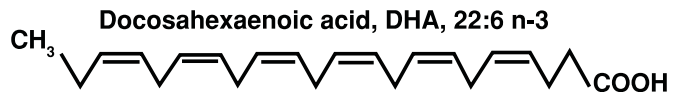
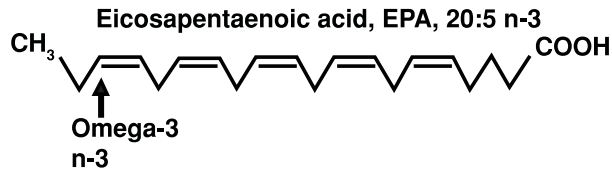


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CONTRIBUTION OF MEAT (BEEF AND LAMB) FROM GRASS-FED RUMINANTS TO THE TOTAL HUMAN DIETARY INTAKE OF LONG CHAIN N-3 POLYUNSATURATED FATTY ACIDS



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SUMMARY

- This project was designed to add to knowledge on the quantities of beneficial long chain omega-3 polyunsaturated fatty acids (LCn-3 PUFA) found in beef and lamb produced in Northern Ireland from grass-fed ruminant animals, and on the potential contribution of grass-fed red meat to human dietary intakes of LCn-3 PUFA.
- The first part of the study involved the collection of samples of beef and lamb from animals slaughtered in Northern Ireland over a 12 month period and the analysis of their lean tissue for fatty acid composition to determine levels and seasonal variation.
- The second part of the study was to determine the animals' finishing diets, and the seasonal variation in the animals' diets. This was done through a telephone survey back to the producers of each sample to identify the finishing diet provided to each animal prior to slaughter. In addition a postal survey was carried out among an additional sample of beef and lamb producers in Northern Ireland in order to assess the influence of season on the type of finishing diet offered by producers.
- The third part of the study was to investigate the effect of human consumption of red meat produced from grass-finished animals on blood concentrations of LCn-3 PUFA. This was done through a human nutrition intervention experiment using healthy subjects.
- Finally, the potential for red meat produced from grass-finished animals to contribute to human intakes of LCn-3 PUFA was assessed using recently published data on intakes of red meat in the Irish population.



The results showed:

1. from the chemical analysis of lean tissue, that beef and lamb contain an average of 21 mg and 34 mg LCn-3 PUFA per 100g of lean tissue respectively; and that these values are similar to those reported by other studies for red meat, although this is the first time that such data has been available for red meat produced in Northern Ireland;
2. from the producer surveys, that grass-based finishing diets are frequently offered to animals by producers of beef and lamb throughout the farming year, being most commonly offered in summer months;
3. that the season of slaughter caused significant variation in concentrations of LCn-3 PUFA and conjugated linoleic acids (CLA) in the lean tissue of beef and lamb, these being highest when grass had formed the major part of the diet prior to slaughter; thereby adding to existing knowledge on factors influencing concentrations of LCn-3 PUFA in red meat;
4. from the human intervention study, that the consumption of red meat from grass-fed animals was associated with significantly higher levels of LCn-3 PUFA in the plasma and platelets of the human subjects than resulted from the consumption of red meat from cereal-fed animals. Furthermore, this effect was achieved at meat intakes similar to that which is currently being consumed by the Irish adult population. Advantageously, there was no effect of these higher LCn-3 PUFA intakes on blood pressure or serum cholesterol in the human subjects of this study;
5. based on current meat intakes in the Irish diet and in a hypothetical situation in which all the red meat was assumed to be from grass-fed animals, that human consumption of grass-fed red meat could contribute modestly higher amounts of LCn-3 PUFA to total daily intakes.

The overall conclusion was:

that the production of red meat from grass-fed animals can contribute to increased LCn-3 PUFA intakes and status among Irish consumers, where red meat is habitually consumed. Further research is needed to investigate the opportunity to maximise concentrations of LCn-3 PUFA within red meat by increased use of grass feeding regimes in beef and lamb production, which would in turn result in improved health benefits to red meat consumers. Such higher LCn-3 PUFA red meats should be regarded as premium products, attracting a higher price at retail and farm-gate, thereby having the potential to increase profitability throughout the supply chain.



