa sulla protezione dei suini, questa tesi ha avuto la finalità di fornire alcuni elementi scientifici che possano fungere da supporto nella adozione di atti normativi e di pratiche produttive che siano eticamente più rispettose e che includano anche, quando esse sono diverse rispetto ad altre categorie produttive, le specifiche esigenze della categoria del suino pesante.

I capitoli a seguire si compongono dei seguenti articoli, tutti editi presso riviste scientifiche internazionali:

- **CAPITOLO 3:** Rubini G, Nannoni E, Di Pasquale J, Martelli G, Sardi L, 2021. Update on animal welfare perception by Italian consumers: A descriptive survey. Italian Journal of Food Safety 10(3):9588. doi: 10.4081/ijfs.2021.9588.
- **CAPITOLO 4:** Di Pasquale J, Nannoni E, Sardi L, Rubini G, Salvatore R, Bartoli L, Adinolfi F, Martelli G., 2019. Towards the Abandonment of Surgical Castration in

Pigs: How is Immunocastration Perceived by Italian Consumers? Animals 9(5):198. doi: 10.3390/ani9050198.

- **CAPITOLO 5:** Nannoni E, Martelli G, Rubini G, Sardi L., 2019. Effects of increased space allowance on animal welfare, meat and ham quality of heavy pigs slaughtered at 160Kg. PLoS One. 14(2):e0212417. doi: 10.1371/journal.pone.0212417.
- **CAPITOLO 6:** Sardi L, Gastaldo A, Borciani M, Bertolini A, Musi V, Martelli G, Cavallini D, Rubini G, Nannoni E, 2020, Identification of Possible Pre-Slaughter Indicators to Predict Stress and Meat Quality: A Study on Heavy Pigs. Animals 10(6):945. doi: 10.3390/ani10060945.

Update on animal welfare perception by Italian consumers: a descriptive survey

Giulia Rubini[a], Eleonora Nannoni[a], Jorgelina Di Pasquale[b], Giovanna Martelli[a], Luca Sardi[a].*

[a] Department of Veterinary Medical Sciences DIMEVET - Alma Mater Studiorum University of Bologna, Ozzano Emilia (BO), Italia;

[b] Faculty of Veterinary Medicine – University of Teramo, 64100 Piano D'Accio, Teramo, Italia;

Italian Journal of Food Safety 10(3):9588. doi: 10.4081/ijfs.2021.9588

Abstract:
The aim of this study was to evaluate if and how the perception of animal welfare by Italian consumers and their purchasing behavior of animal-friendly foods have evolved in recent years. The research was carried out through a survey on a representative sample of Italian consumers (n=969). Responses showed that 69% of consumers declared to pay attention to animal welfare at time of purchasing, and they mostly acquired information about animal welfare through the mass media. In accordance with previous surveys, the categories perceived as having the highest welfare level were fish and dairy cows, whereas the lowest welfare level was attributed to broilers and pigs. Compared to previous surveys, Italian consumers seem to have improved their knowledge about the legislation on animal protection and increased interest toward animal welfare issues. However, they still find it difficult to identify animal-friendly labels, together with a lack of knowledge about non-conventional (e.g. extensive and organic) farming systems.

Keywords: Animal Welfare, Consumer Perception, Survey

3.1 Introduction

The quality of animal products is judged by economically developed societies also in relation to the ethics of their production strategies, including the impact on animal welfare and its possible consequences on food safety. Since genetic selection and management for high productivity may lead to more disease and poor welfare, consumers demand some major changes in animal-production systems (Broom, 2010). In this framework, Goldberg in 2016 defined the concept of "sustainable intensification" and suggested that if the welfare of farmed animals is improved, many of the human health consequences of intensified industrial production can be eliminated or reduced. As a consequence, animal welfare fully becomes one of the elements of the broader "One Health" approach.

Besides of the ongoing public debate about how farm animals should be treated, the issue related to which information on animals living conditions labels should convey still remains open (Vanhonacker and Verbeke, 2014; Clark et al., 2017; Mancini et al., 2018). Regulatory options should reflect public priorities, expectations and requirements (Bennett et al., 2012; FAWC, 2014).

At a national level, the declared interest of Italian consumers towards animal welfare is not always reflected in a transparent communication strategy and, to date, it is still difficult to identify animal-friendly products (i.e., products obtained under production schemes requiring levels of animal protection above the minimum mandatory levels) (EC, 2005; Di Pasquale et al., 2014). The situation is further complicated by the spreading on the market of several private labels referring to animal welfare that often do not contain any specific

indications on the rearing methods. For this reason, the effort being made at European level to develop transparent labeling that helps consumers to recognize foods obtained through greater respect for animal welfare, becomes of fundamental importance (Council of the European Union, 2020).

The aim of the present work was to investigate the case-study of Italian consumers and to provide an update on their perception of animal welfare and on their purchasing behavior with respect to animal-friendly foods. The results of the present research are compared with the outcomes of Eurobarometer surveys (EC 2005, 2007 and 2016) and with those from a previous study on a smaller, local sample of citizens living in Bologna area (Di Pasquale et al., 2014) in order to assess if and how Italian consumers perception of animal welfare has changed over the past years.

3.2 Case-study

A survey was carried out in Italy, between December 2018 and January 2019 by using the questionnaire reported by Di Pasquale et al. (2019).

Interviewees were contacted by a specialized agency (DemetraOpinioni.net S.r.l., Venice, Italy), with CAWI (Computer Assisted Web Interview) methodology. Overall, 1463 invitations were sent. Participation was voluntary and the information collected was processed and used completely anonymously after collecting the consent of the respondents.

The sample obtained was representative of the Italian population for gender, age (over 18 years) and geographical area (ISTAT, 2018). The questionnaire started with a socio-demographic section. A second section (14 questions) focused on consumer background (meat consumption habits, previous farm visits, attitude and perception towards the welfare of farmed animals) and knowledge (of animal protection laws and of animal-friendly foods).

Data are presented and discussed through a descriptive analysis.

To avoid redundancies, from this section of the text onwards the study by Di Pasquale et al. (2014) will be referred as "the previous 2014 study".

3.3 Outcomes of the survey and Discussion

Of the 1062 responses received, 93 were excluded (vegans, vegetarians, or consumers providing incomplete/partial answers), therefore the sample consisted of 969 respondents.

3.3.1 Socio demographic information and declared purchasing habits

Respondents were equally distributed between men (50%) and women (50%). Age class between 39 and 59 years was the most represented (44%), followed by the range 18-39 years (33%). With respect to education, only a few interviewees had low educational level (primary or secondary school, 10%), the majority had a high school diploma (55%) and 35% had a university (or higher) degree.

As regards employment, the three most represented categories were employees (26%), homemakers (11%) and retirees (11%). Students represented approximately 10% of the sample. Respondents lived mostly in urban centers (87%), with 49% out of them living in small-medium size cities (10 to 100 thousand inhabitants).

With respect to annual household income, 21,000-35,000€ was the most represented range (35% of the respondents), followed by the 11,000-20,000€ range (23% of respondents), and by the 35,000-50,000€ range (22%); lastly, the lowest income range (below 10,000€) included 10.5% of the interviewees and the remaining 9.5% were the wealthiest consumers (51,000-75,000€).

Overall, the socio-demographic characteristics of the sample are similar to those reported in the local previous 2014 study carried out in the area surrounding Bologna. The only differences between the two studies consists in consumers in the present study having a lower percentage of University degrees (35% vs. 45%), and an overall lower income level. These two differences can be explained by the fact that Bologna hosts an important University and that Emilia Romagna is one of the Italian regions having the highest income per capita (ISTAT, 2019).

No effect of the area of residence was observed on the importance that consumers attribute to animal welfare at the time of purchasing, with consumers living in urban areas assigning (on a 0-to-10 scale) an average score of 7.5, and those from extra-urban areas a score of 7.7. Since this kind of question may elicit a social desirability bias (a well described psychological phenomenon in which the interviewed tends to answer in order to please the interviewer or to appear in the most favourable light -Nowwood and Lusk, 2011), we proposed a wider scale in order to differentiate between the answers, that we were expecting to fall in the higher half of the scale for the large majority.

Consumers were then asked how often they do buy animal-friendly foods (i.e., products obtained respecting higher animal welfare standards compared to the minimum set up by legislation). Their answers did not differ depending on the area of residence: in both urban and non-urban groups, a significant proportion (41% and 43%, respectively) declared to buy animal-friendly products only sometimes, and 28% claimed to buy them always. Less than one third of respondents declared to never buy these products.

3.3.2 Knowledge of animal welfare

Consumers were asked if they had ever heard about animal welfare previously, and 78% said they did. This figure substantially differs from the previous 2014 study, in which only 65% of the respondents had heard before about animal welfare. This difference may be due to greater attention paid by media towards this issue in recent years and to the subsequent increased consumer concern, as already pointed out by the 2016 Eurobarometer (EC, 2016) in which the absolute majority of Europeans (94%) believed that it was important to protect the welfare of farmed animals.

As concerns the source of information about conditions under which farm animals are kept, most respondents indicated mass media and internet (66%), which were confirmed to be over the years the main sources through which consumers get information (68% in the previous 2014 study). The other main source of information was visiting farms (11% of the sample had visited a farm at least once).

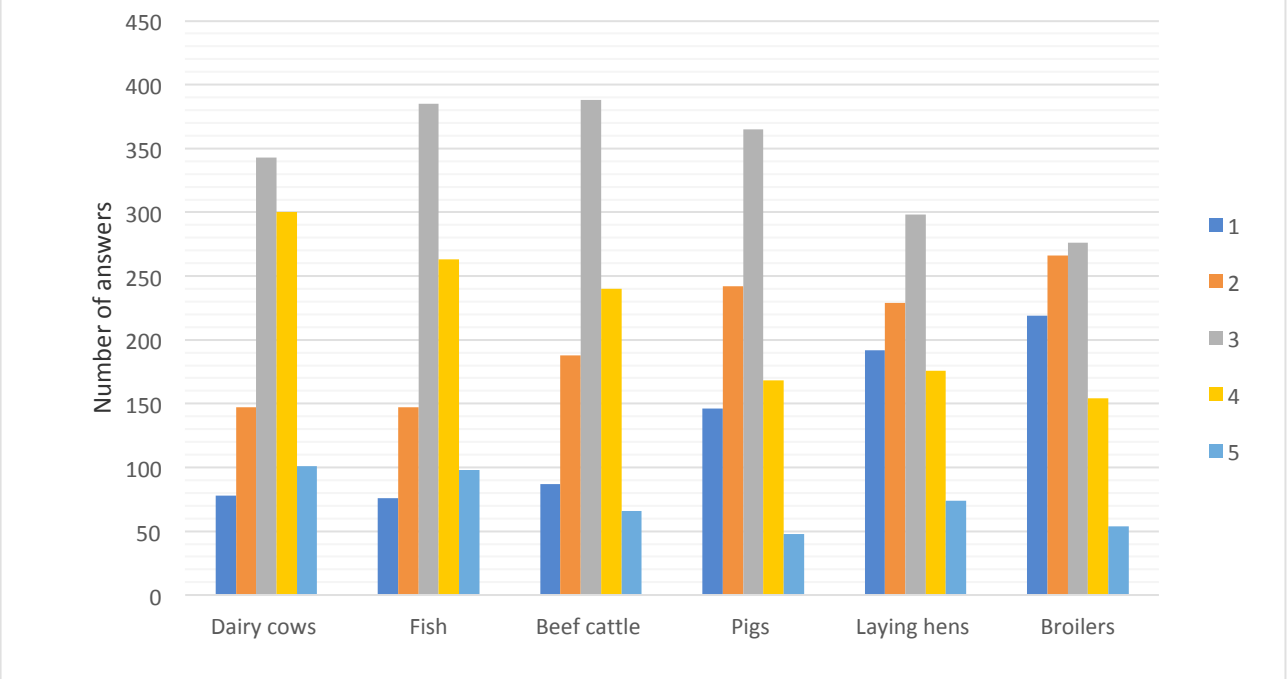
3.3.3 Perception of animal welfare

Those who have acquired direct knowledge of the conditions of the animals through visits to farms assigned, on a 0-to-10 scale, a slightly higher score (7.8) to the importance of animal welfare in their purchasing choices compared to the overall average (7.5). Despite the two questions might not be fully comparable (on the one hand the psychological attitude and on the other hand the economic intention to spend more is investigated), this result does not seem to fully agree with the 2005 Eurobarometer (EC, 2005), in which mainly consumers having repeatedly visited farms were more willing to pay the highest premium price (+25%) for animal-friendly eggs. Our results can be explained by the fact that nowadays more consumers, due to media campaigns and regardless of their direct experience, may be more interested and concerned about animal welfare, therefore opting more easily for "animal-friendly" foods when the animal welfare content is made explicit to the consumer. As discussed in the "purchasing behavior" section, a peculiar consideration applies to the organic method. These products, in fact, are generally marketed using claims about their

overall quality rather than their animal-friendliness. Therefore, their animal welfare content is in fact only marginally known by consumers.

Respondents were also asked to indicate (on a 1-to-5 scale) the perceived level of welfare on farms of different species/production categories (Figure 3.1).

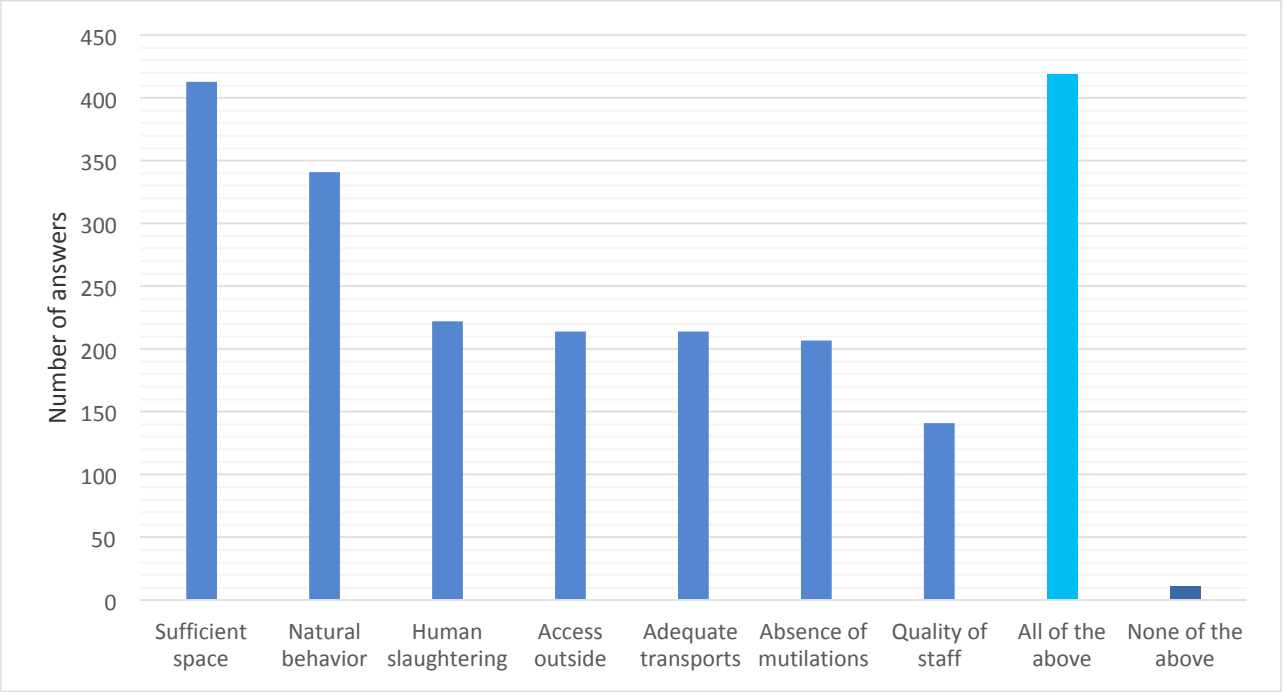
Figure 3.1: Answers to the question 'Please evaluate on a 1-to-5 scale (where 1=minimum welfare; 5= maximum welfare) the level of welfare of the following species on farm.'



Species/categories perceived as having the highest welfare level were fish and dairy cows. The category showing the lowest welfare level was broilers (22% of respondents assigned the minimum welfare score and 27% a value just above). The welfare level of pigs was also perceived as low: 15% of consumers attributed score 1 and 25% a score of 2. These responses reflect those reported in previous surveys (Di Pasquale et al., 2014; EC, 2005). On average, dairy cow welfare level was scored 3.2, followed by the welfare of fish (3.1), beef cattle (3.0), pigs and laying hens (2.7), and broilers (2.5).

To further assess consumers knowledge, we asked which, in their opinion, are the essential factors affecting animal welfare level (Figure 3.2).

Figure 3.2: Answers to the question 'Which, among these aspects, are the most important in determining the level of animal welfare?' (multiple answers allowed)



The most frequent answer (86% of consumers) was 'availability of space', and this result agrees with the previous 2014 study. The second most important factor (identified by 78% of respondents), was the 'possibility for animals to express their natural behaviors'. 'Access to outside areas', 'adequate transport' and 'absence of mutilations' were equally-important factors for consumers (approximately 65% of the interviewees), immediately followed by 'presence of trained stock-people' (58%). These answers reveal that consumers have a clear view on which needs must be met in order to attain a high welfare level; however, this awareness is in contrast with the observed insufficient knowledge of the characteristics of the different production systems and chains (see below).

Contrarily, it is interesting to note that a study carried out almost twenty years ago in Italy (Miele et al., 2001), had shown that, for Italian consumers, the main aspect to be safeguarded against welfare was 'quality of feed'. However, it should be remembered that the end of the 20th century coincided with the 'mad cow disease' scandal, which drew great attention to animal feeding practices and their effects on human and animal health.

Consumers were also asked to answer the question 'Which production phases are regulated by laws on animal protection?' (multiple answers were allowed). Most consumers (66%) believed all stages of the process (farm, slaughtering and transport) being regulated, 20% were aware of the existence of laws regulating animal farming, 19% feeding, 14% slaughtering and 12% transport. Only 5% of the respondents were unaware of any legislation on animal protection. These results deeply differ from those obtained from previous surveys. In 2005, 19% of European consumers (and 17% of Italian ones) were unaware of any legislation on farm animal protection (EC, 2005). In the previous 2014

study, 34% of Italian consumers believed that no production phase was regulated. Albeit with the necessary cautions in comparing surveys carried out on samples of different size and geographical location, these so discordant data might suggest a positive evolution in the knowledge of Italian consumers, possibly indicating also a better awareness regarding the law in comparison with the situation encountered previously.

3.3.4 Purchasing behavior

In the present survey, 69% of consumers declared to pay attention to animal welfare at time of purchasing (as above mentioned, 28% declares to always buy animal-friendly products and about 40% only sometimes). This result is slightly higher than that observed in the previous 2014 study, when 64% of consumers declared to pay attention to buy products with an increased level of animal welfare. In 2005 the share of Italian consumers paying attention to the welfare/protection of the animals at time of purchasing meat was lower (20% most of the times and 31% sometimes) (EC, 2005).

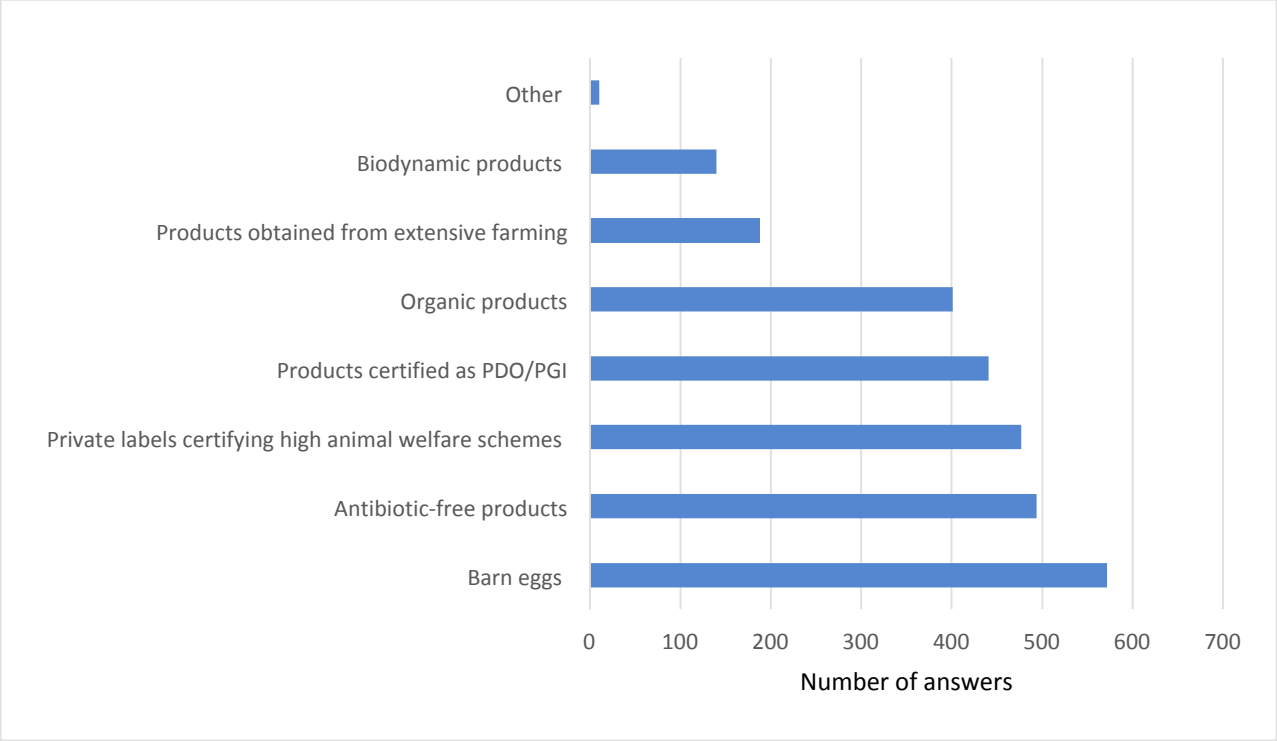
A further question analyzed the role of animal welfare in affecting purchasing choices. Consumers were asked to assign a score from 0 to 10 (with 0="not at all" and 10="extremely") to the importance they attributed to animal welfare at time of purchasing. Most respondents (82%) chose a value equal or above 6 (average score: 7.5), and 25% of consumers assigned a score of 10 (maximum importance), while only 18% assigned a score from 0 to 5.

In our study the income range of the interviewees slightly affected the importance attributed to animal welfare in an unexpected way. About one third (27%) of those who had an annual income below 10,000€ assigned a score of 10, similarly to the highest income class (over 75,000€; 33%). In contrast, only 2% of the lower income range gave no importance to animal welfare in their purchasing choices, compared to the higher income range where 4.8% assigned a score of 0. In the intermediate ranges (from 11.000 to 75.000€) there were no evident trends in consumers' attitudes. From these data it could be deducted that the income level would have only a marginal effect on the importance that consumers give to animal welfare. In this sense, this result does not agree with previous findings (EC, 2005) in which unemployed people and students appeared to be the least concerned. In our study, these same categories assigned an average score of 8.1 to animal welfare, i.e. a value only slightly lower than the general average (8.4) and in any case higher than that of other theoretically richer categories (entrepreneurs score of 7.9 and managers score of 8.0).This result could be very interesting in the light of a possible trend reversal in the correlation between consumers' income and the importance assigned to animal welfare at the time of purchasing. There is wide consensus in the literature that women, younger

participants, pet owners, and those who had spent longer in education and had higher income rates showed the highest concern and were more likely to be willing to pay for welfare-friendly products (Alonso et al., 2020). Therefore, the sensitivity toward animal welfare and other ethical issues is both a matter of education (i.e., instruction level) and individual consciousness (as affected also by socio-demographic characteristics). In our study, it is possible that the high education level observed between the interviewees, together with the high availability of good quality public education institutions in Italy, without quality differentiations with private schools (Bertola et al., 2017), may have had a role in determining the lack of correlation between income and concern for animal welfare. Another, merely speculative, factor, which however cannot be substantiated by objective data, may concern the truthfulness of the annual income declared by the interviewees. Regardless of the impossibility of verifying such data, any false claims would represent a systematic error that would affect the entire sample without substantially changing the result. Furthermore, the tax gaps in Italy are due for the vast majority to VAT (mainly by self-employed workers), and to IRPEF evasion (by self-employed workers and entrepreneurs) (Senate of the Republic, 2021) represent, on the whole, a limited share of our sample (about 10%). However, even if the disposable income does not seem to directly influence the sensitivity and perception of consumers, it undeniably impacts on the real possibility of purchasing animal-friendly foods. In this framework, Clark et al. (2017) highlighted that younger respondents were more willing to spend more for animal welfare, although presumably they had less availability, and that this attitude decreased as age increased.

Despite the purchasing habits declared by the interviewees, it is clearly difficult for consumers to correctly identify animal-friendly products given that, on the European market, labels based on higher animal welfare standards are mainly voluntary and often diversified as there is no harmonized certification covering the whole EU territory. Therefore, communicating to the consumer an additional commitment by the producer on animal welfare may remain problematic. According to the 2005 Eurobarometer surveys (EC, 2005 and 2007), 51% of European citizens could rarely/never identify such products, with deep differences among countries. To assess Italian consumers' ability to identify animal-friendly products, they were asked to choose from a list which products were, in their opinion, obtained respecting higher animal welfare standards (Figure 3.3).

Figure 3.3: Answers to the question 'What products are obtained respecting high animal welfare standards? (multiple answers allowed)'

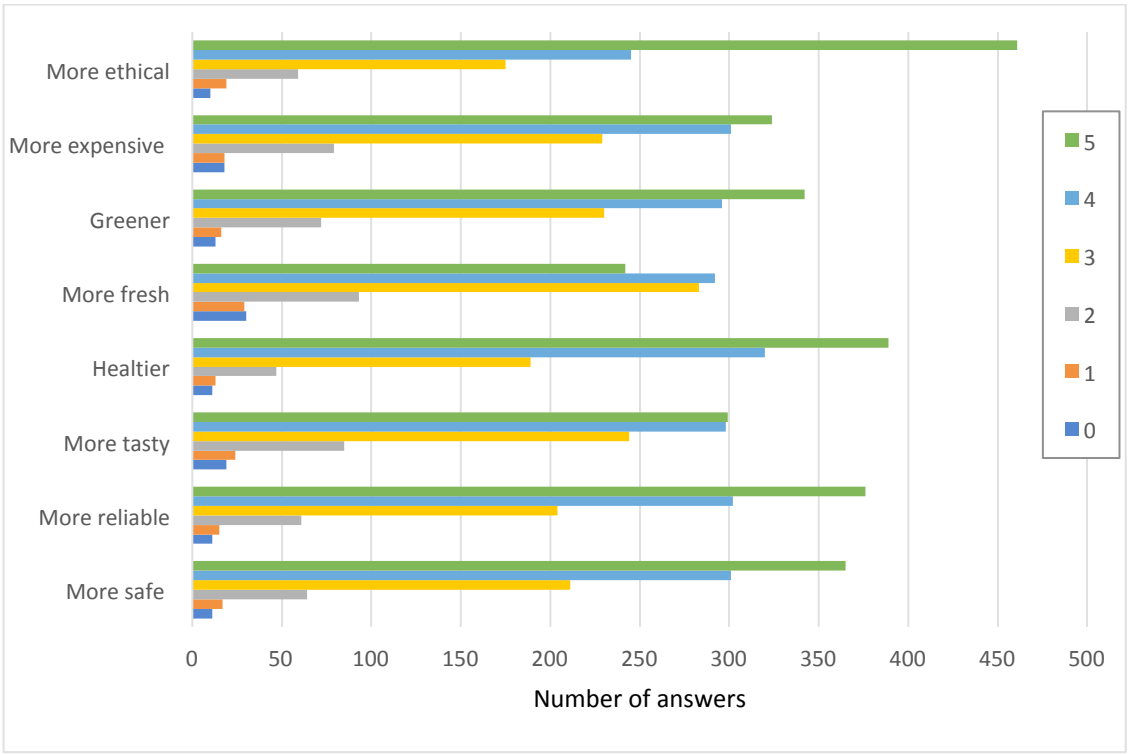


The list of products included also certification having no relevance to animal welfare. According to interviewees, barn eggs are the products that most respect animal welfare (59% of answers), followed by antibiotic-free products (51%), private labels certifying higher welfare standards (49%), products certified as PDO (Protected Designation of Origin)/PGI (Protected Geographical Indication) (45%) and organic products (41%). Products obtained from extensive farming (19%) and biodynamic agriculture (14%) are considered much less impacting on animal welfare. Similar values were reported for PDO, PGI and organic products in the previous 2014 study. The discrepancy beetween the shares of consumers indicating organic products (41%) and extensive farming (19%) as animal friendly indicates the persistence of a certain degree of linguistic confusion, with consumers regarding the concept of 'extensive farming' as less animal-friendly than the organic method, despite the fact that the organic method is a regulated example of extensive farming. It is therefore thinkable that the meaning of the adjective 'extensive' has not been fully understood or, alternatively, that the word 'farming' is perceived as something restrictive and coercive *per se*. It is likely that consumers did not consider that in extensive systems animals have higher space allowances and are normally allowed outdoor

access (thus meeting the expectations of consumers in terms of factors mostly affecting animal welfare). It is also very interesting to note that in the previous study the majority of respondents (65%) indicated 'non-intensive farming' as a high- welfare system. It is therefore arguable that consumers may have attributed to the negative particle 'non', placed before the term 'intensive', a prevailing role in comparison with the term 'extensive' used in the present study. This latter consideration emphasizes, for this kind of surveys, the importance of the way the question is formulated and its influence on the corresponding answer. It is worth noting that more than one half of the respondents associated a greater welfare level with products deriving from 'antibiotic free' systems. This percentage is higher than that reported in the previous 2014 study (40%) and it may be related to the growing concern about the problem of antibiotic-resistance which, in recent times, has been widely brought to the attention of the public. It is therefore arguable that Italian consumers may not be fully aware that also the organic method strongly discourages and limits the use of allopathic drugs. Furthermore, organic farming guarantees better conditions than conventional systems for satisfying the physiological, ethological, and developmental demands of animals (Scozzafava et al. 2019). Despite of all the aforementioned considerations, organic products are deemed less respectful of animal welfare than other certified foods (such as PDOs and PGIs) which often do not include in their regulations specific elements indicating animal protection levels beyond the minimum requirements established by law. This attitude could be explained by the fact that, at a communication level, organic productions have generally mainly focused on food safety rather on animal welfare level and health (Martelli et al., 2010). Another hypothesis is that consumers may think that the organic production is strictly addressed to the production of foods of vegetable origin instead of being also applied to animal rearing.

When invited to indicate the characteristics that differentiate animal-friendly from conventional products (Figure 3.4), about one half of the respondents assigned the highest score (5) to their higher ethical content (48%), followed by higher healthiness (40%), safety and reliability (38%), and environmental sustainability (greener: 35%).

Figure 3.4: Answers to the question 'Please indicate the degree of agreement/disagreement with each of the following statements: Products obtained respecting high animal welfare standards are also... (0= completely disagree; 5= completely agree)'



These results confirm the existence of a perceived link between ethics and food safety. However, the higher price of animal-friendly products, that from a practical standpoint cannot be disregarded due to its possible negative impact on actual purchasing behavior, was pointed out by more than one third of the interviewees.

3.4 Conclusions

With the exception of improved knowledge on the legislation on animal protection and of increased interest toward animal welfare and related issues (demonstrated also by lower-income consumers), our findings on a large sample of Italian consumers basically confirm those reported in a previous, local survey (Di Pasquale et al., 2014).

The issue that remains unsolved is that related to a lack of ability in correctly identifying products obtained following animal welfare standards above the minimum mandatory levels, i.e. animal-friendly foods.

The problem is further complicated by the observed lack of knowledge on non-conventional rearing systems (extensive farming and organic method). These latter should theoretically meet consumer expectations in terms of space availability and expression of the behavioral repertoire of animals thus leading to a higher level of perceived/actual animal welfare. It is therefore advisable that, in order to fill this knowledge gap, the population should be made aware of different farming systems and a more transparent and less heterogeneous labelling approach should be adopted.

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"Towards the abandonment of surgical castration in pigs: how is immunocastration perceived by Italian consumers?"

Jorgelina Di Pasquale[1], Eleonora Nannoni[2,], Luca Sardi[2*], Giulia Rubini[2], Renato Salvatore[3], Luca Bartoli[3], Felice Adinolfi[2], Giovanna Martelli[2]

1 Faculty of Veterinary Medicine – University of Teramo, 64100 Piano D'Accio, Teramo
2 Department of Veterinary Medical Sciences · University of Bologna, Via Tolara di Sopra 50, 40064 Ozzano Emilia (BO) – Italy
3 Department of Economics and Law · University of Cassino and Southern Lazio, Viale dell'Università, 03043 Cassino (FR) – Italy

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Simple Summary: The European Declaration on alternatives to surgical castration of pigs was aimed at abandoning the surgical castration and switching to alternative techniques. Immunocastration (a vaccination against Gonadotropin Releasing Hormone) can be a viable alternative method. This technique offers some advantages in terms of animal welfare compared to surgical castration**.** Nevertheless**,** the main obstacle to the diffusion of immunocastration seems to be related to consumers' acceptance, since the use of new technologies in the food chain often generates mistrust. The objective of this research was to assess how immunocastration is perceived by Italian consumers, and how complex and complete information (on advantages and disadvantages of the technique) can influence their perception. The results show that immunocastration is perceived in a predominantly positive manner (54.5%), with a relatively low level of risk perception (34.2%) and a good willingness to pay more for meat from immunocastrated pigs (+18.7%). However, there were no statistically significant differences between the control group (receiving only a neutral technical information) and groups to which complete and complex information was provided.

Abstract: Immunocastration of pigs represents an alternative method to surgical castration, being more respectful of animal welfare. However, this new technology may not be accepted by consumers due to their perception of possible risks tied to the use of the product, thus representing a concern for the production sector. The study aimed at verifying the attitude of Italian consumers towards immunocastration and to assess whether their perception can be affected by science-based information on advantages and disadvantages of immunocastration. A total of 969 consumers (divided in three groups representative of the Italian population) was contacted and asked to complete an online questionnaire. Only technical (neutral) information on immunocastration was provided to the first group; the second and the third group received information on the advantages (+) and disadvantages (-) of the technique, shown in reverse order (+/- and -/+, respectively). The level of information did not affect consumers' perception of immunocastration. Overall, immunocastration is perceived in a predominantly positive manner (54.5%), with a relatively low level of risk perception (34.2%), and a good willingness to pay more for meat deriving from immunocastrated pigs (+18.7%).

Keywords: animal welfare; consumer; willingness to pay; pig; castration, immunocastration, information; survey

4.1. Introduction

Since 3000-4000 BC male piglets are surgically castrated for diverse reasons [1]: first of all, to reduce the occurrence of boar taint, which is an objectionable odor and flavor meat deriving from entire males. The boar taint is associated with androstenone (a testicular steroid) and skatole (which is bacterially produced from tryptophan degradation in the hindgut of the pig) [2]. The second reason for castration is to reduce aggressive and sexual behaviors [3]. As side effect of castration, it favours a higher fatness degree [4], which is appreciated for peculiar production schemes.

At present, surgical castration is the most frequently applied method in piglets [5]. In agreement with EC Directive 2008/120, this procedure is usually carried out within the first 7 days of life, with minimal (or not at all) pain relief and/or anesthesia; surgical castration is an obviously painful and stressful procedure that undermines piglet's welfare possibly resulting in detrimental effects on growth, the immune system and hence on the health of animals [6]. In 2010, the European Declaration on alternatives to surgical castration of pigs [7] recommended to switch to alternatives (such as castration with anesthesia and/or analgesia, raising entire males, sperm sexing and immunocastration), with the aim to abandon castration by 2018, with the exception of pork meat for products under "Traditional Speciality Guaranteed -TSG", "Protected Geographical Indication PGI" or "Protected Designation of Origin -PDO" labels, for which castration is deemed to be unavoidable to meet the current quality standards [7]. Although to date the target set by the Declaration has not been met by most European countries, the use of local anesthesia during surgical castration is mandatory in Norway since 2002, and in Switzerland but by using general anesthesia [5].

Immunocastration is a viable alternative to surgical castration. It consists in a vaccination against GnRH (Gonadotropin Releasing Hormone), through the administration of a protein-conjugate analogue of GnRH which results in the production of antibodies against the animal's own GnRH. This subsequently stops the synthesis of LH (Luteinizing Hormone) and FSH (Follicle Stimulating Hormone) with consequent testis regression and reduced production and accumulation of steroid hormones, including boar taint-causing androstenone [8]. Immunocastration therefore controls boar taint and aggressive and sexual behavior [3, 9]. This minimally invasive technique offers some advantages compared to surgical castration: absence of acute pain, reduced stress [10] and simplified handling (it consists of a subcutaneous injection at the base of the neck, just behind the ear). Some studies have also shown that immunocastrated pigs have a better feed conversion ratio and their carcasses have a higher percentage of lean meat than surgically castrated animals [4,5,11]. This could be due to the fact that two administrations of the vaccine are needed

for a full response in pigs: the first one is aimed to prime the animals' immune system and the second one is applied when animals approach their sexual maturity [8]. Until the second injection, the immunocastrated males are physiologically more similar to entire males than to surgically castrated animals, with consequent higher lean meat yield, potentially lower environmental impact and higher cost efficiency [2,12,13,14]. Other studies found no differences in terms of carcasses and meat quality [1].

According to the recommendations for vaccine administration, the first injection should be given at week 17-18 or earlier, while the second should be administered at 21-22 weeks old if the pigs are slaughtered at 26 weeks old [15]. For pigs slaughtered at higher age and body weight (such as Italian heavy pigs intended for PDO dry-cured hams), a third dose becomes necessary to control boar taint [8].

The drawbacks of immunocastration are tied to the possibly increased costs for the farmer (purchase of the product and workforce for its administration), the risk of accidental self-injection by the farm workers, and the uncertain consumer's attitude towards meat from pharmacologically castrated animals. From the economic point of view, surgical castration with local anaesthesia could represent a less expensive option in comparison with immunocastration. On the other hand, immunocastration seems to result in better feed conversion rate which can compensate the costs of vaccination, particularly in Italy where pigs are slaughtered at a very high body weight (about 170 kg) [16]. As regards the risks for farm workers, accidental self- injection may produce similar effects in people to those seen in pigs (temporary reduction in sexual hormones and reproductive functions in both men and women, adverse effect on pregnancy), with increased risk after a second or subsequent accidental injection. Therefore, according to specifications, the vaccine must only be administered with a safety vaccinator having both a needle guard and a mechanism to prevent accidental operation of the trigger [15].

One of the issues that most concerns the primary sector seems to be related to consumer acceptance. Some studies have investigated consumer's attitude towards immunocastration [17-26]. These surveys identified two main aspects: concerns for food safety and sensitivity towards animal welfare. Based on their attitudes towards these topics, EU consumers can be divided into two main groups: one broadly in favor and other one broadly against immunocastration [17]. Across the mentioned studies, participants expressed mainly favorable attitudes towards the abandonment of castration without anesthesia and analgesia and its substitution with alternative methods, although in some cases they expressed some apprehensions about immunocastration [18, 26]. In a Norwegian study, despite their considerable trust in national control authorities, respondents were skeptical towards immunocastration, due to concerns about possible

residuals in meat and unpredictable long-term consequences for consumers' health. On the other hand, these consumers categorically refused surgical castration without anaesthesia [18]. Similarly, a study carried out in Italy confirms consumers' skepticism about the use of immunocastration in pigs intended for the production of traditional products (PDO and PGI) with doubts similar to those indicated by Norwegians [17]. Only few studies focus on the role that information plays on the consumer's acceptance of immunocastration. The field of information is a topic of extreme importance for the primary sector. The way and the type of information provided to the consumer can result in the acceptance or refusal of an innovative production technique. The study carried out by Vanhonacker et al. [5], concludes that information concerning the potential benefits and/or risks of immunocastration does not affect much consumers' attitudes. Tuyttens et al. [20], stressed the role of information type: audiovisual information revealed a more marked effect than basic and detailed written information: students were more in favor of immunocastration after viewing videos showing the different methods of castration. Consumers' attitudes towards immunocastration change across countries, differs between citizens and stakeholders, and between different stakeholder categories (individuals vs. organizations). For example, scientists tend to consider immunocastration more favorably than producers, which tend to express worries about operator safety and public acceptance [19], this last in particular when the PDO/PGI supply chains is involved [17]. An exhaustive list of concerns expressed by the stakeholders involved in the pork chains across Europe is detailed in the final report of the CASTRUM project [27]. With respect to studies on consumers' acceptance, a common limitation is is the very little knowledge about boar taint, castration of male piglets or alternative strategies to reduce the occurrence of boar taint [20]. Therefore, in order to study consumer's attitude and perception many variables such as education, social background, gender and age of the respondent need to be accounted for.

Despite the increasing attention toward animal welfare, studies carried out on consumers led to conflicting results on their WTP (Willingness To Pay) for immunocastration: a study carried out in 10 countries in 2013 [28] estimated the WTP in 0.04€/kg of pig meat. Vanhonacker et al. [5] examined Belgian consumers and found a 5% WTP, despite a very positive attitude towards immunocastration. Heid and Hamm [29] found among German consumers a negative WTP for immunocastrated pork compared to both castration with pain relief and fattening of entire males, but a positive WTP (+12%) for immunocastrated pork compared with castration without pain relief, as the result of the fact that all the alternatives have (perceived) drawbacks that force consumers to make trade-offs among different aspects. Lagerkvist et al. [30] found WTP for immunocastration to be

21% higher than that for surgical castration among Swedish consumers, who perceived immunocastration to be a socially viable alternative to castration without anaesthesia.

Given the Italian scenario (castration is necessary because pigs are slaughtered at a very high body weight, i.e. after sexual maturity, and they are intended for PDO, i.e. high quality, products), and considering the advantages of immunocastration in terms of animal welfare, the aim of the present study is to assess the attitude of Italian consumers towards immunocastration, and how this attitude is influenced by the extent in the detail of the information, and by the order in which information is provided.

4.2. Materials and Methods

4.2.1 Questionnaire and consumers sample

A questionnaire was formulated and submitted to a sample of 969 Italian consumers. The questionnaire can be found in the Supplementary Materials (Section 4.6). The survey was carried out in Italy, between December 2018 and January 2019. Interviewees were contacted by a specialized agency (DemetraOpinioni.net S.r.l., Venice, Italy), with CAWI (Computer Assisted Web Interview) methodology. Participation quotas were identified in order to obtain three representative samples of the Italian population for gender, age (over 18 years) and geographic area (Northwestern, Northeastern, Center, South, Islands) [31]. People below 18 years of age, people who do not consume swine meat (or cured products) and people exceeding quotas were excluded from the survey. A total of 1463 invitations were sent and 1062 answers to the survey were received. Of these, 56 interviews were screened-out (people excluded from the survey because they were vegans, vegetarians or non-consumers of pork). The size of the remaining sample was 1006 consumers. However, after a quality control, 37 interviews were excluded from the sample (e.g. incomplete forms, partial answers). The final sample was of 969 Italian respondents. The average completion time was 15 minutes.

After filling the socio-demographic section (gender, age, occupation, education, household size and income, area of residence -rural vs. urban), all consumers were asked to respond to a ***first part*** of the questionnaire (14 questions) focusing on:

- consumer background (meat consumption habits, direct visual experience through visits of animal farms, attitude and perception towards the welfare of farmed animals);
- consumer knowledge (on animal-friendly foods, on swine castration).