INTRODUCTION

Red meat, a food product which refers to mainly beef and lamb, is an integral component of the habitual diet among the UK and Irish population. Red meat contributes important amounts of dietary protein and essential nutrients to consumers, but it is also a source of the long chain omega-3 polyunsaturated fatty acids (LCn-3 PUFA). These are eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA), which are widely recognised for providing numerous benefits to human health, particularly to cognitive function and heart health. Red meat also contains conjugated linoleic acids (CLA), a group of unsaturated fatty acids which offer potential antioxidant and anti-cancer properties.

For optimum health, nutritional recommendations are to consume 450 mg per day of EPA and DHA combined. Oily fish has the richest concentration of these fatty acids. However intakes of fish remain low in the British and Irish populations, raising concerns over how to meet nutritional recommendations. Although quantities of LCn-3 PUFA found in red meat are much lower than those found in oily fish, it is possible that red meat makes a valuable contribution to dietary intakes of LCn-3 PUFA, given that meat is consumed in much greater amounts than fish in the UK and Ireland.

Beef cattle and sheep in Northern Ireland are reared predominantly on a diet rich in grass. One major benefit of feeding grass, as compared to cereals, as part of the finishing diet (i.e. the diet provided prior to slaughter) is that the final meat product contains greater concentrations of LCn-3 PUFA, and could in turn have a potentially greater health benefit when consumed. This is due to grass lipids being rich in alpha-linolenic acid (ALA), the parent molecule of the n-3 PUFA family from which the LCn-3 PUFA may be converted during the process of fat metabolism in the ruminant. In contrast, cereals are rich in linoleic acid (LA), the parent molecule of the n-6 PUFA family, which counteracts the positive health promoting effects of LCn-3 PUFA when the dietary ratio of n-6:n-3 is high. Despite knowledge of the importance of the animal diet to human health, no attempts have been made previously to measure the fatty acid content of red meat reared on different production diets in Northern Ireland, or to relate this data to health implications for consumers of red meat in this region. Such data, were it available, could reveal the feasibility of increasing grass-based red meat production in this region, which would have obvious positive implications for both the market and consumer health.

Previous work in Northern Ireland at the Agricultural Research Institute Hillsborough had found higher concentrations of LCn-3 PUFA and CLA in pasture-fed beef than in concentrate-fed beef. This study was initiated to progress to the next step in the food chain to fill in knowledge gaps on the contribution of grass-fed beef and lamb to the human dietary intake of LCn-3 PUFA in the Irish population.



The objectives of this project were:

1. To undertake an extensive analysis of the fatty acid composition of beef and lamb produced over 12 months in Northern Ireland, investigating the effect of both season and reported finishing diet on quantities of LCn-3 PUFA within meat.
2. To assess the frequency of grass finishing among beef and lamb producers in Northern Ireland over a typical farming year through a postal questionnaire.
3. To investigate the effect of regular consumption of beef and lamb produced from grass-fed animals on plasma and platelet LCn-3 PUFA status in healthy individuals through a human intervention study.
4. To update current estimates of LCn-3 PUFA intakes in the Irish population and to investigate the potential contribution of red meat produced from grass-fed animals to overall LCn-3 PUFA intakes.



OBJECTIVE 1

ANALYSIS OF THE FATTY ACID COMPOSITION OF BEEF AND LAMB

Materials & Methods

Each fortnight approximately 10 beef and 10 lamb samples (weighing approximately 250g) were collected from a commercial abattoir in Northern Ireland during routine carcass processing. This resulted in a total of 234 beef and 217 lamb samples being collected over the 12 month period from May 2007 to April 2008. Carcasses from which samples were taken were chosen at random to avoid over-sampling from a specific producer and therefore to ensure representativeness of beef and lamb production in Northern Ireland.

Samples were subjected to fatty acid analysis, which involved extracting the total lipid fraction from the muscle of the meat samples according to an adaptation of the method of Folch et al. and quantification of fatty acid methyl esters (FAME) using gas chromatography (GC) technology with flame ionization detection (FID).

Using the sample kill number and slaughter date, producer names and contact telephone numbers were obtained with the help of the abattoir and from using Northern Ireland's computerised bovine traceability system known as APHIS (Animal and Public Health Information System), which was available through the Department of Agriculture and Rural Development (DARD). Producers were later contacted by telephone to ascertain the finishing diet that had been provided to the animals in the month prior to slaughter. The finishing diet options were grass only, grass with cereals, cereals only and silage with cereals.

Results

Fatty acid composition and LCn-3 PUFA content of beef and lamb muscle tissue

The total fat and fatty acid composition of beef and lamb samples collected over a 12 month period are presented in Table 1. Results shown are for muscle tissue only, which is what is predominantly consumed, and will therefore have a greater impact on human health. Averaged over the whole 12-month sampling period, beef and lamb were respectively found to contain 28.7 mg/g and 42.4 mg/g total fat, 0.21 mg/g and 0.34 mg/g LCn-3 PUFA, 0.42 mg/g and 0.88 mg/g total n-3 PUFA, and 0.18 mg/g and 0.70 mg/g CLA. These amounts are similar to amounts reported by similar studies for red meat produced in other parts of the UK, but this is the first time that such data has been available for red meat produced solely in Northern Ireland.

In the past, concerns have been raised regarding the amount of saturated fatty acids (SFA) within red meat in relation to risk of cardiovascular disease (CVD). However, these results show that concentrations of monounsaturated fatty acids (MUFA) were similar to SFA within both beef and lamb and, taking the content of PUFA into account; indicate that there is a greater proportion of unsaturated than saturated fats within red meat analysed in the present study. These results also show that docosapentaenoic acid (DPA) is the most abundant LCn-3 PUFA found within beef and lamb. Although DPA is often omitted from nutritional guidelines, recent evidence suggests it is equally as important in its potential cardio protective role as EPA or DHA, and the clinical significance of its consumption from red meat should be further investigated.



Table 1 Mean fat content and fatty acid composition of beef and lamb sampled over 12 months in Northern Ireland (mg/g muscle).

	Beef (n=234)	Lamb (n=217)
Total fat	28.70	42.20
<i>of which:</i>	-	-
Total CLA	0.18	0.70
Total TFA	0.68	2.11
Total SFA	12.04	18.10
Total UFA	13.38	17.95
<i>of which:</i>	-	-
Total MUFA	11.59	15.47
Total PUFA	1.79	2.48
<i>of which:</i>	-	-
Total n-6 PUFA	1.37	1.60
<i>of which:</i>	-	-
LA	1.01	1.19
AA	0.27	0.25
Total n-3 PUFA	0.42	0.88
<i>of which:</i>	-	-
ALA	0.20	0.54
LCn-3 PUFA	0.21	0.34
<i>of which:</i>	-	-
EPA	0.09	0.14
DPA	0.12	0.16
DHA	0.01	0.04

CLA = conjugated linoleic acid; TFA = trans fatty acids;
 SFA = saturated fatty acids; UFA = unsaturated fatty acids;
 MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids;
 LA = Linoleic acid; AA = arachidonic acid; ALA = alpha-linolenic acid;
 Total n-6 PUFA = sum of LA + AA; Total n-3 PUFA = sum of ALA + EPA + DPA + DHA;
 LCn-3 PUFA = long chain omega-3 polyunsaturated fatty acids (EPA+DPA+DHA);
 EPA = eicosapentaenoic acid; DPA = docosapentaenoic acid; DHA = docosahexaenoic acid.



Seasonal effects on LCn-3 PUFA content of beef and lamb muscle tissue

As a result of natural variation in animal diet with season, samples were grouped according to season of collection prior to secondary analysis in order to allow interpretation of trends in fatty acid composition across the year. This secondary analysis showed that beef samples collected in autumn (September- November) and lamb samples collected in summer (June- August) were both found to contain significantly greater concentrations of LCn-3 PUFA (Figure 1), total n-3 PUFA and total CLA than samples collected in other seasons. Using data provided from the follow-up telephone call, it was possible to identify that the majority of beef and lamb samples taken during these periods were from animals primarily finished on a grass diet (cattle would have had a complete season grazing grass, and summer is the period in which the fastest growing lambs would have consumed most grass and reached the slaughter stage). It is highly likely that the longer grazing period during these seasons is accountable for the higher tissue concentrations of LCn-3 PUFA found in red meat produced in these seasons. In addition, it has been reported that perennial ryegrass cut in the months of April and November is highest in ALA content, which would contribute to increased LCn-3 PUFA content of meat produced from animals over these months.