Consumers were then asked to read attentively a short paragraph (approximately 12 lines) containing general information on the reasons why pigs are castrated, on how this procedure is at present carried out mainly surgically, and on immunocastration as

a possible alternative to surgical castration. The paragraph contained technically neutral information. The information was preliminarily evaluated by a group of experts in the field of swine science and pre-tested on a small group of consumers (15 people), and was therefore modified in order to eliminate all the words that could bias the perception of the interviewees. For example, words unfamiliar to the general public or which may generate a greater sensitivity (e.g., "piglet") have been accurately avoided, together with words suggesting advantages or disadvantages of one technique respect to the other.

All consumers were then asked to express their level of agreement with:

- the need to abandon surgical castration without pain relief and/or anaesthesia;
- the use of immunocastration.

For the ***second part*** of the questionnaire, the three groups of consumers previously identified were asked to answer to three different questionnaires, in order to study whether the information provided could affect their attitude towards immunocastration, their WTP and propensity to consume pork obtained with this technique and their risk perception.

The three groups filled the questionnaire as follows:

1. "Neutral information" group (N) (n= 319). This group, after reading the general paragraph described above, was asked to answer a short group of questions (8) on:
   - their preference in purchasing pork obtained either with the different methods of castration (surgical; surgical with analgesia and/or anesthesia, immunocastration, or meat from entire pigs or from pigs selected -genetic improvement- for low boar taint);
   - their WTP a premium price for these products;
   - their perceived risk with respect to immunocastration.
2. "Positive-negative information" group (+/-) (n= 323). This group, immediately after the first part of the questionnaire, was asked to read attentively a short paragraph on the advantages of immunocastration ("positive information") in comparison with surgical castration (reduction in animal pain and discomfort, absence of negative effects on meat quality together with an improved feed efficiency in some cases). Immediately after, these consumers were asked to read a short paragraph ("negative information") on the disadvantages of immunocastration (increased production costs and accidental self-injection risks for farm workers). Lastly, they were asked to respond to a set of questions (11) on
   - their preference in purchasing pork obtained either with the different methods of castration (surgical; surgical with analgesia and/or anesthesia,

immunocastration, or meat from entire pigs or from pigs selected -genetic improvement- for low boar taint);

- their WTP a premium price for these products;
- their perceived risk with respect to immunocastration.

3. "Negative-positive information" group (-/+) (n= 327). This group was presented with exactly the same information and questions than the +/- group, but information was presented in reverse order (first the disadvantages and then the advantages of immunocastration).

The reverse order of presentation of the +/- information to these latter two groups was aimed to avoid any influence due to the order of presentation itself.

Given that the additional information was provided in two subsequent steps, positive/negative or vice versa, we defined this information as "complex". Overall information consumers of groups 2 and 3 owned by the end of the questionnaire (neutral and positive/negative, regardless of the order in which this latter was received) is defined as "complete information".

4.2.2 Statistical analysis

Statistical analysis was carried out using SPSS software (v. 25.0). The dataset was organized in 3 groups according to the sampling methodology and the kind of information provided to consumers, and a one-way ANOVA was used. In the "neutral information" group, the perception of immunocastration was tested after providing technically neutral information, whereas in the other two groups the difference in perception was tested after providing technically neutral information and after providing the complex and complete information. Similarly, ANOVA was applied to the variables related to the willingness to consume products obtained with the use of immunocastration, the WTP and the risk perception.

Brown and Forsythe [32] and the Welch [33] tests were carried out. Using absolute deviations from the group medians, the Brown-Forsythe is a robust test for data that potentially violate the assumption of normality. The test compares the variance within each group with the median value of the variance across groups. The Welch test is an alternative test for the one factor analysis of variance F-test. It is a parametric test for equal population means, to be used when we do not have equal population variances.

Moreover, pairwise comparisons, by using Tukey HSD [34], Duncan [35], and Scheffe [36] post-hoc tests, were carried out to confirm the absence of significant differences between all possible pairs of averages. The Tukey test is a non-parametric test which in our case is particularly suitable since it is structured for data measured in ordinal scales. To

confirm the validity of the test, two other *post-hoc* tests were run: the Duncan test (commonly used in agronomy and in other agricultural economics research), which is more protective against the type II error (although it implies a greater risk of type I errors), and the Scheffe test, which is a more flexible test and was used only as confirmation and reinforcement of the goodness of the ANOVA analysis.

Statistical significance was set at $P<0.05$ for all tests.

4.3. Results

4.3.1 Consumers background and knowledge on animal welfare

According to our results, the direct knowledge of Italian consumers regarding animal welfare can be defined as very limited. Only 12.6% of the interviewees gathered their knowledge through direct visiting of farms, and for about half of them this experience was sporadic (1 or 2 farm visits in their lifetime). About one fifth (21.2%) of the responders say to have no knowledge on issues related to animal welfare and 66.3% have received their information through the mass media.

Among those who visited a farm at least once, the most common species seen is swine (n=84), followed shortly by beef cattle (n=79), while the less observed species is sheep (n=4) (multiple answers allowed – total number of answers received: 411).

In general, consumers believe that avian species are those having the worst welfare conditions. On a Likert scale with a score of 1 to 5 (where 1 = minimum welfare, 5 = maximum welfare), broilers have an average score of 2.54 and laying hens 2.70. Pigs do have a level of welfare comparable to that of laying hens (2.72), while dairy cows and beef cattle get relatively higher scores (3.2 and 3.0, respectively).

On a scale from 0 to 10 (with 0 = "not at all" and 10 = "extremely"), 82% of respondents attributed a value equal or higher than 6 to the importance of animal welfare during purchases. In particular, a quarter of the interviewees stated that they attribute a valor equal to 10 to animal welfare. The average value attributed by the whole group of respondents was 8.4.

The large majority of consumers (69.7%) declared to purchase food obtained respecting a level of animal protection higher than the minimum set up by legislation; out of them,40% declare to do it always, while the remaining 60% only sometimes. Among consumers who purchased these products, 59% bought organic foods or products obtained from animals having an outdoor access. However, only one half of those giving very high importance to animal welfare at time of purchasing (score 10 = extremely) declare to buy "animal friendly" products always.

4.3.2 Consumers knowledge and perception on swine castration

Only about a quarter of respondents (n=259) are aware that male pigs undergo castration within the first week of their life. On a total of 381 selections made (multiple answers were allowed), 198 answers indicated that this practice is aimed to improve meat quality or meat production and 106 indicated that castration is aimed to avoid boar taint.

After reading the short "neutral" paragraph, respondents were asked to express their level of agreement with the abandonment of surgical castration (without anesthesia and/or analgesia) in favor of alternative methods. 68% of respondents agreed (i.e., scores equal or above 6 on a 0-to-10 Likert scale) with the abandonment of surgical castration without anesthesia and analgesia and with the implementation of alternative castration techniques. Approximately two out of three respondents expressed a positive score (equal to or greater than 6) and more than a quarter (28%) was extremely in favor of immunocastration (scores 9 and 10).

When asked to choose among meat from surgically castrated pigs (with or without anesthesia and/or analgesia) or from animals subject to alternative methods (such as immunocastration, breeding of entire males, or animals genetically selected to not express the boar taint), consumers indicated a clear preference towards products obtained through the use of immunocastration (34%), followed equally by entire males and pigs surgically castrated with anesthesia (20.8 and 20.4%, respectively). Genetic selection was the penultimate choice (16%), followed only by surgical castration without anesthesia/analgesia.

However, at the end of the first part of the questionnaire, apprehension about immunocastration was expressed by 23% of the respondents, on the other hand, 19%, has no fear of this technique, but the remaining 58% was undecided about whether the vaccine is harmless or not. Among the consumers who perceived risks or were undecided at the previous question (n=782 consumers), 596 answers express concern about "possible unknown long-term risks", 478 about residues in meat, and 255 indicated apprehension for pigs' health (multiple answers allowed – total answers received: 1329).

4.3.3 Effect of complex and complete information on pig immunocastration

Immediately after providing neutral information to all three groups, they were asked to indicate their degree of agreement with the use of immunocastration on a scale from 0 to 10. This answer will be defined as "starting point" in the results description below.

The same question was then repeated only to the second and the third groups ("positive-negative group" and "negative-positive group") after they had received the complex

and complete information. This second answer to the question will be defined as "ending point" in the results description below. It is intuitive that, for the neutral group, the starting point and the ending point coincide.

Table 4.1 shows the results for the question "Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration (0 = completely disagree, 10 = completely agree)"

Table 4.1 - One-way ANOVA results for consumers' answers to the question "Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration (0 = completely disagree, 10 = completely agree)" after receiving different levels and complexity of information

	Total	**Information (Means)**			**ANOVA**	
	Mean (n=969)	**Neutral (n = 319)**	**Complete +/- (n = 323)**	**Complete -/+ (n = 327)**	**F-test**	***P*-value**
Starting Point	6.18	6.40	6.14	6.00	1.321	0.267
Ending Point	6.36		6.31	6.38	0.09	0.914

The analysis shows no significant differences of variances among groups at the starting point. Therefore, the three groups can be considered homogeneous at the beginning of the questionnaire. Moreover, taking into account the order of the information presented, there are no significant differences at the end point after complete information has been given to the second and the third group, confirming the impossibility to reject the null hypoyhesis of equality of means. Although the sample is composed of a large number of cases, the two parametric tests have been runned, assuming the possibility that the assumption of normality could be violated

As show in Table 4.2, the robust test of equality of means was carried out, with the results of Welch and Brown-Forsythe tests confirming the impossibility ro reject the null hypothesis of equality of means.. The post-hoc tests of Tukey HSD, Duncan, and Scheffe confirmed the absence of statistically significant differences and therefore the presence of homogeneous subsets for alpha = 0.05.

Table 4.2 – Robust and *post hoc* tests and results for consumers' agreement/disagreement on the use of immunocastration

		Statistic[a]	Sig.
Starting Point	Welch	1.348	0.260
	Brown-Forsythe	1.322	0.267
Ending Point	Welch	0.092	0.912
	Brown-Forsythe	0.090	0.914

		Starting Point	**Ending Point**
Tukey HSD[b,c]	Sig.	0.243	0.913
Duncan[b,c]	Sig.	0.130	0.705
Scheffe[b,c]	Sig.	0.275	0.920

Means for groups in homogeneous subsets are displayed.

[a.] Asymptotically F distributed;

[b.] Uses Harmonic Mean Sample Size = 322,967;

[c]. The group sizes are unequal, the harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The one way-ANOVA analysis between the starting and ending point for each of the groups led to the same results as above, i.e. no significant differences were observed indicating that complex and complete information did not change consumers' perception of immunocastration.

The results on the effect of information on the willingness to consume products obtained with the use of immunocastration, the WTP for the same products and the level of risk perception related to the technique are shown in Table 4.3.

Table 4.3 – One-way ANOVA results for consumers' willingness to consume, willingness to pay and level of perception of risks for consumers' health tied to immunocastration (answers were expressed on a 0-to-100 scale) after receiving different levels and complexity of information

	Total	**Information (Means)**			**ANOVA**	
	Mean (n = 969)	**Neutral (n = 319)**	**Complete +/- (n = 323)**	**Complete - /+ (n = 327)**	**F-test**	**P-value**
Willingness to consume	54.54	54.80	54.29	54.54	0.020	0.980
Willingness to pay	18.74	18.04	18.58	19.58	0.489	0.613
Level of risk perception	34.23	33.273	32.31	37.06	2.775	0.063

Information did not affect willingness to pay or to consume products obtained from immunocastrated pigs, as confirmed also by the *post-hoc* tests summarized in Table 4.4. The tests carried out confirmed the absence of significant differences between all possible pairs. A tendency (P=0.063) towards a higher level of risk perception by consumers receiving at first the negative information was observed, confirmed also by the measures of Welch and Brown-Forsythe (used to confirm our results if the assumption of normality is violated) and the *post-hoc* tests summarized in Table 4.4.

In absence of statistically significant differences among the three groups, they can be considered as a single representative population of Italian consumers. From our study it emerges that average WTP stands at 18.7%, the willingness to consume products obtained through the use of immunocastration at 54.5%, and the extent to which consumers perceived the presence of risks for their health due to immunocastration was on average 34.2%.

Table 4.4 – Robust tests and *post hoc* tests results for consumers' willingness to pay, willingness to consume and perception of risks tied to immunocastration

		Statistic[a]	**Sig.**
Willingness to consume	Welch	0.020	0.981
	Brown-Forsythe	0.020	0.980
Willingnes to pay	Welch	0.490	0.613
	Brown-Forsythe	0.490	0.613
Level of risk perception	Welch	2.747	0.065
	Brown-Forsythe	2.776	0.063
		Statistic[a]	**Sig.**
Willingness to consume	Welch	0.020	0.981
	Brown-Forsythe	0.020	0.980
Willingnes to pay	Welch	0.490	0.613
	Brown-Forsythe	0.490	0.613
Level of risk perception	Welch	2.747	0.065
	Brown-Forsythe	2.776	0.063
		Statistic[a]	**Sig.**

Willingness to consume	Welch	0.020	0.981
	Brown-Forsythe	0.020	0.980
Willingnes to pay	Welch	0.490	0.613
	Brown-Forsythe	0.490	0.613
Level of risk perception	Welch	2.747	0.065
	Brown-Forsythe	2.776	0.063

		Willingness to consume	**Willingness to pay**	**Level of risk perception**
Tukey HSD[b,c]	Sig.	0.978	0.594	0.068
Duncan[b,c]	Sig.	0.852	0.363	0.077
Scheffe[b,c]	Sig.	0.980	0.623	0.085

Means for groups in homogeneous subsets are displayed.

[a.] Asymptotically F distributed;

[b.] Uses Harmonic Mean Sample Size = 322,967;;

[c]. The group sizes are unequal, the harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

4.4. Discussion

The results of the present survey show that the Italian population does not have a high level of direct knowledge on livestock living conditions. Most of the sample gets information on this issue from the mass media (TV, internet and newspapers). Similar results were previously observed by our research group on a smaller sample of Italian consumers [37]. It is therefore reasonable to hypothesize that consumers' perception of the reality of farm animals' welfare can be chronically distorted, or at least not realistic. Information provided by media is often either entirely negative (focus on scandals, inhumane practices, mistreatments etc.) or extremely positive (description and videos showing animals kept

under bucolic conditions such as grazing on green pastures), omitting the more debatable issues/practices, e.g., mutilations.

In agreement with the findings of the 2005 Eurobarometer survey on animal welfare [38], the present study confirms that Italian consumers still perceive a marked difference between species in the level of welfare attained under common farming conditions. In particular, the welfare level of avian species is believed to be worse than cattle welfare, while pig welfare is perceived as intermediate.

Results also indicate that the Italian population is not particularly aware about the practice of pig castration. However, those who are aware of pig castration are also aware of the reasons for this practice (improving meat quality and avoiding boar taint). This lack of knowledge about castration of the general public has already pointed out by several Authors [20, 25, 26].The majority of respondents declared to buy product obtained with high animal welfare standards (at least sometimes), and their self-assessment regarding the level of attention paid to animal welfare during purchases returns a high score (8.4 on a 0-10 scale). This result is not entirely surprising considering that in the 2016 Eurobarometer survey on animal welfare [39], 97% of EU consumers (and the same percentage of Italian consumers) declared to perceive the protection of farmed animals as an important topic, however it should be noted that these two questions are not directly comparable. The high percent of people indicating organic products or products obtained from animals having outdoor access mirrors the positive trend of organic market and the understanding of a link between animal welfare and ethical value of food. [37]

The high attention toward animal welfare is probably the reason why the majority of respondents fully agree with the abandonment of surgical castration without anesthesia. However, there is no full agreement within the population on the alternative methodology that should be used. In fact, one third of the respondents would prefer immunocastration, but the other two thirds expressed preferences for other methods.

The risks perceived by Italian consumes in this study ("possible unknown long-term risks", followed by "residues of the product in meat") are in agreement with those recorded by Fredriksen et al. [18], although Norwegian consumers indicated the fear of residuals in meat as the main reason. Nevertheless, Italian consumers declared a good willingness to pay a premium price for products obtained from immunocastrated pigs (+ 19%). In the light of specific literature, this result can be considered as particularly positive. The value is higher than those reported in other studies on animal-friendly foods [37] and on immunocastrated meat [5, 29], and similar to the WTP observed among Swedish consumers [30], although in this last study WTP was measured through a choice experiment. This is of peculiar interest for the Italian market, since it has been

hypothesized that for pigs slaughtered at high body weights the increase of costs associated with immunocastration would be offset by the increase in production [16, 19] and therefore would not affect the final cost of the product. .It should anyway be noted that all studies (including the present one) based on a declared (i.e., hypothetical) WTP, might lead to its overestimation.

Also the willingness to consume pork from immunocastrated animals was positive (54.5%), even if our result is only slightly higher than the central value. This outcome must be read in light of the results obtained on the level of risk perception, i.e. consumers are not completely convinced of the harmlessness of immunocastration, even if the level of risk perception expressed by consumers was relatively low on average (34%).

The values of willingness to pay, willingness to consume and level of risk perception do not change after reading neutral or complete and complex information. Given the lack of direct knowledge of the consumer regarding the conditions of rearing and the technique of surgical castration without anesthesia, this remains a topic to be investigated further in future research. Some studies reported similar findings [5, 20] and pointed out that it is likely that the written information does not have particularly evident effects, whereas images (videos, pictures, etc.) may produce a greater impact. However, it is also possible that, given the substantial naiveness of the general public with respect to this topic, simply providing consumers with the technically neutral information about castration might have been sufficient to negatively affect their perception, by letting them know about a mutilation of which they were completely unaware before. If this is the case, it could be argued that the information we provided as “neutral” might not have been perceived as actually neutral by consumers, and every subsequent piece of information they received might not have been able to change their initial opinion. To the best of our knowledge, this aspect has never been investigated before and could be of interest for future surveys. Although the experiment did not aim to assess the effect of the information order, an aspect worth mentioning is the tendential difference we observed in the level of risk perception, giving some evidence that probably the order in which the information was provided changed at least a little the level of risk perception by consumers: in one case (+/-) it slightly decreased the level of risk perception, whereas in the other one (-/+) it slightly increased it. It would be of interest exploring if such a tendency is confirmed or becomes stronger with larger groups of consumers.

4.5 Conclusions

The sensitivity on the European population towards animal welfare is progressively increasing and the demands for adaptation of the production systems are becoming

increasingly urgent. However, it is not always easy to respond to consumer demands, as the introduction of new technologies (including vaccines) in the food chain often generates mistrust. Information can shift consumers' preference from organoleptic characteristics to intangible characteristics such as ethic attributes (e.g., animal welfare) [40]. Anyway, until a real influence of information in favor of immunocastration will be verified, the concerns of the livestock sector over the acceptance of immunocastration by consumers are obviously legitimate.

The results of this study confirm that in the Italian population the level of attention to animal welfare is increasing and that more and more consumers are looking for and buying animal friendly products, also demonstrating their willingness to recognize a premium price to farmers for their efforts. In this study, immunocastration was perceived in a predominantly positive manner, with a relatively low level of risk perception and a good willingness to pay, showing that, once gained the consumer's trust (by means of transparent information on production systems), immunocastration may become an acceptable way forward for Italian producers. However, from a practical standpoint, the numerical paucity of studies concerning the adoption of immunocastration in PDO production chains may represent a gap to be filled by future research.

4.6 Supplementary Materials

SOCIO-DEMOGRAPHIC SECTION

(To allow the creation of representative groups of consumers)

Sex

□ Female
□ Male

Year of birth

_____

Occupation

□ Employee
□ Business owner / freelance
□ Retired
□ Housewife
□ Unoccupied
□ Student
□ Other

Household size (including yourself)

_____

Household income per year

□ Below 10.000 €

Education

- ☐ None
- ☐ Primary school
- ☐ Middle School
- ☐ High School
- ☐ Bachelor of Science
- ☐ Master of Science

- ☐ Between 11.000 and 20.000 €
- ☐ Between 21.000 and 35.000 €
- ☐ Between 36.000 and 50.000 €
- ☐ Between 51.000 and 75.000
- ☐ Over 75.000

Place of residence: _____

Urban area:

- ☐ Yes
- ☐ No

PART ONE

1) **Which kind of diet do you follow?**
   a) Omnivorous (consumption of both vegetal products and animal-derived foods: meat, milk, eggs, etc.)
   b) Vegetarian (the questionnaire ends here)
   c) Vegan (the questionnaire ends here)

2) **How often do you eat the following kind of meat / meat products? (e.g., salami, hamburgers, et.)?**

	At least once a week	More than once a week	At least once a month	Less than once a month	Never (the questionnaire ends here)
Chicken / Turkey	○	○	○	○	○
Pork	○	○	○	○	○
Beef	○	○	○	○	○

3) **Where does your knowledge on the conditions under which farm animals are raised come from?**
   a) I don't have any specific knowledge
   b) mass media (Television, web, newspapers)
   c) direct knowledge (1-2 visits to animal farms)
   d) direct knowledge (more than 2 visits to farms)
   e) I am a farmer / veterinarian / agronomist / etc.
   f) Other (please specify)_____

4) **If you answered c, d or e, could you please indicate the species? (multiple choice)**
   a) Laying hens
   b) Broilers / Poultry
   c) Pigs
   d) Beef cattle
   e) Dairy cows
   f) Fish
   g) Other (please specify)_____

5) **Have you ever heard/read about animal welfare?**
   a) Yes
   b) No

6) **Which ones, among these aspects, are the most important in determining the level of animal welfare? (multiple choice)**
   a) Sufficient space
   b) Adequate transports
   c) Quality of staff
   d) Access outside
   e) Natural behaviour
   f) Humane slaughtering

g) Absence of mutilations
h) All of the above
i) None of the above

7) Which one/ones among the following production phases are regulated by laws on animal protection? (multiple choice)

a) Rearing
b) Feeding
c) Transport (between farms, from farm to slaughter)
d) Slaughtering
e) All of the above
f) None of the above

8) Please evaluate on a 1-to-5 scale (where 1=minimum welfare; 5= maximum welfare) the level of welfare of the following species on farm

	1	2	3	4	5
Laying hens	○	○	○	○	○
Broilers	○	○	○	○	○
Pigs	○	○	○	○	○
Beef cattle	○	○	○	○	○
Dairy cows	○	○	○	○	○
Fish	○	○	○	○	○
Other (please specify)	○	○	○	○	○

9) What products are obtained respecting high animal welfare standards? (multiple choice)

1. Organic products
2. Private labels certifying high animal welfare schemes
3. Products certified as PDO / PGI
4. Products obtained from extensive farming
5. Barn eggs
6. Biodynamic products
7. Antibiotic-free products
8. Other (please specify)

10) Please score, on a 1-to-10 scale, the importance you attribute to animal welfare at time of food purchasing

0	1	2	3	4	5	6	7	8	9	10
Not important at all										Extremely important

11) According to your purchasing habits, do you buy products obtained respecting animal welfare standards above the minimum set up by legislation?

a. No
b. Sometimes
c. Yes (please specify which kind of product_____)

12) **Please indicate the degree of agreement/disagreement with each of the following statements:**
Products obtained respecting high animal welfare standards are also… (0= completely disagree; 5= completely agree)

	0	1	2	3	4	5
More safe	○	○	○	○	○	○
More reliable	○	○	○	○	○	○
More tasty	○	○	○	○	○	○
Healthier	○	○	○	○	○	○
More fresh	○	○	○	○	○	○
Greener	○	○	○	○	○	○
More expensive	○	○	○	○	○	○
More ethical	○	○	○	○	○	○
Other (please specify_____)	○	○	○	○	○	○

13) **Are you aware that male pigs are castrated within the first week of life?**
- ☐ Yes
- ☐ No

14) **If you answered yes, do you know the reason/reasons why male pigs are castrated? (multiple choice)**
- ☐ No, I do not know the reason
- ☐ To avoid questionable odours/flavours in meat
- ☐ To limit aggression/competition among animals
- ☐ To improve animal growth
- ☐ To avoid unwanted mating
- ☐ All of the above
- ☐ None of the above
- ☐ Other (please specify _____)

15 INTRO – Please read carefully the following paragraph before continuing answering the questionnaire

In many countries of the world male pigs are castrated. The aim of castration is to avoid the development of objectionable meat odours (the so-called 'boar taint', whose development is due to sexual maturity) and to limit aggression and competition between animals.
One of the most frequently used methods (also in Italy) is surgical castration. According to legislation, surgical castration can be carried out without the administration of anaesthetics and/or analgesics when done within the first week of age. After the 7th day of life, castration must be carried out with the administration of anaesthetics and analgesics.
In Italy pigs are usually castrated before the 7th day of life.
Some alternative castration methods have been proposed. Among these, the most frequently used in countries such as Brazil, New Zealand and Australia is immunocastration. This method consists in the administration of a vaccine which stops the production of sexual hormones, therefore preventing sexual maturity.

15) **Do you agree with the abandonment of surgical castration without anaesthetics/analgesics and with the adoption of immunocastration?**

- ☐ Yes
- ☐ No

15 NEW –Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration

0	1	2	3	4	5	6	7	8	9	10
Completely disagree										Completely agree

‘‘NEUTRAL INFORMATION’’ GROUP

17 Which of the following meat products would you buy? (single choice)

- ☐ Pork from animals surgically castrated
- ☐ Pork from animals surgically castrated with the administration of anesthesia/analgesia
- ☐ Pork from animals genetically selected for their low risk of developing boar taint
- ☐ Pork from immunocastrated animals
- ☐ Pork from entire (non castrated) animals (I do not care of boar taint)
- ☐ Other (please, specify _____)

18 Would you be willing to pay a premium price for these products?

- ☐ Yes
- ☐ No

19 If you answered ‘yes’, which premium price would you be willing to pay? (Please express it as a percentage – your answer can exceed 100%)

_____%

NEW 02- Assuming that the abandonment of surgical castration and the adoption of immunocastration would improve pig welfare, at what extent, would you be willing to consume products obtained through the use of immunocastration? Please rate your score on a 0 to 100 scale.

_____

New 01 – Which premium price, expressed as a percentage, would you be willing to pay for immunocastrated pork? Please rate your score on a 0 to 100 scale.

_____

16 Do you think that immunocastration might carry some risks?

- ☐ Yes
- ☐ I don’t know
- ☐ No

New 03 – Please indicate (expressing it as a percentage) at what extent do you think that immunocastration might carry some risks (even if still unknown) for consumers’ health

_____ **%**

16s If you answered ‘‘yes’’ or ‘‘I don’t know’’ to question 16, please indicate what kind of risks are you worried about

- ☐ Vaccine residues in meat
- ☐ Risks for pigs’ health
- ☐ Long-term, still unknown risks for the consumers
- ☐ Other (please specify_____)

END OF THE ‘‘NEUTRAL INFORMATION’’ GROUP

‘‘POSITIVE-NEGATIVE INFORMATION’’ (+/-) GROUP

d.20 – Please read carefully the following paragraph before continuing answering the questionnaire

When compared to surgical castration, immunocastration has some **advantages**:

- Improvement of animal welfare: immunocastration involves 2-3 administrations of the vaccine (subcutaneous injection). The administration causes only minimal pain, especially if compared to surgical castration carried out without anesthesia/analgesia.
- Meat quality: immunocastration does not affect meat quality. According to some studies, improvements in pigs' productive performances can be observed.

Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration

0	1	2	3	4	5	6	7	8	9	10
Completely disagree										Completely agree

17 Which of the following meat products would you buy? (single choice)

- ☐ Pork from animals surgically castrated
- ☐ Pork from animals surgically castrated with the administration of anesthesia/analgesia
- ☐ Pork from animals genetically selected for their low risk of developing boar taint
- ☐ Pork from immunocastrated animals
- ☐ Pork from entire (non castrated) animals (I do not care of boar taint)
- ☐ Other (please, specify _____)

18 Would you be willing to pay a premium price for these products?

- ☐ Yes
- ☐ No

19 If you answered 'yes', which premium price would you be willing to pay? (Please express it as a percentage – your answer can exceed 100%)

_____%

d21 Please read carefully the following paragraph before continuing answering the questionnaire

When compared to surgical castration, immunocastration brings some **disadvantages:**

- Increased costs: due to both vaccine price and manpower for vaccine administration (each male pig must receive 2-3 injections during his lifetime).
- Risks for the operator: heavy pigs need 3 administrations of the product and the last doses must be administered when animals have reached a high body weight (100-160 kg). In case of accidental self-injection, the operator might experience similar effects to those seen in pigs, including a temporary reduction in sexual hormones and reproductive functions.

Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration

0	1	2	3	4	5	6	7	8	9	10
Completely disagree										Completely agree

D22b Do you believe that the use of immunocastration might carry additional risks, with respect to those you just read about?

- ☐ Yes (goes to question 22bb)
- ☐ No (goes to question 23)

D22bb Please indicate which kind of risks are you worried about

- ☐ Vaccine residues in meat
- ☐ Risks for pigs' health
- ☐ Long-term, still unknown risks for the consumers
- ☐ Other (please specify_____)

23 Which of the following meat products would you buy? (single choice)

- ☐ Pork from animals surgically castrated
- ☐ Pork from animals surgically castrated with the administration of anesthesia/analgesia
- ☐ Pork from animals genetically selected for their low risk of developing boar taint
- ☐ Pork from immunocastrated animals
- ☐ Pork from entire (non castrated) animals (I do not care of boar taint)
- ☐ Other (please, specify _____)

24 Would you be willing to pay a premium price for these products?

- ☐ Yes
- ☐ No

25 If you answered 'yes', which premium price would you be willing to pay? (Please express it as a percentage – your answer can exceed 100%)

_____%

NEW 02- Assuming that the abandonment of surgical castration and the adoption of immunocastration would improve pig welfare, at what extent would you be willing to consume products obtained through the use of immunocastration? Please rate your score on a 0 to 100 scale.

_____

New 01 – Which premium price, expressed as a percentage, would you be willing to pay for immunocastrated pork? _____ %

16 Do you believe that the use of immunocastration might carry some risks?

- ☐ Yes
- ☐ I don't know
- ☐ No

New 03 – Please indicate (expressing it as a percentage) at what extent do you think that immunocastration might carry some risks (even if still unknown) for consumers' health
_____ %

16s If you answered ''yes'' or ''I don't know'' to question 16, please indicate which kind of risks are you worried about

- ☐ Vaccine residues in meat
- ☐ Risks for pigs' health
- ☐ Long-term, still unknown risks for the consumers
- ☐ Other (please specify_____)

END OF THE +/- GROUP

"NEGATIVE-POSITIVE INFORMATION" (-/+) GROUP

d21 Please read carefully the following paragraph before continuing answering the questionnaire

When compared to surgical castration, immunocastration brings some **disadvantages:**

- Increased costs: due both to vaccine price and manpower for vaccine administration (each male pig must receive 2/3 injections during his lifetime).
- Risks for the operator: heavy pigs need 3 administrations of the product and the last doses must be administered when animals have reached a high body weight (100-160 kg). In case of accidental self-injection, the operator might experience similar effects to those seen in pigs, including a temporary reduction in sexual hormones and reproductive functions.

Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration

0	1	2	3	4	5	6	7	8	9	10
Completely disagree										Completely agree

D22b Do you believe that the use of immunocastration might carry additional risks, with respect to those you just read about?

- ☐ Yes (goes to question 22bb)
- ☐ No (goes to question 23)

D22 bb please indicate which kind of risks are you worried about

- ☐ Vaccine residues in meat
- ☐ Risks for pigs' health
- ☐ Long-term, still unknown risks for the consumers
- ☐ Other (please specify_____)

17 Which of the following meat products would you buy? (single choice)

- ☐ Pork from animals surgically castrated
- ☐ Pork from animals surgically castrated with the administration of anesthesia/analgesia
- ☐ Pork from animals genetically selected for their low risk of developing boar taint
- ☐ Pork from immunocastrated animals
- ☐ Pork from entire (non castrated) animals (I do not care of boar taint)
- ☐ Other (please, specify _____)

18 Would you be willing to pay a premium price for these products?

- ☐ Yes
- ☐ No

19 If you answered 'yes', which premium price would you be willing to pay? (Please express it as a percentage – your answer can exceed 100%)

_____%

d.20 Please read carefully the following paragraph before continuing answering the questionnaire

Compared to surgical castration, immunocastration has some **advantages**:

- Improvement of animal welfare: immunocastration consists of 2-3 administrations of the vaccine (subcutaneous injection). The administration causes only minimal pain, especially if compared to surgical castration carried out without anesthesia/analgesia.
- Meat quality: immunocastration does not affect meat quality. According to some studies, improvements in pigs' productive performances can be observed.

Please indicate, on a 0-to-10 scale, your degree of agreement/disagreement with the use of immunocastration

0	1	2	3	4	5	6	7	8	9	10
Completely disagree										Completely agree

23 Which of the following meat products would you buy? (Single choice)

- ☐ Pork from animals surgically castrated
- ☐ Pork from animals surgically castrated with the administration of anesthesia/analgesia
- ☐ Pork from animals genetically selected for their low risk of developing boar taint
- ☐ Pork from immunocastrated animals
- ☐ Pork from entire (non castrated) animals (I do not care of boar taint)
- ☐ Other (please, specify _____)

24 Would you be willing to pay a premium price for these products?

- ☐ Yes
- ☐ No

25 If you answered 'yes', which premium price would you be willing to pay? (Please express it as a percentage – your answer can exceed 100%)

_____%

NEW 02- Assuming that the abandonment of surgical castration and the adoption of immunocastration would improve pig welfare, at what extent would you be willing to consume products obtained through the use of immunocastration? Please rate your score on a 0 to 100 scale.

_____

New 01 – Which premium price, expressed as a percentage, would you be willing to pay for immunocastrated pork? _____ %

16 Do you believe that the use of immunocastration might carry some risks?

- ☐ Yes
- ☐ I don't know
- ☐ No

New 03 – Please indicate (expressing it as a percentage) at what extent do you think that immunocastration might carry some risks (even if still unknown) for consumers' health

_____ %

16s If you answered ‘‘yes’’ or ‘‘I don’t know’’ to question 16, please indicate which kind of risks are you worried about

- ☐ Vaccine residues in meat
- ☐ Risks for pigs’ health
- ☐ Long-term, still unknown risks for the consumers
- ☐ Other (please specify_____)

END OF THE -/+ GROUP

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Capitolo 5:

Effects of increased space allowance on animal welfare, meat and ham quality of heavy pigs slaughtered at 160Kg

Eleonora Nannoni, Giovanna Martelli, Giulia Rubini, Luca Sardi

Department of Veterinary Medical Sciences, University of Bologna, Ozzano Emilia, Italy

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Abstract:

Sixty barrows (Body Weight –BW- range: 23.9-160 kg) were allotted to two experimental groups (6 pens of 5 pigs each): the control group was kept at a space allowance of 1m^2/head; the second group was kept at 1.3m^2/head. Behaviour, growth parameters, carcass and meat quality were assessed, as well as fat and cured ham quality. Results showed that pigs raised at 1.3m^2/head spent more time laying (particularly in lateral recumbency, P<0.01 and P<0.001, respectively) compared to pigs kept at lower space allowance. They also reduced the aimless exploration of the slatted pen floor (P<0.001) and increased overall expression of other, mainly active, behaviors (*e.g.*, drinking, walking and standing, P<0.01). Pigs raised at 1.3m$^{2/}$head showed higher final BW (P=0.02), more favourable Average Daily Gain (ADG) and gain-to-Feed ratio (G:F) both during the last period of the trial (P<0.05 for both parameters) and over the entire trial (P=0.01 for both parameters). No significant difference was observed between groups for carcass traits and the main meat quality attributes. Subcutaneous fat from green hams had higher α-linolenic acid content (P<0.01) in the group reared at greater space allowance. Green hams from this group lost less weight at trimming (P<0.01) and the resulting cured hams received better sensory evaluations (P<0.05). No difference was observed in fatty acid composition and unsaturation levels of the subcutaneous fat from cured hams. Our data suggest that heavy pigs intended for Parma ham would benefit from the adoption of higher individual floor space allowances, both in terms of animal welfare (increased possibility to rest) and of productive parameters, without having any detrimental effect on the suitability of the thighs for dry-curing or on the quality of the final product.

5.1 Introduction

Floor space allowance can affect welfare and productive parameters of pigs [1-4]. European legislation [5] sets to 1m^2/head the minimum floor space allowance for pigs over 110kg BW, but gives no further requirement for heavier animals, such as for example Italian heavy pigs (which reach and exceed 160 kg BW at the end of their production cycle [6]). Minimum space allowances (A) set by law [5] are calculated after the equation $A=0.030\times BW^{0.67}$ where the coefficient of the equation (k) is set to 0.030 [3]. However, according to EFSA recommendations [4], higher coefficients should be used (k=0.036 for pigs up to 110kg and k=0.047 above 110 kg) in order to allow all pigs to lay down separately and at the same time [7]. Noteworthy, these minimum space requirements, which are based on lying behavior, do not consider the space needed for other fundamental behaviors (feeding, drinking, excretion, exploration, etc.) [8]. To the best of the authors' knowledge, only Pastorelli et al. [9] have carried out a study aimed at calculating the space requirements

for heavy pigs, despite the fact that Italian consumers perceive space allowance as the first structural factor affecting animal welfare [10]. As concerns studies on the impact of space allowance on carcass and meat quality, Serrano et al. [11] found a decrease in backfat MUFA (Mono Unsaturated Fatty Acids) as space allowance increased. Rossi et al. [12] found no differences in meat quality together with increased backfat thickness in heavy pigs raised at space allowances of 1.4 vs. 1m^2/head. Conversely, the effects of different space allowances on cured ham quality have never been investigated. The aim of the present pilot study was to investigate the effects of two different space allowances (minimum space set by legislation vs. space calculated according to EFSA recommendations) on behavior, growth parameters, meat and ham quality of heavy pigs intended for Parma Ham production. It is hoped that this study could contribute to a better knowledge on allometric needs of heavy pigs and provide useful scientific background for a more inclusive legislation on pig protection.

5.2 Materials and methods

The experiment was carried out in accordance with Directive 2008/120/EC on the protection of pigs. Animals were raised and sacrificed for commercial purposes. They were obtained from a commercial farm and raised in the facilities of the Department of Veterinary Medical Sciences of the University of Bologna (farm code: IT046BO065). Pigs were slaughtered at a commercial abattoir (CLAI, Ravenna, Italy). They were not subjected to any invasive procedure (blood sampling, etc.) therefore the trial did not fall within the field of application of the Directive 2010/63/EU on the protection of animals used for scientific purposes.

5.2.1 Animals, housing and experimental design

Sixty crossbred Duroc × (Landrace × Large White) barrows were used. The average Body Weight (BW) at the beginning of the trial was 23.9 kg. Animals were homogeneously allotted to two experimental groups on the basis of their BW and litter of origin. Animals were raised until reaching the minimum age of 9 months and the BW of approximately 160 kg, according to the rules established for Parma Ham production [6].

Pigs were kept in small groups (5 animals per pen) on a totally slatted floor. Pens were located in temperature-and humidity-controlled rooms (22-24 °C, 70–80% RH) equipped with a forced-air ventilation system. Each pen was equipped with a bite drinker and a collective stainless steel feeder. Environment was enriched by providing steel hanging chains. Commercial feed was offered twice a day as a meal, rationed at 9% of the metabolic BW. Every two weeks a sub-sample of animals (two pens) was weighted, and the feed

allowance was adjusted to their BW, up to a maximum of 3.3 kg dry matter per pig, per day. Animals were allotted to two experimental groups, each comprising 6 pens of 5 pigs:

- the first group (control group) was kept at an individual space allowance of 1 m^2/head (according to the minimum requirement set by European legislation [5];
- the second group (higher space allowance group)was kept at an individual space allowance of 1.3 m^2/head (calculated according to Petherick and Baxter [7] and EFSA [4] recommendations on the basis of an average BW of 135 kg).

In agreement with the European legislation, the space occupied by the collective feeder was not considered as part of the floor space allowance per head.

5.2.2 Behavioral observations

The behavior of all pigs (6 replications for each group) was videotaped (b/w cameras) over the diurnal hours (7:00 to 19:00) by means of a digital closed circuit system (Mesa, Arezzo, Italy). Cameras were mounted on a rail attached to the ceiling above the pens (approximately 3m above the ground). Pigs were videotaped over the diurnal hours once every two weeks, for a total of 11 videotaping sessions. Each session was automatically divided into 12 1-hour videos, which were stored in a dedicated hard drive, divided by day and camera. The stored videos were later examined by a single trained observer. The behavioral patterns were assessed by scan-sampling technique, which consists of sampling 10 seconds of video every 10-min of its duration and noting down the prevailing activity of each of the pigs in the 10 seconds of observation. Activities were recorded according to predetermined ethogram for heavy pigs, reporting the following behaviors: standing inactive, sitting inactive (dog-sitting), sternal recumbency, lateral recumbency, walking, eating, rooting/exploring the floor, social interactions. A detailed description of the behaviors observed in the ethogram is given in [13]. Data were then used to calculate the daily proportion of time spent performing each behavior by the pen of pigs. Results are expressed as the average per treatment of all the videotaping sessions across the trial.

5.2.3 Growth parameters, carcass and meat quality

All pigs were individually weighed during the trial, at the approximate BW of 30, 60, 100 and 160 kg. Average daily gain (ADG) was subsequently calculated. Feed intake of every replication (i.e., pen) was recorded daily to calculate the feed conversion ratio (FCR). In order to comply with the required BW for Parma Ham production (on average 160 kg), pigs were slaughtered in two sessions. Data collection of growth parameters stopped on day 224, when 2/3 of the pens (4 entire pens per treatment) reached the average BW of 160 Kg and were slaughtered. The remaining pigs (2 entire pens per treatment) were kept under the

experimental conditions up to the day in which they in turn attained the final body weight of about 160 kg. Pigs were transported to the abattoir, and slaughtered after a 15-h fast. Dressing out percentage was calculated, lean meat yield and subcutaneous fat thickness were measured by Fat-o-Meater (FOM-SFK, Copenhagen, Denmark). The pH value of the *Semimembranosus* (SM) and of the *Longissimus lumborum and toracis* (LL) muscles was assessed by means of a portable pH meter (model 250A; Orion Research, Boston, MA) at 45 min. post mortem. At 24 h post mortem, a second read oh the pH in the SM muscle was taken with the same instrument described above. Carcasses were dissected and the weight of the main commercial cuts (thigh, loin and shoulder) was recorded, to calculate their yield. Color of the lean portion of the thighs (SM muscle) was measured using a Minolta Chromameter CR-400 (Konica Minolta optics INC., Japan) set with the D65 illuminant, according to the CIE Lab (L*, a*, b*) color space [14]. A sample was taken from the LL muscle of each pig and used to assess meat quality. Drip and cooking loss analysis were carried out on LD samples, according to the method proposed by Honikel [15]. Warner Bratzler Shear Force (WBSF) was measured on six cores from each cooked sample using an Instron Universal Testing Machine, model 1011 (Instron Ltd., England) fitted with a Warner-Bratzler (WB) device at a cross-head speed of 200 mm/min.