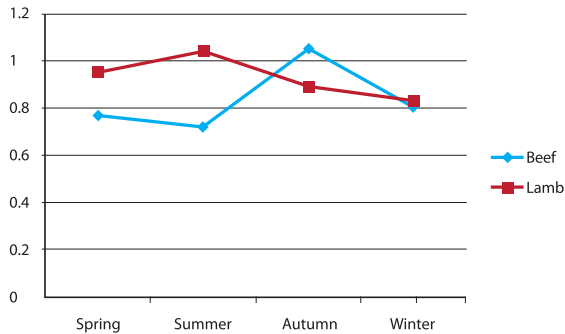


Figure 1 Seasonal variation in proportion of LCn-3 PUFA found in beef and lamb tissue (% total fatty acids).

This study has shown that the fatty acid composition of beef and lamb muscle is subject to seasonal variation, with autumn-produced beef and summer-produced lamb having significantly higher concentrations of LCn-3 PUFA than that produced in other seasons. To our knowledge, no study to date has measured the variation in fatty acid composition over all four seasons and in lambs the effect of season has not been studied previously; therefore results reported here add important and novel findings to the published information.



OBJECTIVE 2

USE OF FINISHING DIETS BY BEEF AND LAMB PRODUCERS

Materials & Methods

A 'Farm Feeding Regime' survey was conducted. Survey participants were selected from farms which produce beef and/or lamb across Northern Ireland using the Agricultural Census obtained from DARD. A questionnaire was distributed by post to a total of 600 farms in April 2007, along with information about the research project, and a stamped addressed envelope to facilitate ease of return by post. The questionnaire was designed with the objective of identifying finishing diets of animals in the one month period prior to slaughter. The options given for finishing diets were: grass only, grass with cereals, cereals only and silage with cereals.

Results

A total of 127 (21%) postal questionnaires were returned of the 600 that were distributed. Some 97 were deemed valid based on the fact that they finished animals, of which 72 (74%) reported finishing beef cattle and 60 (63%) reported finishing lambs.

Overall the most common finishing diet prior to slaughter was grass for lambs (reported by 73% respondents) and silage with cereals for beef cattle (reported by some 72% respondents).

In order to look at the effect of season of finishing on finishing diet, months were grouped into four seasonal periods and the diets provided during these periods determined (Table 2). This analysis showed that exclusive grass-finishing of both cattle and lambs occurred mainly in the summer months, from June to July, as reported by 48% and 66% of responding farms respectively. In autumn, the majority of lambs continued to have a grass-only diet, reported by 55% of farms, whilst cattle were offered supplementary cereals while grazing grass by 50% of farms. It was observed that the majority of lambs were grass-only finished over a greater period of the year (June to November) than cattle (June to August), and even during the spring and winter periods a greater proportion of farms provided grass-only diets for lambs than was the case for cattle (28% and 25% for lamb compared to 8% and 0% for beef cattle). However the majority of lamb farms supplemented grazed grass with cereals in spring and winter, whereas beef cattle were finished in these periods on silage plus cereals (60% in spring and 81% in winter).

These results show that the reported finishing diets used by producers of beef and lamb vary by season, with both beef cattle and lamb being predominantly offered grass during the summer season. These results support the fatty acid profiles measured for beef and lamb, suggesting that red meat produced in Northern Ireland from grass-fed animals, particularly during summer and autumn months, is greater in its content of healthy fatty acids.



Table 2 Seasonal use of finishing diets reported by beef and lamb producers as determined from the farm feeding survey (expressed as % of total beef/lamb responses for each season).