5.2.4 Fat and ham quality

For each experimental group, 14 green hams were randomly selected and subcutaneous fat was sampled in the area overhanging *Biceps Femoris* (BF) muscle. Total lipids were isolated according to Folch [16] and, after methylation, fatty acid composition was determined by gas chromatography (HRGC8560 Series Mega 2 gas chromatograph; Fisions Instruments, Milan, Italy). Fatty acids were esterified using 5% methanolic hydrogen chloride. The fatty acid methyl esters were separated by gas chromatography using a Supelco SP- 2330 capillary column (length: 30m; internal diameter:0.25mm; film thickness: 0.2 μm; Supelco, Bellefonte, PA, USA). Injector and detector temperatures were kept at 220°C and 280°C, respectively. The column was programmed as follows: 140°C for 1 min; the temperature was then raised to 220°C (3°C/min) and held constant for 15 min. Fatty acids were identified by comparing the retention times of the peaks with those of known standards. Results are expressed as percentages of total fatty acids. The iodine number was determined according to the AOAC method [17].

All hams were dry-cured according to Parma Ham production rules [6] for 18 months, and followed during the entire dry-curing process. Green hams were weighted before and after trimming, after salting and at the end of the dry-curing period. Weight losses were calculated for each productive step.

At the end of the dry-curing process, the same 28 hams (14/group) analyzed for raw fat quality were deboned and a sample-slice (including BF and SM muscles), was taken transversally from the caudal portion of ham to the middle of the femoral bone impression. The slice was evaluated by a panel of trained experts. Evaluation was expressed according to [18] on a scale ranging from 1 to 10 (1=absence of the trait; 10=maximum presence) for the following parameters: texture, color dishomogenity and marbling for the lean portion; texture and thickness for the fat portion. An overall score was attributed as a global evaluation of the ham, expressed on a scale ranging from 1 to 10 (1=very bad quality; 10=optimal characteristics). With the same techniques described before (Minolta colorimeter), color of the SM muscle and of the subcutaneous fat was measured.

Subcutaneous fat samples (outer and inner layers) were taken from the skin-covered cured fat in the overhanging area of the BF muscle and analyzed by gas chromatography as described above (HRGC8560 Series Mega 2 gas chromatograph; Fisions Instruments) for fat from the raw thighs. Subcutaneous fat was analyzed for peroxide value [19]. Purified lipid samples were diluted in iso-octane and conjugated dienes and trienes were determined by measuring specific extinction at 232 and 268 nm (K232 and K268, respectively) [20].

As concerns the lean fraction, samples were taken from the BF muscle. Moisture and crude protein were analyzed according to AOAC methods [17], sodium chloride content and proteolysis index (non-protein nitrogen/protein nitrogen) were determined according to [21-22].

5.2.5 Statistical analysis

Data were analysed using the STATISTICA 10 package [23]. Data were submitted to a linear model using individual space allowance as the main effect.. The statistical unit was the pen for the growing (live weight, ADG, G:F) and behavioral parameters, the individual (pig or ham) for carcass, and ham quality data. For carcass and meat quality parameters, a mixed model with the pen as a random factor was tested. Since there were no differences with the results of the linear model, the results of the linear model are included in the manuscript. For nonparametric data (behavioral traits and sensory evaluation of hams), the Mann–Whitney test was used. The significance level for all statistical tests was set at $P<0.05$. All data are presented as raw means ± SE.

5.3 Results

Table 5.1 shows the ethogram of the two experimental groups. General behavior was affected by space allowance, with pigs raised at 1.3m^2/head spending an increased amount of time lying (and, in particular, in lateral recumbency, P=0.007 and P=0.001, respectively)

if compared to pigs kept at lower space allowance. Besides, the group raised at increased space allowance reduced the time spent in aimless exploration of the slatted pen floor (P=0.001) and increased the overall expression of other, mainly active, behaviors (such as drinking, walking and standing, P=0.01).

Table 5.1. Behavior of heavy pigs raised at different floor space allowances. Data are expressed as a percentage of total observed behaviors

	Floor space allowance			
	1 m^2/head	**1.3 m^2/head**	**SE[1]**	**P-value**
Replications, n.	6	6		
Sitting inactive	2.8	3.4	0.2	0.56
Lateral recumbency	29.4	35.4	0.9	<0.01
Sternal recumbency	33.7	32.3	0.8	0.20
Total recumbency	63.1	67.7	0.9	<0.01
Eating	8.9	9.2	0.6	0.91
Exploring of pen floor	22.0	15.0	0.7	<0.01
Social Interactions	2.2	3.1	0.3	0.52
Other (drinking, walking and standing)	1.0	1.6	0.1	0.01

[1] Standard Error

Results on growth performance and carcass traits are reported in Table 5.2. Overall, pigs raised at increased space allowances showed more favourable growth parameters: higher BW at the end of the zootechnical trial (P=0.02), more favourable ADG and G:F both during the last period of the trial (d 140-224, P=0.002 and P=0.03, respectively) and over the entire trial (P=0.01 and P=0.02, respectively). Tendential differences were observed also for BW at d 139 (P=0.1) and for ADG in the intermediate period (d 82-139, P=0.1). Differences between the experimental groups increased linearly, becoming more significant as the trial progressed: the differences in BW were 0.1 (n.s.),1.2 (n.s.), 3.5 (P=0.1) and 8.2 (P=0.02) kilograms at day 1, 81, 139 and 224 respectively. As a consequence, the difference in ADG and G:F followed a similar pattern: for ADG (P-value: n.s., 0.1, 0.002 in the three periods, P=0.01 over the entire trial) and for G:F (P-value: n.s., 0.1, 0.03, in the three periods, P=0.02 over the entire trial). No significant difference was observed between the groups in carcass traits (carcass weight, dressing out percentage, lean meat

percentage) or in the yield of the main lean cuts (thigh, shoulder and loin). Backfat thickness was tendentially higher in the group raised at higher space allowance (P=0.08).

Table 5.2 – Growth performance and carcass qualityof heavy pigs raised at different floor space allowances.

	Floor space allowance			
	1 m^2/head	1.3 m^2/head	SE[1]	P-value
Pens, n° (replications)	6	6		
Body Weight (BW), kg				
Initial (d 1)	23.8	23.9	1.0	0.96
d 81	65.6	66.8	1.0	0.59
d 139	100.8	104.3	1.1	0.10
Final (d 224)	154.4	162.6	1.8	0.02
Average Daily Gain (ADG), kg/d				
d 1-81	0.516	0.529	0.006	0.27
d 82-139	0.606	0.647	0.012	0.10
d 140-224	0.631	0.686	0.010	<0.01
Overall ADG (d 1-224)	0.583	0.619	0.008	0.01
G:F (Gain-to-Feed ratio)				
d 1-81	0.345	0.353	0.004	0.28
d 82-139	0.269	0.287	0.005	0.10
d 140-224	0.206	0.223	0.004	0.03
Overall G:F (d 1-224)	0.256	0.271	0.004	0.02
Pigs, n°	30	30		
Carcass Weight (CW, kg)	134.8	136.7	1.0	0.37
Dressing out, %	83.0	83.5	0.2	0.13
Backfat thickness, mm	22.6	24.0	0.4	0.08
Lean meat, %	52.6	51.7	0.3	0.16
Thigh, %CW	24.2	24.5	0.1	0.19
Shoulder, %CW	14.9	14.9	0.1	0.87
Loin, %CW	10.6	10.9	0.1	0.15

[1]Standard Error

The main meat quality attributes (post-mortem acidification, water-holding capacity and tenderness) did not significantly differ between the experimental groups (Table 5.3). The only difference observed was in the color of SM muscle, with muscles from pigs raised at increased space allowance showing lower a* and Chroma values (P=0.001 and 0.002, respectively), and tendentially higher hue values (P=0.06).

Table 5.3. Meat qualityof heavy pigs raised at different floor space allowances.

	Floor space allowance			
	1 m^2/head	**1.3 m^2/head**	**SE[1]**	**P-value**
Pigs, n°	30	30		
pH 45min. LL	6.53	6.46	0.03	0.24
pH 45min. SM	6.53	6.50	0.003	0.70
pH 24h. SM	5.79	5.73	0.02	0.17
Color SM muscle				
L*	40.1	41.1	0.4	0.18
a*	9.5	7.9	0.3	<0.01
b*	3.0	2.8	0.1	0.51
Hue	0.31	0.35	0.01	0.06
Chroma	10.0	8.5	0.3	<0.01
Drip loss, %	1.48	1.59	0.04	0.19
Cooking loss, %	19.6	20.6	0.3	0.14
Shear force (WBSF), N/cm	5.1	5.4	0.2	0.34

[1]Standard Error

With respect to the quality of subcutaneous fat from green hams (shown in Table 5.4), no significant difference was observed in its fatty acid composition or in its overall unsaturation level. The only exception recorded concerns α-linolenic acid (C18:3), which was significantly higher (P=0.01) in the experimental group reared at greater space allowance.

Table 5.4. Quality of subcutaneous fat of green hams from heavy pigs raised at different floor space allowances

	Floor space allowance			
	1 m^2/head	**1.3 m^2/head**	**SE[1]**	**P-value**
Hams, n.	30	30	/	
Samples, n.	14	14	/	
Fatty acid composition, %				
C:14	1.60	1.59	0.02	0.87
C:16	23.6	23.7	0.1	0.87
C16:1	2.51	2.30	0.06	0.10
C18:0	12.1	12.2	0.2	0.73
C18:1	43.2	42.9	0.2	0.58
C18:2	12.9	13.2	0.2	0.42
C18:3	0.48	0.59	0.02	0.01
C20:4	0.57	0.59	0.02	0.33
SFA(Saturated Fatty Acids)	38.2	38.3	0.2	0.88
MUFA(Monounsaturated Fatty Acids)	47.5	47.0	0.2	0.29
PUFA(Polyunsaturated Fatty Acids)	14.3	14.7	0.2	0.33
Iodine number	64.6	65.2	0.3	0.38

[1]Standard Error;

Table 5.5 shows the weight losses of the hams during the entire dry-curing process, the instrumental color, and the results from the proximate and sensory analysis of the cured

hams. Hams from pigs raised at higher space allowance lost less weight during trimming (P=0.004) if compared to the control group. Instrumental color both of the lean and of the fat fraction highlighted no significant difference between groups. As concerns sensory evaluation, despite similar average results in the single parameters, the overall evaluation was significantly better (P=0.012) for cured hams from the group kept at 1.3 m^2/head.

Table 5.5 Weight losses, instrumental color, proximate and sensory analysis of dry-cured hams from heavy pigs raised at different floor space allowances

	Floor space allowance			
	1 m^2/head	**1.3 m^2/head**	**SE[1]**	**P-value**
	30	30		
Ham weight losses, %				
After trimming	16.4	15.4	0.2	<0.01
Hams, n.	3.78	3.91	0.07	0.33
Cured ham[♯]	32.4	31.9	0.5	0.59
Samples, n.	14	14		
Proximate analysis				
Moisture, %	59.8	59.6	0.2	0.67
Crude Protein, %DM	27.3	27.6	0.2	0.34
Proteolysis Index, %	25.5	25.8	0.5	0.79
Sodium Chloride, %	6.15	6.22	0.09	0.69
Instrumental color				
SM muscle				
L*	35.9	34.8	0.4	0.22
a*	12.9	13.0	0.2	0.79
b*	5.5	5.5	0.2	1.00
Hue	0.40	0.40	0.01	0.91
Chroma	14.1	14.2	0.2	0.85
Subcutaneous fat				
L*	73.2	74.6	0.3	0.06
a*	4.2	4.1	0.2	0.78
b*	4.0	4.2	0.2	0.61
Hue	0.77	0.79	0.03	0.77
Chroma	5.8	5.8	0.2	0.99
Sensory analysis				
Lean fraction				

Texture	7.9	8.1	0.2	0.67
Color inhomogeneity	1.7	1.5	0.3	0.77
Marbling	3.0	2.4	0.4	0.45
Fat fraction				
Texture	8.1	7.9	0.2	0.54
Thickness	6.9	7.3	0.3	0.78
Overall evaluation	6.6	7.1	0.1	0.02

[1] Standard Error

[#] expressed as a percentage of trimmed weight

The quality of the fat from the dry-cured hams (acidic composition and oxidative status) is shown in Table 5.6. The two experimental groups had similar fatty acid composition and unsaturation levels. However, the extinction coefficient measured at 232nm was significantly higher in the control group than in the group kept at higher space allowance (P=0.01).

Table 5.6. Quality of dry-cured hams from heavy pigs raised at different floor space allowances: lean and fat portion

	Floor space allowance			
	1 m^2/head	**1.3 m^2/head**	**SE[1]**	**P-value**
Samples, n.	14	14	/	
Fatty acid composition (%)				
C:14	1.37	1.36	0.02	0.73
C:16	22.8	23.0	0.2	0.75
C16:1	2.37	2.41	0.07	0.95
C18:0	11.5	11.5	0.2	0.94
C18:1	43.4	43.9	0.2	0.17
C18:2	11.3	11.0	0.2	0.40
C18:3	0.17	0.17	0.004	0.51
SFA(Saturated Fatty Acids)	37.0	37.1	0.3	0.94
MUFA(Monounsaturated Fatty Acids)	50.3	50.7	0.3	0.51

PUFA(Polyunsaturated Fatty Acids)	12.6	12.3	0.2	0.38
Lipid oxidation				
Peroxide value, $meqO_2$	15	13	1	0.49
$K_{232}^{\#}$	5.0	4.0	0.2	0.01
$K_{268}^{\#}$	0.20	0.17	0.01	0.14

[1]Standard Error

[#] specific extinction coefficient measured at 232 and 268 nm according to [20]

5.4 Discussion

Space allowance per head can be varied by varying either the pen size or the number of pigs in a pen. However, in the second case, an effect of group size on the experimental outcomes cannot be ruled out [24, 25]. Petherick [26] pointed out that group members time-share space, therefore the amount of free space to be shared is dependent not only on the space allowance per individual, but also on group size. Another confounding effect is that rearing systems offering increased space allowances often imply also an enriched environment (*e.g.,* straw, access to an outdoor area) [27, 28]. Nevertheless, to the best of the Authors' knowledge, in the literature the number of studies investigating the effects of space allowance without the confounding effect of group size and enriched environments is very limited. In the present study, we aimed at eliminating any bias due to group size (especially with respect to productive and behavioral data) by using different pen dimensions and keeping group size constant (5 pigs/pen).

Our results show that under our experimental conditions increased space allowance positively affected pigs' behavior, with an increased degree of calmness (greater time spent resting in lateral recumbency, reduced time spent exploring the pen floor). The increased space allowance was calculated in order to give pigs the possibility to lay down all at the same time [7], and it may have prevented (or, at least, reduced) sleep disruption by other pen-mates. This, in turn, could have increased the pigs' possibility to carry out longer (and/or synchronized) sleeping bouts. Vermeer et al. [8] used synchronized lying as an indicator of improved welfare, due to the fact that pigs, when possible, prefer to synchronize their behavior. In our study, also awake behavior was positively affected by increased space allowance: pigs showed a significant reduction in pen floor exploration, a behavior that, given the slatted floor and therefore the absence of rooting material, if over-expressed should be interpreted as a stereotypy [29,30]. Positive effects of increased space

allowance on general behavior were observed also by Jensen et al. [24], who described increased exploration of rooting materials. Contrarily, Cornale et al. [31] observed no differences in behaviour, but lower fecal cortisol concentration in uncrowded pigs. However, it is worth noting that in both studies high space allowances were obtained by reducing group size. Lastly, as mentioned above, Vermeer et al. [8] observed an increased synchronization of resting periods and improved usage of functional areas, both behaviours indicating a reduced competition for resources (laying space or functional areas) and therefore an improved welfare of the animals.

As concerns growth parameters, overall ADG was in agreement with the recommendations for the Italian heavy pig production (i.e., approximately 600 g/d on the whole production cycle). Following specifications [6], this production requires animals of at least 9 months of age at slaughter, and weighing on average 160 ± 10 kg per lot. Rearing animals intended for dry-cured ham production therefore requires restricted feeding during the last phase, leading to sensibly less favorable growth parameters than those observed in most pig-producing countries, which typically market lighter (and younger) pigs. Regardless of the peculiarities in the Italian production system, our results show an improvement in growth parameters in the group raised at higher space allowances. Similar results were previously observed in pigs weighing up to 100kg [32, 33]. However, it's interesting to note that in the present study differences between the experimental groups became more significant as the trial progressed. This aspect, although to the Authors' knowledge has never been reported before, may indicate that space constraints may limit resources sharing by pigs (e.g., access to feed or to a resting area), and these effects might become more severe as animals grow up. A similar effect was observed also by Flohr et al. [34], who studied the effect of the removal of pigs from a group and observed that relieving stock pressure and providing additional floor space resulted in improvements in gain, suggesting that the allometric method is valid also for the prediction of floor space needs for heavy pigs. With respect to overall growth parameters, the only similar study carried out on Italian heavy pigs [12] found tendentially higher final BW in pigs kept at high space allowance (however, in the mentioned study group size was not constant). Other studies were carried out using lighter pigs (below 100 kg BW): Jensen et al. [35] found a tendential improvement in ADG for pigs kept at higher space allowances, whereas Gonyou et al. [36] separately analyzed the effects of group size and space allowance and found that both reduced group size and increased floor space area lead to higher ADG. It should however be noticed that, given the limited number of animals used in the present study and the small group size (due to the behavioural observations they were subjected to), the improvement in growth parameters should be regarded as indicative and might not be as evident if transposed to on-farm

environment. Despite these limitations, under our experimental conditions the animals kept at lower space allowance took on average 7 days more (234.5 vs. 227.5 days) to reach the same slaughtering BW (162.5kg).

Carcass traits were not affected by space allowance, despite the differences we observed in growth parameters. Given the specialty nature of the derived meat products, in this kind of study the assessment of carcass, meat and subcutaneous fat quality is necessary (even when differences in such parameters are not to be expected), in order to show that the typical features of the raw material (and, therefore, of the dry-cured products) are not affected. This is particularly true when differences in growth rates (which could in turn affect carcass, meat and fat quality) are observed.

In this study, overall meat quality was not affected by the experimental treatment. In her review on stress reactions at slaughter (regardless of BW), Terlouw [37] hypotesized that pigs reared in an enriched environment (with larger pens and straw bedding), being less active and reactive during transport and lairage, might have higher glycogen levels at slaughter, possibly resulting in decreased pH. In the present study, the only difference observed was in SM muscle color, with muscles from pigs raised at increased space allowance showing lower redness and lower Chroma values (*i.e.,* lower difference from a grey of the same lightness) if compared to the control group. However, these differences are of difficult interpretation considering that no alteration in the rate of postmortem glycolysis was found between the experimental groups.

Overall, fatty acid composition of the raw subcutaneous fat (total MUFA, PUFA and SFA content) did not differ between the experimental groups, despite the differences in growth parameters described above. The only significant difference was detected for linolenic acid content, which reached greater values in the group kept at higher individual space allowances. However, these differences did not affect the overall level of unsaturation (*i.e.*, the oxidative stability) of green hams, as highlighted by iodine number, which did not differ between the experimental groups. Linoleic acid content and iodine number fell within the limits imposed by Parma Ham production rules [6]. The information available on the influence of housing density on fatty acid profiles is scarce [38,11] and differences in linolenic acid content were never observed before, although the mentioned papers studied different housing systems and lower slaughtering BW. In particular, Patton et al. [38] observed that adipose tissue from pigs provided less space was more saturated and was composed of higher percentages of PUFA. Such differences were not observed in the present study, similarly to Serrano et al. [11], who observed only differences due to gender and no difference due to housing density in the fatty acid composition of the outer layer of the subcutaneous fat.

Trimming is a traditional procedure aimed at obtaining the desired shape of the thighs. The lower relative weight loss after trimming observed for hams deriving from pigs kept at the higher space allowance can be attributable to the higher fat thickness of the thighs themselves depending, in turn, on the tendentially higher subcutaneous fat thickness observed in the pigs of this group, despite the similar body weight at slaughtering and carcass weight.

The higher overall sensory evaluation obtained by dry-cured hams from this group might be due to the numerically lower marbling score and higher fat thickness in these hams if compared with the control group. In fact, excessive marbling in the lean fraction may slow down salt penetration [39], whereas a minimum thickness of the subcutaneous fat is prescribed by the production specifications [6] in order to protect the lean portion from excessive proteolysis during the long dry-curing process.

Chemical analysis of the lean fraction (moisture, proteolysis index and salt) confirmed the compliance of the dry-cured hams to the production specifications, without differences between the experimental groups, with the only exception of the extinction coefficient measured at 232nm (K_{232}), which was significantly lower in the group kept at higher space allowance. This absorbance is due to the formation of conjugated dienes (CD) deriving from the oxidation of linoleic acid. The formation of CD, which parallels the production of hydroperoxides, occurs at the early stages of lipid oxidation [40, 41]. These intermediates are then expected to decompose to secondary products, which, in the present study, have not been investigated. Although such a difference could be positively regarded (since it indicates a reduced presence of primary oxidation products), it is difficultly ascribable to the different space allowances at which animals were kept. Overall, it is worth noting that the slight difference in fatty acid composition (of the green hams) and in lipid oxidation (after dry-curing) did not impair the suitability of the thighs for dry-curing or the quality of the final product. Besides the positive effects on animal welfare due to the fact that pigs are allowed to rest more comfortably, it should be highlighted that the adoption of higher individual floor space allowances can improve the production parameters even in restricted-fed animals, without having any detrimental effect on meat or ham quality.

5.5 Conclusions

The absence of specific requirements for individual space allowance of heavy pigs (about 160 kg BW) can result in the adoption of the minimum floor area required by the EU law (1 m^2/head for all pigs weighing more than 110 kg), although such a provision does not keep into account the basic needs of heavier pigs especially in terms of space for resting. Our

data suggest that, in the case of Italian heavy pigs, the adoption of higher individual floor space allowances (1.3 m^2/head) can have positive effects on animal welfare (increased possibility to rest) and improve their productive parameters, without negative effects on the suitability of the thighs for dry-curing or on the quality of the final product. However, given the experimental conditions under which the present trial was carried out (small group size), further on farm investigations might be necessary to corroborate the differences observed in terms of growth parameters and behavioural traits.

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Capitolo 6:

Identification of Possible Pre-Slaughter Indicators to Predict Stress and Meat Quality: A Study on Heavy Pigs

Luca Sardi, Alessandro Gastaldo , Marzia Borciani , Andrea Bertolini , Valeria Musi , Giovanna Martelli , Damiano Cavallini , Giulia Rubini and Eleonora Nannoni

Department of Veterinary Medical Sciences, University of Bologna, Via Tolara di Sopra 50, 40064 Ozzano Emilia (BO), Italy; luca.sardi@unibo.it (L.S.); damiano.cavallini@unibo.it (D.C.); giulia.rubini8@unibo.it (G.R.); eleonora.nannoni2@unibo.it (E.N.)

Foundation C.R.P.A. (Research Centre on Animal Production) Studies and Researches, Viale Timavo 43/2, 42121 Reggio Emilia, Italy; a.gastaldo@crpa.it (A.G.); m.borciani@crpa.it (M.B.); a.bertolini@crpa.it (A.B.); v.musi@crpa.it (V.M.)

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Simple Summary: This study aimed at identifying, on the basis of objective evaluations (blood parameters): (1) the pre-slaughter treatments that result in higher stress for heavy pigs and can therefore be used as pre-slaughter stress indicators; (2) the meat quality parameters that show the largest variation as a response to the stress experienced during pre-slaughter handling. Two blood parameters (cortisol and creatine kinase) were used to categorize pigs into two groups (clusters) depending on transport conditions: "higher stress" and "lower stress". Our results indicate that the variables/indexes which differed more widely between the two clusters (namely, average vehicle speed during transport, welfare slaughter score, overall transport and slaughter welfare index (TSWI), distance travelled, group stability, and behaviors—slips, falls, and overlaps—during unloading) might be considered as the best descriptors of the welfare conditions experienced by Italian heavy pigs during pre-slaughter handling. However, we observed no consistent effects of the stress experienced during pre-slaughter handling on meat quality, which warrants the need for further studies addressing: (1) the individual stress response and meat quality variability in pigs within the same transport; (2) the relationships between the variables examined and meat quality, with the aim to improve the TSWI.

Abstract: This study aimed at identifying possible pre-slaughter indicators and/or indexes to be used to predict pig stress response and meat quality variation. Data were collected on 44 shipments (loads) of Italian heavy pigs. For each shipment, several pre-slaughter parameters were recorded on farm, during transport, and at the slaughterhouse. Blood and meat samples were taken from 10 pigs from every of the 44 loads included in the study (N = 440). Blood samples were used to assess cortisol and creatine kinase levels, whereas meat samples were used to assess meat quality (pH, instrumental color, tenderness, water-holding capacity, and sensory analysis). Cluster analysis of blood parameters allowed the categorization of the shipments into two main clusters: Lower Stress (LS) and Higher Stress (HS). The variables/indexes statistically differing between the two clusters were: average vehicle speed during transport, welfare index at slaughter (i.e., "slaughter score"), overall transport and slaughter welfare index (TSWI), distance travelled, and behaviors (slips, falls, overlaps) during unloading, which appeared to be the best descriptors of the welfare conditions experienced by Italian heavy pigs during pre-slaughter handling. No consistent effects of the stress level experienced on meat quality was detected, which warrants the need for further studies conducted under more variable pre-slaughter conditions, with the aim of simplifying and improving the TSWI.

Keywords: animal welfare; transport; stress; pigs; blood parameters; meat quality; indicators

6.1 Introduction

A detailed study of the associations between pre-slaughter handling and stress response would benefit the industry and animals by reducing transport losses and promoting good animal welfare and meat quality [1]. In the present work, we focused on the welfare during pre-slaughter handling, of Italian heavy pigs, which are transported and slaughtered at a minimum age of 9 months and at the average body weight (BW) of 160 kg ± 10% [2].

Pre-slaughter handling "consists of several stages, starting when pigs leave their pen and including transport, lairage, stunning, and exsanguination" [3]. All these practices can induce stress, a term which will be used in the present work with the meaning of "a way of suggesting negative implications (defined as acute or chronic stress) on pig welfare" during pre-slaughter handling and transport [1]. Overall, the stress experienced by pigs in these phases is the result of complex interactions between on-farm conditions (e.g., housing system, feed withdrawal, and handling) and conditions experienced during transport (e.g., vehicle design, transport duration, space allowance, climate) and lairage (e.g., duration and handling), which affect animal losses, pigs' physiological and behavioral responses before slaughter, and carcass and meat quality variation [4].

The physiological response to transport has been studied considering various blood parameters. In particular, although its values vary widely across the literature and comparisons among studies are not always easy to make, cortisol has been frequently used as an indicator of acute stress resulting from handling, transport, and restraint [5]. Creatine Kinase (CK) in blood increases when animals are subjected to intense physical activity (as that experienced during loading or harsh handling) or muscle damage; therefore this enzyme can be used, together with other parameters, as a long-term indicator of welfare during transport [6], since its concentration peaks at 6 h and returns to basal levels between 8 and 48 h after muscle damage [7,8]. Blood CK increases during transport (it is released in the bloodstream due to the rupture of muscle cell membranes caused by vigorous muscle effort) and decreases during lairage [9]. Although less common in the literature, another possible stress indicator is blood aldolase. Similarly to CK, aldolase is an enzyme which leaks into the circulation from damaged muscle, and its values increase over time (peaking after at least 48–72 h) [10]. A study showed that aldolase activity is correlated to meat quality traits, such as pH and sarcoplasmic and myofibrillar protein solubility [11], all indicators of poor water-holding capacity. Furthermore, in human medicine, aldolase has been indicated as a more accurate and objective indicator of muscle

damage than CK due to its lower inter-individual variability [10]. For these reasons, aldolase was also assessed in the present work as a possible, long-term muscle damage indicator.

Several studies investigated the correlations between blood stress parameters (and other physiological indices) and meat quality, but their results were inconsistent. Additionally, the correlations observed ranged from weak to moderate, indicating that blood stress parameters can only be used as a complementary measurement in the assessment of pigs' response to transport stress [12–14].

A recent review also highlighted that the current literature available on pig transportation mostly focuses on pigs at the average market weight (100–135 kg) [1]. Therefore, there is a considerable lack of knowledge regarding the handling of smaller and larger pigs, which may react differently to pre-slaughter stressors. Lighter and heavier pigs are more susceptible to heat stress, especially during transport of long (between 8 and 24 h [1]) and short duration (90 min [15]), respectively.

Our broad aim was identifying (and possibly validating) pre-slaughter indicators and animal welfare indexes—such as the transport and slaughter welfare index (TSWI) to be used to predict stress response and meat quality variation in heavy pigs. More specifically, the aim of this work was two-fold: (1) to assess, based on objective measures (blood parameters), the impact of pre-slaughter events (loading, transport, unloading, lairage, and stunning), as single factors or in combination, on heavy pigs' stress response; (2) to identify the meat quality parameters that show the largest variation in response to variations in blood parameters.

6.2 Materials and Methods

6.2.1. Ethical Statement

The experiment was carried out in full accordance with the European legal requirements for the protection of pigs on farms (Directive 2008/120/EC [16]), during transport (Council Regulation -EC- N° 1/2005 [17]), and at slaughter (Council Regulation -EC- N° 1099/2009 [18]). Animals were raised in commercial farms, transported and sacrificed for human meat consumption in the respect of the above-mentioned legislation. Pigs were not subjected to any experimental invasive procedure *in vivo* (blood samples were taken at exsanguination once the animals were stunned, and meat samples were taken from the carcasses). For these reasons, these trials did not fall within the field of application of the Directive 2010/63/EU [19] on the protection of animals used for scientific purposes and therefore did not require a specific authorization by the local animal welfare and ethical review body.

6.2.2. Experimental Design and Sampling Scheme

Data collection was carried out across one year on 44 shipments of Italian heavy pigs. A shipment was defined in the present study as "a group of animals undergoing the same pre-slaughter handling (originating from the same farm, transported at the same time on the same truck, and subjected to the same lairage and slaughter conditions)". The shipments originated from 11 randomly selected, commercial farms and were made to the same commercial slaughter plant, all located in Northern Italy (Emilia Romagna region). The slaughterhouse involved in the trial has a manual, head-only electrical stunning system with a restraining cage. Each farm provided 4 loads of pigs, of which 2 transported during the warm season (April–September) and 2 transported during the cold season (October–March). The TSWI was assessed for every shipment (i.e., load) of pigs (N = 44). This work represents the first description and the first ever attempt of validating the TSWI and its single components. The index will be described in more in detail in the Section 2.3, and additional information on the methodology for score assessment and index calculation is provided in the Supplementary Materials (Section 6.5).

6.2.3. Transport and Slaughter Welfare Index (TSWI)

The TSWI has been proposed by a group of researchers from the Research Centre on Animal Production (CRPA, Reggio Emilia, Italy) with the aim to create a new tool for the evaluation of farm animals' welfare during transport. Similarly to the Farm Welfare Index (FWI) [20], the TSWI is based on the compilation of three checklists for each shipment and on a calculation system in which the different parameters assessed on departure at the farm, during transport, and at the slaughterhouse are weighed. This allows the attribution

of a final score to each shipment. The evaluations start with a relatively limited number of objective parameters that can be easily measured during the farm and slaughter visits and during transport.

For each shipment, the assessor is asked to fill in 3 checklists:

- **On-departure (from the farm) checklist** (to be filled in at the farm, when animals are moved from the pen to the truck). This checklist results in an "on-departure score", which ranges from a minimum of −30.5 points (pts) for the lowest welfare level to a maximum of 15.5 pts for the highest welfare level. The main aspects considered are:
    - loading duration;
    - path from the pen to the truck (length, width, design, flooring, presence of internal and external corridors, ramps, loading facilities) and time taken to move and load the pigs;
    - handling (tools used and mode of use);
    - pig behaviors during handling (slipping, falling, overlapping).
- **Transport checklist** (to be filled in during the journey). This checklist results in a "transport score" which ranges from a minimum of −18 pts for the lowest welfare level to a maximum of 9.5 pts for the highest welfare level. The main aspects considered are:
    - distance and duration of the journey;
    - space allowed to each pig;
    - presence and number of drinkers;
    - cooling systems;
    - other characteristics of the truck (possibility to inspect animals and take care of them, internal illumination, floor type and condition, presence or absence of bedding).
- **Slaughter checklist** (to be filled in at the slaughterhouse during unloading, lairage, and stunning). This checklist results in a "slaughter score", which ranges from a minimum of −41.5 pts for the lowest welfare level to a maximum of 50.5 pts for the highest welfare level. The main aspects considered are:
    - duration of the unloading operations;
    - path from the truck to the lairage pen and from the lairage pen to the stunning area (flooring, passages, presence of one-way gates);
    - handling (tools used and mode of use);
    - pig behaviors during handling (slipping, falling, overlapping).

- lairage pens (stocking density, ventilation, illumination, thermal insulation, conditions of floors and surfaces, type of pens, presence of mobile partitions, drinkers, cooling systems);
- stunning area (partitions, gates, devices, method of stunning, stun-to-stick interval, procedure for the use and check of the efficiency of the stunning system, emergency stunning procedures, training of the personnel involved).

All data are then submitted to the calculation system, which weights the different measures from the three checklists and calculates the overall TSWI. Additional details on how the factors in the TSWI are weighed can be found in the Supplementary Materials (Section 6.5).

In the present study, the same two researchers (who were involved in the index formulation) worked together and collaborated in filling in the three checklists for every shipment (on farm, during transport, and at slaughter). Before the experiment, the protocol was tested by the same two assessors on some pilot shipments (from loading until stunning) to ensure the feasibility of the whole protocol and to verify the time necessary to take all measurements. The assessors also carried out several inspections at the slaughterhouse involved in the trial to ensure the applicability of the slaughter checklist.

In the present work, we chose to include only a single slaughterhouse in the data collection in order to focus on transport variables and to avoid the confounding effects of factors related to the slaughter plant. Furthermore, besides being included within the calculated index, some measures will be also elaborated and discussed separately from the index. The choice of the measures was made based on their expected importance in the overall animal welfare level during pre-slaughter handling and/or on their easy assessment under commercial conditions. The measures chosen are: on-departure (at farm) score, transport score, slaughter score, number of pigs loaded/unloaded per hour, loading and unloading duration, waiting time of the loaded truck at the farm (before leaving) and at the slaughter plant (before unloading), transport duration, total journey duration (from loading to unloading), lairage duration (from unloading to stunning), and behavior of the pigs during loading/unloading (i.e., slipping, falling, overlapping).

6.2.4. Blood Sampling and Analysis

A blood sample (10 mL) was collected at exsanguination from 10 randomly selected animals from each of the 44 loads (N = 440). Blood was collected in lithium heparin tubes and immediately stored at +4 °C to be transferred to the laboratory of the Department of Veterinary Medicine of the University of Bologna. Blood tubes were then centrifuged (at

2000× *g* for 20 min), and plasma was separated and stored at −20 °C, pending subsequent analysis for cortisol, CK, and aldolase.

Cortisol concentration (expressed as ng/mL) was then measured with a radioimmunological assay as described by Bacci et al. [21]. Cross reactions of various steroids with the rabbit anti-cortisol serum were as follows: cortisol 100%, cortisone 20.4%, 11-deoxicortisol 49.8%, corticosterone 1.13%, progesterone 0%. The mean cortisol recovery was 96.6 ± 2.2%. The intra- and inter-assay coefficients of variation (5 determinations in triplicate) were 4.30% and 7.12%, respectively. The assay sensitivity was 1.23 pg/tube.

Creatine kinase and aldolase concentrations (both expressed as U/L) were measured using two commercially available kits for their assessment in plasma (CK Nac Liquid and Aldolase, Sentinel Diagnostics, Milano, Italy), both based on a colorimetric method with subsequent spectrophotometric UV readings. The intra- and inter-assay coefficients of variation for CK (5 determinations in triplicate) were both below 13%.

6.2.5. Meat Quality and Sensory Analysis

At the slaughter plant, pH values of the longissimus thoracis and lumborum *(*LTL) muscle were assessed at the 2nd/3rd last rib level using a portable pH meter equipped with a temperature compensation probe (model 250A; Orion Research, Boston, MA) 45 min post-mortem. Two chops of the LTL muscle were collected from each carcass from the same anatomical location. The first chop (approximately 6 cm thick) was used for meat quality analysis, whereas the second one (approximately 12 cm thick) was used for sensory analysis. Meat quality and sensory assessments were carried out on the same animals from which the blood samples were collected (10 animals per shipment, N = 440).

For meat quality assessment, LTL muscle chops were individually stored in plastic bags, placed in a portable cooler, and immediately transferred to the laboratories of the Department of Veterinary Medical Science of the University of Bologna. Upon arrival, the samples were stored at +4 °C pending subsequent analysis, which was carried out the day after. At 24 h post-mortem, a thin layer of the LTL muscle chop surface was removed to expose the muscle and measure color, pH, drip loss, cooking loss, and shear force. After a 30 min blooming time (during which the sample was wrapped in an oxygen-permeable plastic film), the instrumental color of the LTL muscle samples was assessed by means of a Minolta Chromameter CR-400 (Konica Minolta optics INC., Tokyo, Japan) set with the D65 illuminant, according to the CIE Lab (L*, a*, b*) color space [22]. At the same time, pH was measured using the same pH meter described above. Drip and cooking loss were assessed subsequently on the same meat samples according to the method described by Honikel

[23]. Briefly, for the drip loss, a 2 × 3 × 3 cm sample (approximately 80–100 g) was cut, put on top of a plastic mesh, and stored for 48 h in a sealed container at chill temperature (+5 °C). For cooking loss, each muscle chop was put in a plastic bag to avoid direct contact with water and cooked in a water bath until reaching the final core temperature of 75 °C. Warner–Bratzler Shear Force (WBSF) was measured as previously described [23] on six cores (diameter 1.13 cm) from each cooked meat chop using an Instron Universal Machine (model 1011, Instron Ltd., Wycombe, UK) fitted with a Warner–Bratzler (WB) device at a cross-head speed of 200 mm/min. WBSF is expressed as kg/cm^2.

For the sensory analysis, muscle sections were transferred to the laboratories at the Research Centre on Animal Production (Reggio Emilia, Italy), where they were divided into 1.5 cm slices which were immediately vacuum-packed and stored at −20 °C until analysis, which was carried out within one month. The sensory analysis was then carried out by a panel of nine trained assessors according to the method described by Della Casa et al. [24]. The assessors were selected and trained according to the UNI EN ISO 8586:2012 [25]. The preparation of the test and the evaluation of the sensory quality of the products was operated according to the UNI EN ISO 13299:2010 "Sensory analysis—Methodology—General guidance for establishing a sensory profile" [26]. The analysis was carried out in a controlled environment (laboratory "CRPA Lab"), according to UNI EN ISO 8589:2014 [27]. Factors were evaluated with the use of a structured continuous scale of values between 1 and 10 (1 = absence of sensation, 10 = greatest intensity of sensation). Lean color and marbling (visible intramuscular fat) were visually assessed on raw samples. For these two parameters, a reference photographic scale (the same described by Dalla Casa et al. [24]) was provided to the assessors to help them estimate the surface characteristics. After the visual assessment, the samples were cooked on a hot plate until slices reached the core temperature of 70°. Sensory traits assessed on the cooked samples were: initial tenderness (effort required to cut the meat sample with incisor teeth), chewing tenderness (effort required to chew the meat sample with molar teeth), juiciness, final residue (presence of muscle fibers in the mouth at the end of chewing), chewiness (number of chews required to make the sample suitable for swallowing), aroma intensity, buttery aroma, and off-flavors (rancid, metallic, blood taste, etc.).

6.2.6. Statistical Analysis

All data were analyzed using the software JMP v14.3 (SAS Institute Inc., Cary, NC, USA). After logarithmic transformation, cortisol and CK values within the corresponding shipment were used in k-means cluster analysis in order to differentiate more or less stressful shipments. Models with 2, 3, and 4 clusters were tested, but the 2-cluster model

was chosen, based on its higher fit statistics (Cubic Clustering Criterion (CCC) values of −2.2212, −2.5827, and −3.7648 for the 2-, 3-, and 4-cluster models, respectively). The 2-cluster model resulted in two groups, including 21 and 23 shipments (a more detailed description of the clusters will be given in the Results and Discussion section). For numerical variables, a linear mixed-model procedure was carried out with the aim of identifying statistical differences between the two clusters in the measures taken on departure, during transport, and at slaughter. Each shipment from the farm of origin was considered as an experimental unit and used as a random variable for all analyses. For blood parameters and meat quality, each shipment was used as the experimental unit, and the 10 measures for each shipment were considered as repeated measures with an autoregressive covariance structure (AR1). The cluster grouping was used as a fixed effect within the model. Means were separated on the basis of the least-square mean, and all pairwise multiple comparisons were performed using Tukey as a post-hoc test. For categorical variables, a nominal logistic model with the chi-square likelihood ratio test was carried out. A p-value ≤ 0.10 was considered as a tendency, a $p \leq 0.05$ was considered statistically significant.

6.3. Results and Discussion

6.3.1. General Characteristics of the Shipments

The descriptive statistics of the shipments is reported in Table 1. Both the average TSWI and the scores obtained in the separate checklists were positive, with the only exception of some negative scores (minimum value: −1.75 pts) recorded in a few visited farms. Overall, the three average scores (1.75, 3.28, and 28.8 pts, for the farm, transport, and slaughter scores, respectively) were in the moderate-to-high range of the checklist (ranges: from −30.5 to 15.5 pts for the on-departure parameters, −18 to +9.5 pts for the transport, and −41.5 to +50.5 pts for the slaughter checklist, as described in the Material and Methods section). This indicates the absence of critically negative situations for the welfare of animals due to the fact that all practices observed in the present study were respectful of the European legislation on the protection of pigs during rearing, transport, and slaughter [16–18]. The total journey duration was low (on average 136 min), which may result from the proximity of the farms to the slaughterhouse (12 to 50 km) and the short waiting time of the truck at loading and before unloading (below 20 min on average, for both). Short travel durations are not uncommon in Northern Italy. Previous, larger retrospective studies carried out in the same area revealed that approximately one-half of the transports lasted below 90 min [15] and that the large majority of pigs (approximately 90%) were transported for less than 2 h [28]. The average lairage duration (9 ± 8.6 h)

recorded in the present study resulted from the variable lairage times applied at the slaughterhouse audited in this study according to the arrival order (morning or later hours of the slaughter day). In particular, it was observed that some loads (26 shipments, corresponding to 59% of loads) were slaughtered within few hours after unloading, of which one was slaughtered immediately after unloading (minimum lairage duration of 3 min), whereas others (18 shipments, corresponding to 41% of loads) were kept in lairage overnight (lairage duration above 10 h). Although there is a certain degree of contradiction among studies about the definition of optimal lairage duration in relation to its effects on meat quality [29], a lairage of 2–3 h is generally recommended [4]. It has been observed that, in the case of heavy pigs, overnight lairage may increase the risk of pre-slaughter animal losses [15], although this effect seems to be largely dependent on the characteristics of the slaughterhouse such as stocking density, presence of large open windows, and use of sprinklers as cooling devices [28]. The number of pigs loaded per hour also presented a high variation (SD = 62), which likely reflects differences in farm and truck design (loading facilities), personnel training/experience, as well as handling techniques. Lastly, accidents during handling (such as slipping, falling, and overlaps) were observed on approximately a quarter of the animals (24% of animals observed having accidents at loading or at unloading). Such percentages are either considerably lower or slightly higher than those reported in other studies at loading and unloading [30–32].

Table 1. Descriptive statistics of the pig shipments (N = 44).

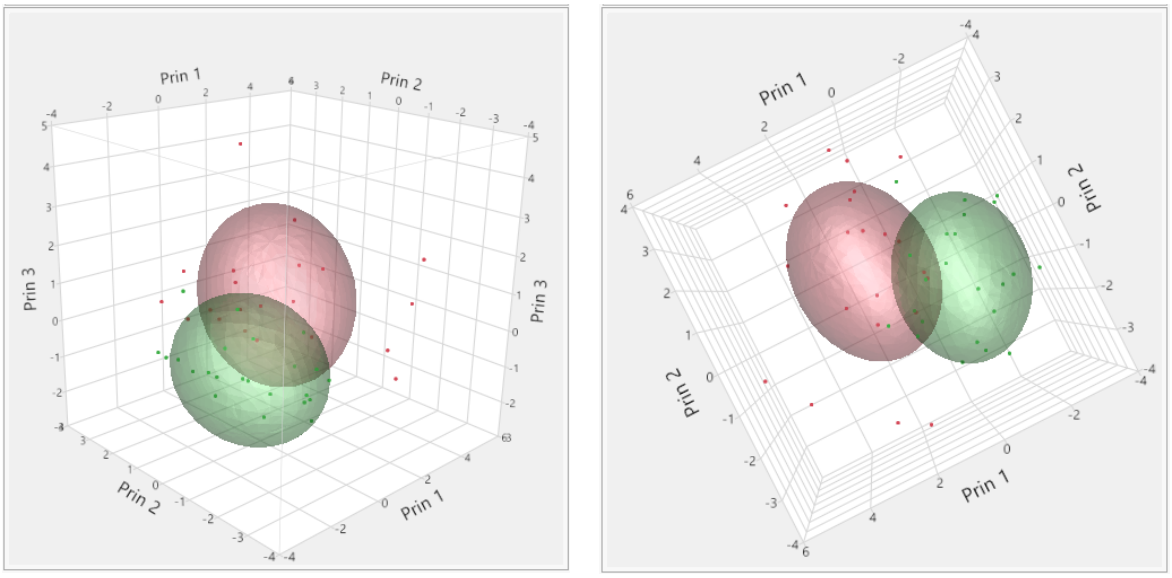
Parameter [1], U.M. [2]	Average	S.D.	Min	Max
On-departure (at farm) score, pts	1.75	1.73	−1.5	5.5
Transport score, pts	3.28	1.64	0.5	6.5
Slaughter score, pts	28.08	2.27	24.5	31.0
TSWI [3] (farm + transport + slaughter), pts	33.11	3.48	26.0	42.0
Loading duration, min	46.7	21.5	20	110
Pigs loaded per hour, n	170	62	71	323
Waiting time at the farm before departure, min	13.7	5.0	3	25
Journey duration, min	37.2	18.8	18	90
Average speed during transport, km/h	73.3	16.4	42	111
Distance travelled, km	26.2	11.6	11	59
Ambient temperature, °C	16.8	8.5	−2.5	32
Waiting time at the slaughterhouse (before unloading), min	21.3	14.8	3	62
Total waiting time on the truck (farm + slaughterhouse), min	34.9	16.2	11	75

Unloading duration, min	16.9	5.1	9	30
Pigs unloaded per hour, n	433	125	200	870
Total journey duration (from loading to unloading), min	135.8	32.8	80	197
Lairage duration (from unloading to stunning), min	565.5	514.8	3	1393
Transport + lairage duration, min	701.3	519.0	159	1521
Behaviors (slipping, falling, overlapping):				
Loading, %	18.12	10.90	2.2	45.8
Unloading, %	5.43	3.55	0.0	16.33
Total, %	23.60	12.18	2.2	52.8

[1] Detailed information on the variables assessed can be found in the Supplementary Materials (Section 6.5); [2] Unit of Measurement; [3] Transport and Slaughter Welfare Index.

6.3.2. Clusters Based on Blood Parameters

Blood parameters allowed the separation of the shipments in two clusters (ure 1). Cluster 1 (red color) included 21 shipments, and cluster 2 (green color) included 23 shipments. The average values of the two blood parameters (cortisol and CK) in the two clusters are summarized in Table 2. Cluster 1 included shipments with animals presenting higher average cortisol and CK levels than Cluster 2, therefore the two clusters were renamed Higher Stress (HS), and Lower Stress (LS) clusters, respectively. In this study, blood cortisol and CK levels were similar to those observed in lighter pigs in other studies [9,12,30,33,34], which may indicate the lack of difference in the physiological response to pre-slaughter stress between heavier and lighter pigs.



(**a**) (**b**)

Figure 6.1. Three-dimensional representation of the shipments clustered according to blood cortisol and creatine kinase (CK) levels and seen from different angles (**a**) and (**b**). Each dot on the graph represents a shipment. Cluster 1 (red color, 21 shipments), Cluster 2 (green color, 23 shipments). The colored area represents the area around the cluster centroid.

Table 6.2. Summary of the characteristics of the two clusters (backtransformed data are presented between square brackets).

Parameter, U.M. [3]	**Cluster 1 (HS** [1]**) (N = 210 Pigs)**		**Cluster 2 (LS** [2]**) (N = 230 Pigs)**		***p*-Value**
	Estimate	**SE** [4]	**Estimate**	**SE** [4]	**-**
log Cortisol, ng/mL	1.10 [12.72]	0.03	0.97 [9.32]	0.03	0.007
log CK, U/L	3.37 [2394]	0.02	3.20 [1583]	0.02	<0001

[1] Higher Stress; [2] Lower Stress; [3] Unit of Measurement; [4] Standard Error.

6.3.3. Differences in Transport Variables between Clusters

Table 6.3 presents the differences observed in a selected list of variables measured in the TSWI checklists between the two clusters. Variables were sorted by significance level (from higher to lower) in order to show first those having the highest significant effect.

Parameters significantly or tendentially differing between the two clusters were average vehicle speed during transport, slaughter score, TSWI, distance travelled, group stability, and pig behavior during handling at unloading. Overall, the observed differences between clusters in the parameters listed were in line with the expected differences between two groups of animals being subjected to different stress levels. More specifically, slaughter scores and TSWIs were higher in the LS than in the HS group (p = 0.01 and p = 0.04, respectively). The same was true also for average vehicle speed during transport and distance travelled (p = 0.002 and p = 0.05, respectively), which confirms the low impact of long-distance hauls when pigs are transported in good conditions (e.g., use of highway instead of secondary, country roads). Group stability tended to be higher (p = 0.07) in LS shipments, implying that during these shipments, the groups were less mixed (either at

loading or during lairage), and less hierarchical fighting occurred. Irregular behaviors during handling at unloading (slipping, falling, and overlapping) tended to be higher (p = 0.07) in the HS shipments.

Table 6.3. Differences in the measured transport and slaughter variables between the two clusters. Variables are sorted by significance level in decreasing order of significance (from higher to lower).

	HS [1]		LS [2]		
Number of Shipments	**21**		**23**		
Variable [3]	**Estimate**	**SE [4]**	**Estimate**	**SE**	***p*-Value**
Average vehicle speed during transport, km/h	65.62	3.23	80.35	3.09	0.002
Slaughter score, pts	27.19	0.47	28.89	0.44	0.012
TSWI [5] (farm + transport + slaughter), pts	32.00	0.73	34.13	0.70	0.041
Distance travelled, km	22.62	2.45	29.48	2.34	0.050
Stable (unmixed) groups, odds ratio	0.48	0.32	0.74	0.32	0.072
Behaviors (slipping, falling, overlapping) at unloading, %	6.49	0.75	4.58	0.72	0.075
Total behaviors (slipping, falling, overlapping), %	26.50	2.62	20.94	2.50	0.132
Loading duration, min	51.48	4.63	42.30	4.43	0.160
Behaviors (slipping, falling, overlapping) at loading, %	20.03	2.37	16.38	2.27	0.272
Pigs loaded per hour, n	159.19	13.53	179.13	12.93	0.293
Total journey duration (from loading to unloading), min	140.81	7.16	131.17	6.84	0.336
Waiting time at the farm (before departure), min	14.29	1.10	13.13	1.05	0.450
On-departure (at farm) score, pts	1.57	0.38	1.91	0.36	0.519
Total waiting time on the truck (farm + slaughterhouse), min	36.10	3.58	33.87	3.42	0.655
Unloading duration, min	17.29	1.13	16.61	1.08	0.667
Journey duration, min	35.95	4.14	38.39	3.96	0.672
Waiting time at the slaughterhouse (before unloading), min	21.81	3.26	20.74	3.12	0.814
Transport score, pts	3.24	0.36	3.33	0.35	0.861
Pigs unloaded per hour, n	434.38	27.57	431.52	26.35	0.941
Transport + lairage duration min	705.48	114.60	697.52	109.50	0.960
Ambient temperature, °C	16.88	1.87	16.75	1.79	0.961

Lairage duration (from unloading to stunning), min	564.67	113.67	566.35	108.61	0.992

[1] Higher Stress, [2] Lower Stress; [3] Detailed information on the variables assessed can be found in the Supplementary Materials; [4] Standard Error [5] Transport and Slaughter Welfare Index.

With respect to average vehicle speed during transport and distance travelled, as mentioned above, the LS cluster included shipments having a slightly longer (p = 0.05) travel distance but a notably higher (p = 0.002) average vehicle speed during transport. Considering that the average travel duration of all transports was relatively low (below 40 min in both clusters), it is likely that most transports for the LS cluster were carried out on smoother roads (e.g., on motorways or highways) instead of on rougher roads (e.g., country or city roads). Rougher travels, despite being shorter in duration, may have caused a higher stress response. The combination of travelling on a poor road surface and short transport might actually be even more stressful, as pigs mostly stand during the first phases of transport and so are more prone to injuries and falls [1,35]. Similar effects of the road type on the stress response and behavior were previously observed both in lambs and in pigs [36,37].

Regarding the calculated indexes, we observed that both the slaughter score and the TSWI were significantly higher in the LS than in the HS cluster (p = 0.01 and p = 0.04, respectively), indicating an overall better welfare both during the entire pre-slaughter period (from loading to stunning) and, in particular, at the slaughter plant. This indicates that the TSWI, in its current formulation, seems to be a valid tool to be used as a pre-slaughter stress indicator. However, it should also be considered that the absence of differences between clusters in the transport and farm scores may be due to the possibility that cortisol (and, to a lower extent, creatine kinase) is affected also by the acute stress response at slaughter, not only by the on-farm and transport stress response. Among the components of the TSWI, the slaughter score significantly differed between the two clusters (p = 0.01), whereas the differences in the transport and farm scores failed to reach statistical significance (p > 0.10). This result was quite surprising considering the variation in loading and departure conditions at the farms and in transport conditions, while the slaughterhouse conditions were always the same. The low SD of the slaughter score (Table 1) is therefore the result of the variation in those farm and transport variables which were also analyzed separately (e.g., unloading duration, lairage duration, pig behaviors during handling at unloading). Despite the limited variability in the slaughter score observed in the present study, both the slaughter score and the TSWI index seem to be sensible enough to identify stressful events occurring at slaughter or during the entire pre-slaughter period.

However, a validation of the efficiency of the TSWI under more variable slaughter conditions is needed.

The limited variability in farm and transport scores may have had a masking effect, excluding the possibility to highlight differences in these indexes between clusters. Such a low variability might be due to the fact that all transports were carried out in full accordance with the EU legislation, allowing to obtain a moderate-to-high animal welfare score. These observations highlight the need to give a different weight to the parameters within the farm and the transport scores, increasing the importance of those parameters (i.e., average vehicle speed during transport, distance travelled, group stability, pig behaviors during handling, and loading duration) which, when considered separately, proved to have a more consistent effect on cluster differentiation. However, it should also be considered that monitoring a shorter list of pre-slaughter variables (either by summarizing them in a simplified index or by considering them separately) might lead to a more accurate prediction of the stress experienced by pigs during pre-slaughter handling.

The greater group stability observed in the LS cluster compared with the HS one ($p = 0.07$) confirms the effects of mixing unfamiliar pigs on increased aggression, poorer welfare, and increased blood CK [38] and salivary cortisol levels [39] compared with keeping pigs in their social groups, even when groups of pigs are mixed only at loading.

Overall, (1) combining the measure of two objective blood parameters (cortisol and CK) at slaughter may help use the physiological response of pigs to differentiate the impact of different transport systems on animal welfare; (2) the variables which differed more largely between the two clusters might be considered, under our conditions, the best descriptors of the welfare conditions experienced by Italian heavy pigs during pre-slaughter handling.

6.3.4. Differences in Meat Quality Traits and Serum Aldolase Between Clusters

Table 4 summarizes the differences in meat quality and in blood aldolase levels between the two clusters. None of the instrumentally assessed meat quality parameters differed ($p > 0.10$). However, similarly to cortisol and CK, blood aldolase level was higher ($p < 0.001$) in the HS cluster compared to the LS one. This result may indicate a higher degree of muscle damage in the HS cluster pigs, which may be associated to the factors characterizing the HS cluster. All these characteristics result in acute stress and fatigue [1,4,40]. For example, long journeys, group mixing and accidents during handling may cause both direct (traumatic) and indirect (fatigue-induced) muscle damage (therefore leading to an increase in serum leaking enzymes), together with an increase in the stress response. Similarly, low slaughter scores are the consequence of a combination of unfavorable conditions occurring at the slaughter plant (unloading, lairage and stunning

facilities, moving devices, etc.); therefore, they result in a similar effect. In an exploratory statistical model, shipments were clusterized based on the three blood parameters here assessed (cortisol, aldolase, and CK). Interestingly, with the only exception of one shipment, using three blood parameters resulted in no differences in shipments clusterization compared to the results which are presented in this study (data not shown). However, the model using also aldolase was discarded on the basis of the relatively limited literature available on aldolase compared to cortisol and CK, and aldolase was therefore used as a response variable. However, our data would support the use of blood aldolase as a long-term indicator of muscle damage in response to stress in future studies.

The juiciness score of the cooked meat was lower in the HS group despite the similar pH, drip loss and cooking loss values, and marbling scores observed between clusters, which in theory should lead to comparable sensory profiles [41]. This lack of difference in these technological meat quality traits makes it hard to explain the differences observed in the sensory parameters as a consequence of the different stress level to which the two clusters were exposed. It is however possible that the differences observed in these sensory traits might be due to marbling which, despite not reaching statistical significance (p = 0.3), was higher in the LS than in the HS group, therefore possibly determining an increase in the perceived juiciness and aromatic profile. However, it should also be considered that all the differences observed, although significant, were quite low (between 0.2 and 0.45 points differences on a 10-point sensory scale) and may not be perceived by the average consumer. Lastly, the overall sensory differences observed seem to indicate a more favorable sensory profile for the LS meat (higher juiciness, aroma intensity, and buttery aroma), except for the off-flavor score which, however, was lower than its standard level of acceptability (3 on a scale of 10 points).

Table 6.4. Results of the linear mixed-model procedure to identify statistical differences between the two clusters in the measured meat quality parameters and in blood aldolase levels.

	HS [1]		**LS [2]**		
Number of Samples	**210**		**230**		
Variable	**Estimate**	**SE [3]**	**Estimate**	**SE**	***p*-Value**
log Aldolase, U/L	1.7106 [51.35]	0.031	1.5693	0.030 [37.10]	0.002
pH45	6.00	0.04	6.00	0.04	0.938
pH24	5.53	0.02	5.50	0.02	0.254
Drip Loss, %	1.16	0.07	1.03	0.06	0.180
L*	47.08	0.83	48.95	0.79	0.109

a*	4.20	0.24	4.01	0.23	0.572
b*	4.77	0.23	5.09	0.22	0.307
Hue	0.87	0.02	0.92	0.02	0.097
Chroma	6.46	0.31	6.62	0.29	0.697
Cooking loss, %	26.04	0.75	26.58	0.71	0.609
WBSF, kg/cm^2	3.86	0.15	3.91	0.14	0.801
Color score	4.57	0.12	4.72	0.11	0.362
Marbling score	4.76	0.25	5.11	0.24	0.308
Initial tenderness	5.32	0.15	5.57	0.14	0.231
Chewing tenderness	4.86	0.14	5.11	0.13	0.212
Juiciness	3.58	0.14	4.09	0.14	0.021
Final residue	2.90	0.06	3.04	0.06	0.125
Chewiness	5.28	0.10	5.50	0.10	0.138
Aroma intensity	5.11	0.12	5.56	0.12	0.014
Buttery aroma	2.76	0.08	2.99	0.08	0.054
Off-flavours	2.18	0.05	2.38	0.05	0.008

[1] Higher Stress, [2] Lower Stress; [3] Standard Error.

Overall, the absence of differences in meat quality between clusters found in this study confirms the poor to moderate relationship between the physiological response to pre-slaughter stress and meat quality, as previously reported by a number of studies [12–14,42]. The moderate-to-high animal welfare experienced by pigs during transport in this study, resulting in a low meat quality variation, may explain this poor relationship. This observation is in agreement with the findings of a review on transport research, which concluded that when transport stress is mild, meat quality is not influenced significantly, as these effects are biased by rest time in lairage (overnight lairage in this study) [43].

6.4. Conclusions and Future Work

This study was the first ever application of a new index (TSWI) as a possible pre-slaughter indicator to predict stress and meat quality in heavy pigs. This work allowed the identification, among the parameters included in the TSWI, of a list of pre-slaughter indicators which can be considered the best descriptors of the welfare conditions experienced by heavy pigs during pre-slaughter handling. Some of these indicators were simple transport variables (i.e., average vehicle speed during transport, distance travelled, group stability, and pig behaviors during handling at unloading), whereas others were complex welfare indexes (i.e., the welfare index at slaughter, and the overall transport and slaughter welfare index).

Although these first results appear promising, a further validation of the TSWI as a stress and meat quality predictor is needed under more variable pre-slaughter conditions. For a more reliable validation, future studies should assess:

(1) The correlations between individual blood and meat quality parameters and the presence of individual variation within the same load;

(2) The effects of the variables showing the largest difference between clusters on meat quality variation. To this end, it would also be of interest to assess the effect of the single behaviors observed during handling (slips, falls, and overlaps) on meat quality variation, as they are an expression of different physical and psychological condition of the pigs.

6.5 Supplementary Materials

This document summarizes the parameters recorded for each shipment and how they were weighed for *Transport and Slaughter Welfare Index (TSWI)*.
Data were collected as follows:

- Farm checklist (parameters recorded at the farm, when animals are moved from the pen to the truck). This checklist results in a "Farm score", which ranges from a minimum of -30.5 points (pts) for the lowest welfare level to a maximum of 15.5 pts for the highest welfare level.
- Transport checklist (parameters recorded during the journey). This checklist results in a "Transport score" which ranges from a minimum of -18 pts for the lowest welfare level to a maximum of 9.5 pts for the highest welfare level.
- Slaughter checklist (parameters recorded at the slaughterhouse, during unloading, lairage, and stunning). This checklist results in a "Slaughter score", which ranges from a minimum of -41.5 pts for the lowest welfare level to a maximum of 50.5 pts for the highest welfare level.

Notes to the tables:
id: unique alphanumeric identification of each parameter
Type of parameter:

- **cod** = codified (for example, a specific code exists for type of floor, type of partitions, system foe water provision, etc.)
- **yn** = yes / no
- **aut** = automatically calculated from the measures taken
- **num** = numerical

Id		Description	Type	Points (range) [points attribution] min	max
A		**ON DEPARTURE (AT THE FARM)**			
A2	*Calc2*	*Number of pigs loaded per hour*	*aut*	*-0.5*	*0*
		< 70		[-0.5]	
		≥ 70		[0]	
A3	*Calc2*	*Average width of the loading hallway (m)*	*aut*	*-1*	*1*
		< 0.45		[-1]	
		0.45-0.55		[0.5]	
		0.56-0.79		[0]	
		0.8-0.9		[1]	
		> 0.9		[0]	
A3	2.c	Hallway design	cod	-1	0
		Presence of 1 or more corners		[-1]	
		Straight		[0]	
A3	2.d	Type of walls in the hallway	cod	-1	0
		See-through walls		[-1]	
		Solid walls		[0]	
A3	2.e	Fences height (m)	num	-1	1
		< 0.9		[-1]	
		0.9-1.09		[0]	
		≥ 1.1		[1]	
A3	2	Conditions of the hallway floor			
	f	slippery	yn	yes=-0.5	no=0
	g	irregular/worn out	yn	yes-0.5	no=0
	h	difficult to clean	yn	yes=-0.5	no=0
A4	*Calc2*	*Average external hallway width (m)*	*aut*	*-1*	*1*
		< 0.45		[-1]	
		0.45-0.55		[0.5]	
		0.56-0.79		[0]	
		0.8-0.9		[1]	
		> 0.9		[0]	
A4	3	Design of external hallway	cod	-1	0
		Presence of 1 or more corners		[-1]	
		Straight		[0]	
A4	4	Type of side walls	cod	-1	0
		See-through walls		[-1]	
		Solid walls		[0]	
A4	5	Side wall height (m)	num	-1	1
		< 0.9		[-1]	
		0.9-1.09		[0]	
		≥ 1.1		[1]	

A4	6	Condition of external alley floors:			
	a	slippery	yn	yes=-0.5	no=0
	b	irregular/worn out	yn	yes=-0.5	no=0
	c	difficult to clean	yn	yes=-0.5	no=0
A4	*Calc3*	*Total path length (m)*	*aut*	*-1*	*1*
		< 60		[1]	
		60-120		[0]	
		> 120		[-1]	
A5	3	Loading ramp width (m)	num	-1	1
		< 0.45		[-1]	
		0,45-0,55		[0.5]	
		0,56-0,79		[0]	
		0,8-0,9		[1]	
		> 0,9		[0]	
A5	*Calc1*	*Ramp slope (%)*	*aut*	*-2*	*1*
		0-15		[1]	
		15.1-25		[0]	
		25.1-36.4		[-1]	
		> 36.4		[-2]	
A5	5	Type of side walls	cod	-1	0
		See-through walls		[-1]	
		Solid walls		[0]	
A5	6	Side protection height (m)	num	-1	1
		< 0.9		[-1]	
		0.9-1.09		[0]	
		≥ 1.1		[1]	
A5	7	Ramp floor condition:			
	a	slippery	yn	yes=-0.5	no=0
	b	irregular/worn out	yn	yes=-0.5	no=0
	c	difficult to clean	yn	yes=-0.5	no=0
A5	8	Quality of loading ramp design	yn	no=0	yes=1
A5	*Calc1*	*System for climbing and ramp slope*	*aut*	*-2*	*0*
A5	9	Presence of steps between:			
	a	hallway and loading ramp	yn	yes=-0.5	no=0
	b	Loading ramp and vehicle gate/dock	yn	yes=-0.5	no=0
A5	10	Discontinuity of the floor between ramp and vehicle access	yn	yes=-0.5	no=0
A5	11	Is the hallway larger than the loading ramp?	yn	yes=0	no=0.5
A5	12	Presence of funnel-shaped partitions to facilitate the entrance in the loading ramp	yn	no=0	yes=0.5
A5	13	Is the loading ramp larger than the vehicle	yn	yes=0	no=0.5

		entrance?			
A5	14	Presence of funnel-shaped partitions to facilitate the entrance to vehicle	yn	no=0	yes=0.5
A6	1	Handling tool used			
	a	electric prod	yn	yes=-1	no=0
	b	board	yn	no=0	yes=0.5
	c	rubber stick	yn	no=0	yes=0.5
	d	soft plastic stick	yn	no=0	yes=0.5
	e	goad and/or other pointed instruments	yn	yes=-1	no=0
A6	2	Use of electric prods			
	a	only for pigs refusing to move and having free space ahead	yn	no=0	yes=0.5
	b	applied for more than 1 s	yn	yes=-1	no=0
	c	applied only to the hindquarters	yn	no=0	yes=0.5
	d	repeatedly applied if the animal does not move forward	yn	yes=-1	no=0
A7	1	Overlapping			
A7	*Calc1*	*% of pigs overlapping during loading*	*aut*	*-1*	*0.5*
		< 10		[0.5]	
		10-20		[0]	
		> 20		[-1]	
A7	2	Slips			
A7	*Calc2*	*% of pigs slipping during loading*	*aut*	*-1*	*0.5*
		< 10		[0.5]	
		10-20		[0]	
		> 20		[-1]	
A7	3	Falls			
		< 10		[1]	
		10-20		[0]	
		> 20		[-2]	
A7	*Calc3*	*% of pigs falling during loading*	*aut*	*-2*	*1*

Id		Description	Type	Points min	Max
B		**TRANSPORT**			
B1	7	Transporters attended courses on animal welfare	yn	no=-1	yes=0
B1	8	Training certificate	yn	no=-1	yes=0
B2	*Calc1*	*Transport duration (h:min; 0.00)*	*aut*	*-1*	*2*
		< 4:00		[2]	
		4:00-6:00		[1]	
		6:01-8:00		[0.5]	
		8:01-10:00		[0]	
		10:.01-12:00		[-0.5]	
		> 12:00		[-1]	
B3	*Calc3*	*Truck floor surface available (transported weight / maximum allowed weight, %)*	*aut*	*-3*	*1*
		≤ 100		[1]	
		101-105		[0]	
		106-110		[-1]	
		111-120		[-2]	
		> 120		[-3]	
B4	1	Average number of drinkers per compartment	cod	-1	1
		None		[-1]	
		1		[0]	
		More than 1		[1]	
B4	2	Drinkers cleanness and functioning:			
	a	dirty	yn	yes=-1	no=0
	b	water leakage	yn	yes=-1	no=0
B4	3	Water reserve	yn	no=-1	0
B4	4	Water tank capacity (l)	num		
B4	*Calc1*	*Ratio between tank capacity and live weight (l/100 kg)*	*aut*	*-1*	*1*
		< 2		[-1]	
		2-6		[0]	
		> 6		[1]	
B5	1	Compliant forced ventilation system (capable to work for at least 4h after the engine of the truck is turned off)	yn	no=-2	yes=0
B5	2	Ventilation system functioning during transport	yn	no=0	yes=1
B5	3	If present, the ventilation system is equipped with:			
	a	sensors for temperature control	yn	no=0	yes=0.5
	b	temperature recording	yn	no=0	yes=0.5
	c	alarm for critical threshold temperature	yn	no=0	yes=0.5
B5	4	Fan misting/sprinkling cooling system	yn	no=0	yes=1
B6	1	Access to animals for inspection and care	yn	no=-1	yes=0
B6	2	Live animals sign exposed on the vehicle	yn	no=-0.5	yes=0
B6	3	Protection barriers for platforms and upper	yn	no=-1	yes=0

			floors			
B6	4		Illumination inside the vehicle	yn	no=-0.5	yes=0
B6	5		Cleaning and disinfection of the vehicle immediately after unloading	yn	no=-0.5	yes=0
B6	6		Floor condition:			
		a	slippery	yn	yes=-0.5	no=0
		b	irregular/worn out	yn	yes=-0.5	no=0
		c	difficult to clean	yn	yes=-0.5	no=0
B6	7		Presence of sufficient bedding	yn	no=0	yes=1

Id		Description	Type	Points min	Points max
C		**SLAUGHTER**			
C2	*Calc1*	*Time between arrival and unloading (h.min)*	*aut*	*-1*	*0*
		≤ 1		[0]	
		> 1		[-1]	
C2	*Calc4*	*Number of pigs unloaded per hour*	*aut*	*-0.5*	*0*
		< 70		[-0.5]	
		≥ 70		[0]	
C3	3	Width of the unloading ramp (m)	num	-1	1
		< 0.45		[-1]	
		0.45-0.55		[0.5]	
		0.56-0.79		[0]	
		0.8-0.9		[1]	
		> 0.9		[0]	
C3	*Calc1*	*Ramp slope (%)*	*aut*	*-2*	*1*
		0-15		[1]	
		15.1-25		[0]	
		25.1-36.4		[-1]	
		> 36.4		[-2]	
C3	5	Type of side walls	cod	-1	0
		See-through walls		[-1]	
		Solid walls		[0]	
C3	6	Wall height (m)	num	-1	1
		< 0.9		[-1]	
		0.9-1.09		[0]	
		≥ 1.1		[1]	
C3	7	Conditions of the unloading ramp floor			
	a	slippery	yn	yes=-0.5	no=0
	b	irregular/worn out	yn	yes=-0.5	no=0
	c	difficult to clean	yn	yes=-0.5	no=0
C3	8	System for descending without risks and/or difficulties	yn	no=0	yes=1
C3	9	Presence of steps between:			
	a	vehicle floor and unloading ramp	yn	yes=-0.5	no=0
	b	unloading ramp and floor of the unloading dock	yn	yes=-0.5	no=0
C3	10	Gap between vehicle floor and unloading dock	yn	yes=-0.5	no=0
C3	11	Vehicle exit larger than the unloading ramp	yn	yes=0	no=0.5
C3	12	Presence of funnel-shaped partitions to facilitate the passage between vehicle exit and loading ramp	yn	no=0	yes=0.5
C3	13	Unloading ramp larger than the hallway	yn	yes=0	no=0.5
C3	14	Presence of funnel-shaped walls to facilitate the passage between unloading ramp and lairage hallway	yn	no=0	yes=0.5
C3	19	Type of side walls	cod	-1	0
		See-through walls		[-1]	

		Solid walls		[0]
C3	20	Side protection height	num	-1 1
		< 0.9		[-1]
		0.9-1.09		[0]
		≥ 1.1		[1]
C3	21	Ramp flooring condition:		
	a	slippery	yn	yes=-0.5 no=0
	b	irregular/worn out	yn	yes=-0.5 no=0
	c	difficult to clean	yn	yes=-0.5 no=0
C3	22	Presence of steps between:		
	a	vehicle floor and unloading bridge/runaway	yn	yes=-0.5 no=0
	b	unloading bridge/runaway and unloading area	yn	yes=-0.5 no=0
C3	23	Gap between:		
	a	vehicle floor and unloading dock/runaway	yn	yes=-0.5 no=0
	b	unloading dock/runaway and unloading area	yn	yes=-0.5 no=0
C3	24	Illumination of the unloading area	yn	no=0 yes=1
C4	1	Moving tools used		
	a	electric prod	yn	yes=-1 no=0
	b	board	yn	no=0 yes=0.5
	c	rubber stick	yn	no=0 yes=0.5
	d	soft plastic stick	yn	no=0 yes=0.5
	e	goad and / or other pointed instruments	yn	yes=-1 no=0
C4	2	Use of electric prods		
	a	only for pigs refusing to move and having free space ahead	yn	no=0 yes=0.5
	b	applied for more than 1 s	yn	yes=-1 no=0
	c	applied only to the hindquarters	yn	no=0 yes=0.5
	d	repeatedly applied if the animal does not move forward	yn	yes=-1 no=0
C5	1	Overlapping		
	Calc1	*% of pigs overlapping during unloading*	*aut*	*-1 0.5*
		< 10		[0.5]
		10-20		[0]
		> 20		[-1]
C5	2	Slips		
	Calc2	*% of pigs slipping during unloading*	*aut*	*-1 0.5*
		< 10		[0.5]
		10-20		[0]
		> 20		[-1]
C5	3	Falls		
	Calc3	*% of pigs falling during unloading*	*aut*	*-2 1*
		< 10		[1]
		10-20		[0]
		> 20		[-2]
C6	1	Presence of a lairage area	yn	no=0 yes=5
C6	2	Presence of a hallway for moving pigs	yn	no=0 yes=1

C6	3	Flooring of the hallway:			
	a	slippery	yn	yes=-0.5	no=0
	b	irregular/worn out	yn	yes=-0.5	no=0
	c	difficult to clean	yn	yes=-0.5	no=0
C6	4	Type of side walls	cod	-1	0
C6	*Calc2*	*Space allowance per pig, m^2*	*aut*	*-2*	*3*
		≤ 0.8		[-2]	
		0.81-1		[-1]	
		1.01-1.1		[0]	
		1.11-1.2		[1]	
		1.21-1.3		[2]	
		> 1.3		[3]	
C6	7	Type of roof of the lairage area	cod	-1	1
		Flat roof		[-1]	
		Single pitch roof		[0]	
		Double pitch roof		[1]	
C6	8	Insulation of the roof	yn	no=0	yes=1
C6	9	"Chimney" opening at the peak of the roof	yn	no=0	yes=1
	Calc7	*Ventilation surface (% of theoretical surface)*	*aut*	*-2*	*2*
		< 40%		[-2]	
		40-59%		[-1.5]	
		60-79%		[-1]	
		80-89%		[0]	
		90-99%		[1]	
		100-119%		[1.5]	
		≥ 120%		[2]	
C6	11	Air flow regulation	yn	no=0	yes=1
C6	12	Dusty environment	yn	yes=-0.5	no=0
C6	13	Perceptible presence of noxious gases (ammonia)	yn	yes=-0.5	no=0
C6	14	Risk of cold drafts at animal level	yn	yes=-0.5	no=0
C6	15	Illumination of the lairage area	yn	no=0	yes=1
C6	*Calc8*	*Power of fluorescent lamps (W/m2)*	*aut*	*0*	*2*
		< 1.5		[0]	
		1.5-2.49		[1]	
		≥ 2.5		[2]	
C6	17	Type of pen floor	cod	-1	3
		Fully slatted floor		[-1]	
		Solid floor		[0]	
		Solid floor with outside defecation area		[1]	
		Partially slatted floor		[2]	
		Solid floor with bedding		[3]	
C6	18	Pen for sick and/or injured pigs	yn	no=0	1
C6	19	Movable pen partitions	yn	no=0	0.5
C6	20	Groups of pigs are stable (not mixed)	yn	no=0	yes=1
C6	21	Flooring type in the service hallway:			
	a	slippery	yn	yes=-0.5	no=0

		b	irregular/worn out	yn	yes=-0.5	no=0
		c	difficult to clean	yn	yes=-0.5	no=0
C6	22		Flooring in the lairage area:			
		a	poor level of cleanliness	yn	yes=-0.5	no=0
		b	very deteriorated internal surfaces	yn	yes=-0.5	no=0
C6	23		Deteriorated equipment and/or presence of protruding parts	yn	yes=-1	no=0
C6	24		System for water provision	cod	0	1
C6	25		Average number of drinkers per pen	cod	-1	1
C6	26		System for food administration	cod	-1	1
C6	27		Type of cooling system	cod	0	2
C7	1		Alley between the lairage and the stunning area			
C7	2		Alley design	cod	-1	0.5
C7	3		Presence of one-way gates	yn	no=0	yes=1
C7	4		Flooring of the alley:			
		a	slippery	yn	yes=-0.5	no=0
		b	irregular/worn out	yn	yes=-0.5	no=0
		c	difficult to clean	yn	yes=-0.5	no=0
C7	5		Pigs are exposed to noise (constant or sudden)	yn	yes=-0.5	no=0
C8	1		Presence of barrier to prevent pigs from seeing the stunning and bleeding area	yn	no=0	yes=1
C8	2		Adequate restraining system	yn	no=0	yes=1
C8	3		Type of restraining/stunning system	cod	0	1
			Manual		[0]	
			Automatic		[1]	
C8	4		Type of stunning	cod		
C8	5		Average stun-to-bleeding time (s)	num	-1	0
			≤ 30		[0]	
			31-60		[-0.5]	
			> 60		[-1]	
C8	6		Equipment is designed, built and maintained so as to prevent injuries to the animals	yn	no=0	yes=1
C8	7		There is a procedure for the use and check of the efficiency of the stunning system	yn	no=0	yes=1
C8	8		Presence of equipment for emergency stunning	yn	no=0	yes=1
C9	1		Number of employees in the lairage area	num		
C9	2		Employees attended courses on preslaughter welfare	yn	no=0	yes=1
C9	3		Specific training on stunning and killing	yn	no=0	yes=1

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Conclusioni

Alla luce di quanto emerso dai lavori inclusi in questo elaborato appare evidente come, in aggiunta alle note criticità che caratterizzano la attuale suinicoltura, dettate per lo più dalla spiccata attitudine intensiva che caratterizza questo tipo di allevamento, siano evidenti problematiche riguardanti il benessere, in particolare di alcune categorie (con spiccato riferimento al suino pesante) e fasi produttive.

È chiaro come la normativa a tutela del benessere del suino, sia a livello comunitario che nazionale, risulti essere un efficace strumento per il legislatore, per l'Autorità Competente in tema di controlli, per l'allevatore, per il consumatore e, soprattutto, per l'animale, fissando degli standard minimi grazie ai quali viene garantito un livello accettabile di benessere.

Allo stesso tempo possiamo concludere che, seppure garanzia di un livello minimo inderogabile di tutela, la *baseline* normativa non risulti ad oggi sufficiente a proteggere alcune categorie produttive che presentano particolari necessità o, in linea generale, non protegga in maniera equivalente tutti gli animali in determinate fasi dell'allevamento.

Risulta chiaro che alcune pratiche dell'allevamento suinicolo, come la castrazione, siano ad oggi particolarmente delicate, sottoponendo gli animali a stress e dolore che sarebbero evitabili con l'adozione di tecniche alternative quali l'immunocastrazione o l'utilizzo di analgesici ed anestetici. Occorrerebbe pertanto migliorare la gestione di questa pratica, adeguamento necessario sia dal punto di vista etico che economico, poiché tema particolarmente sensibile agli occhi dei consumatori.

I consumatori italiani infatti si sono confermati attenti ed interessati non solo alla tutela del benessere, in linea con il trend delineato dagli studi condotti sulla popolazione europea, ma anche disposti a pagare di più a favore di un maggior impegno da parte dell'allevatore e in generale della filiera. In particolare modo, si sono dimostrati interessati ad investire maggiormente sia in termini di scelta di acquisto sia in termini strettamente economici (per quanto con disponibilità a spendere non particolarmente elevate) al fine di tutelare maggiormente il benessere attraverso l'adozione di pratiche innovative, come

l'immunocastrazione, in fasi che causano forti stress ai suinetti come quella della castrazione tradizionale.

Come anticipato l'allevamento del suino pesante può mettere a rischio la tutela del benessere poiché spesso non offre agli animali risorse ambientali e gestionali tali da poter soddisfare in maniera completa ed esaustiva i propri bisogni fisiologici e comportamentali.

Il principale fattore tra tutti che è necessario tutelare e migliorare risulta essere lo spazio disponibile per ogni singolo capo, tale parametro è, anche agli occhi dei consumatori, un criterio importante per elevare il benessere dei suini allevati.

Questo requisito diventa ancora più importante e nevralgico nella categoria dei suini pesanti italiani destinati alla produzione di prodotti DOP e IGP come il Prosciutto di Parma.

Gli animali destinati a questo tipo di produzione infatti raggiungono al momento della macellazione un peso di circa 160-180kg, ed appare evidente quindi come lo spazio pro capite indicato dalla normativa europea risulta totalmente inadeguato poiché fa riferimento a suini al di sopra dei 110kg, uniformando i requisiti minimi di spazio (1m^2/capo) in una categoria di animali che possono raggiungere pesi anche notevolmente superiori (superando di oltre il 50% il peso indicato nella normativa).

Le nostre evidenze sperimentali mostrano che garantire a tale categoria di suini requisiti di spazio superiori a quelli richiesti dalla normativa, portandoli a 1,3 m^2/capo, apporta decisi miglioramenti dal punto di vista comportamentale (maggiore possibilità di riposo), migliorando i parametri produttivi e non intaccando i parametri legati alla qualità delle carni e dei prosciutti.

Un altro momento particolarmente delicato e a cui anche i consumatori rivolgono la loro attenzione è il trasporto degli animali. Questo tema è ancora più "caldo" per quanto riguarda la specie suina, particolarmente sensibile allo stress da trasporto, che può portare a gravi conseguenze non solo dal punto di vista del benessere ma anche produttivo ed economico.

Su questo tema, la valutazione oggettiva dello stress indotto ai suini durante il trasporto pone delle complessità legate all'elevato numero di fattori che intervengono durante il carico, il trasporto, e al macello, per questo nella nostra ricerca in merito abbiamo abbinato l'utilizzo di indicatori ematologici e di qualità delle carni a indicatori più complessi come TSWI (*Transport and Slaughter Welfare Index*) che intergra un numero elevao di parametri musurati durante la fase di pre-macellazione. Nel caso del suino pesante, lo

studio da noi condotto ha permesso di rilevare alcuni parametri che potrebbero essere utilizzati come indicatori del livello di stress degli animali: la velocità media del veicolo, la distanza percorsa, la stabilità dei gruppi, e i comportamenti anomali durante il carico e lo scarico. Anche gli indici complessi calcolati sia al macello sia sull'intera fase di pre-macellazione risultano avere una buona correlazione con i parametri emato-biochimici di stress.

A conclusione di queste variegate esperienze di ricerca, si evidenzia quindi come investire in impegni aggiuntivi da parte del settore suinicolo, perseguendo l'obiettivo di minimizzare gli stress a cui i suini pesanti vengono sottoposti nell'arco della loro vita, dall'adozione di tecniche di castrazione meno invasive, al miglioramento delle condizioni di stabulazione e di trasporto, dovrebbe essere l'obiettivo comune di tutti i protagonisti della filiera, nel perseguimento anche di un contenuto etico dei prodotti finali che soddisfi le aspettative implicite del consumatore.

Abstract Tesi di Dottorato di Giulia Rubini

"Il benessere del suino pesante italiano: esperienze di ricerca in allevamento, durante il trasporto e nella percezione dei consumatori"

Questo elaborato racchiude studi riguardanti il benessere del suino pesante italiano e in particolar modo si concentra su alcuni aspetti che, se opportunamente modificati, potrebbero portare ad un miglioramento sensibile delle condizioni di benessere di questa categoria produttiva. Gli aspetti oggetto di ricerca hanno riguardato la percezione da parte del consumatore italiano del benessere in allevamento (e in particolare la sua disponibilità a consumare prodotti derivanti da suini immunocastrati); inoltre sono stati indagati gli effetti sul benessere (e sulla qualità delle carni e dei prodotti da esse derivati) di alcune caratteristiche dell'allevamento (disponibilità di spazio) e delle caratteristiche multifattoriali che intercorrono durante il trasporto verso la sede di macellazione.

Alla luce dei lavori inclusi in questo elaborato, emerge come rivedere la normativa, considerando anche la categoria del suino pesante, potrebbe notevolmente migliorarne le condizioni di benessere.

I consumatori italiani infatti si sono confermati attenti ed interessati al benessere animale, nonché disposti a spendere di più (anche se con quote non particolarmente elevate) per animali derivanti da pratiche innovative più rispettose del benessere, come l'immunocastrazione.

Un altro criterio importante, soprattutto nella categoria dei suini pesanti italiani, è la disponibilità di spazio. Le nostre evidenze sperimentali mostrano che garantire a tale categoria di suini requisiti di spazio superiori a quelli richiesti dalla normativa (1,3 vs. 1 m^2/capo) migliora il comportamento degli animali (maggiore possibilità di riposo) e i parametri produttivi, senza intaccare la qualità delle carni e dei prosciutti.

Infine, in tema di trasporto, lo studio da noi condotto ha permesso di individuare parametri da utilizzarsi come indicatori del livello di stress degli animali, risultando avere una buona correlazione con i parametri emato-biochimici di stress. Tali parametri sono: la velocità media del veicolo, la distanza percorsa, la stabilità dei gruppi, e i comportamenti anomali durante il carico e lo scarico, gli indici complessivi di benessere calcolati sia al macello sia sull'intera fase di pre-macellazione.

A conclusione di queste variegate esperienze di ricerca, si evidenzia quindi come investire in impegni aggiuntivi da parte del settore suinicolo, perseguendo l'obiettivo di minimizzare gli stress a cui i suini pesanti vengono sottoposti nell'arco della loro vita, dall'adozione di tecniche di castrazione meno invasive, al miglioramento delle condizioni di stabulazione e di trasporto, dovrebbe essere l'obiettivo comune di tutti i protagonisti della filiera, nel perseguimento anche di un contenuto etico dei prodotti finali che soddisfi le aspettative implicite del consumatore.