Diet	Beef				Lamb			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Grass	8	48	16	0	28	66	55	25
Grass with Cereals	26	39	50	16	54	32	41	53
Cereals	4	6	2	3	8	0	0	3
Silage with Cereals	60	7	32	81	5	0	2	16
Other	2	0	0	0	5	2	2	3

Seasons were defined as:

Spring = March-May

Summer = June- August

Autumn = September- November

Winter = December- February



OBJECTIVE 3

HUMAN INTERVENTION STUDY

Materials & Methods

A dietary intervention study was carried out in 40 healthy free-living volunteers (20 male and 20 female) recruited from staff and students at the University of Ulster. Participants were randomly allocated to one of two groups, to consume red meat from animals that had been offered either a finishing diet of grass or of cereals. Red meat for the study was sourced from producers in Northern Ireland who offered diets to animals under experimental conditions. Half of the animals were offered a finishing diet of grass only, whilst the other half were offered a finishing diet of cereals only for a minimum period of six weeks prior to slaughter. At the end of the pre-slaughter feeding regime, animals were slaughtered according to routine practice at a commercial abattoir, after which beef striploins and topsides, and lamb loins were used to prepare cuts of meat for human consumption. Additional samples were taken from each type of meat for confirmatory fatty acid analysis, which was carried out as described previously.

In each week of the 4-week intervention period, participants in each group were provided with, and required to consume in place of their normal red meat intake, one portion of beef mince (250g raw weight), one beef sirloin steak (200g raw weight) and four small lamb medallion pieces (240g raw weight). The weekly consumption of these meats, taking into account an approximate 32% weight loss during cooking was approximately 470g cooked weight, and did not exceed the limit of 500g cooked weight per week as recommended by the World Cancer Research Fund (WCRF, 2007). Participants were instructed not to consume any oily fish during the 4-week intervention period, but were otherwise encouraged to follow their normal dietary habits. Fasting blood samples were collected from the study volunteers at baseline (week 0) and post-intervention (week 4). Plasma and platelets were separated, from which total lipid was extracted using an adaptation of the Folch et al. method as described previously, and FAME were quantified using a GC with mass spectrometer detector (MS). Serum was also obtained from blood samples and used to analyse total cholesterol and lipoproteins. Weight, height, blood pressure and dietary intakes were measured at baseline and post-intervention. The assessment of dietary intakes using 4-day food diaries allowed mean daily macronutrient, micronutrient and fatty acid intake of each subject to be evaluated before and during the intervention period.

Results

Of the 40 volunteers who were recruited, two withdrew as a result of being unable to commit to the study requirements. Therefore, 18 subjects in the group that consumed meat from grass-fed animals and 20 in the group that consumed meat from cereal-fed animals successfully completed the study by consuming all portions of provided beef and lamb per week for 4 weeks. Table 3 shows the characteristics of the study volunteers at baseline. There were no significant changes in serum cholesterol, lipoproteins or blood pressure in either study group as a result of the intervention.



Table 3 Baseline characteristics of the study participants (mean values).

	Grass Group (n=18)	Cereal Group (n=20)
Sex (male / female) (n)	9 / 9	10 / 10
Age (range)	25 (19-41)	26 (18-41)
Height (m)	1.70	1.72
Weight (kg)	66.90	69.80
BMI (kg/m ²)	22.90	23.50
SBP (mmHg)	117.94	121.55
DBP (mmHg)	76.61	79.70
Total cholesterol (mmol/l)	4.07	4.74
LDL (mmol/l)	2.16	2.50
HDL (mmol/l)	1.44	1.54
TAG (mmol/l)	0.99	1.16

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL, low-density lipoprotein; HDL, high-density lipoprotein; TAG, triacylglycerols

Table 4 shows the results of fatty acid analysis of the muscle tissue of meat portions. Beef steaks, beef mince and lamb medallions from grass-fed animals were found to contain significantly greater concentrations of LCn-3 PUFA than those from cereal-fed animals. Meat from grass-fed animals was also lower in total fat compared to meat from cereal-fed animals.

Table 4 Concentrations of LCn-3 PUFA found in the meat portions consumed in the human intervention study, from animals fed two different diets (mg/g muscle tissue).

	Grass-fed animals	Cereal-fed animals
Beef steaks	0.24	0.13
Beef mince	0.24	0.13
Lamb medallions	0.36	0.26



Figures 2 and 3 show the directional change in blood plasma and platelet fatty acid LCn-3 PUFA concentration from baseline to post-intervention for each study group. There were no significant differences in either blood plasma or blood platelet concentration of LCn-3 PUFA between the grass and cereal groups at baseline. However in response to dietary intervention in humans both blood plasma and platelet concentrations of LCn-3 PUFA and total n-3 PUFA were significantly increased within the group that consumed meat from grass-fed animals compared to the group that consumed meat from cereal-fed animals.

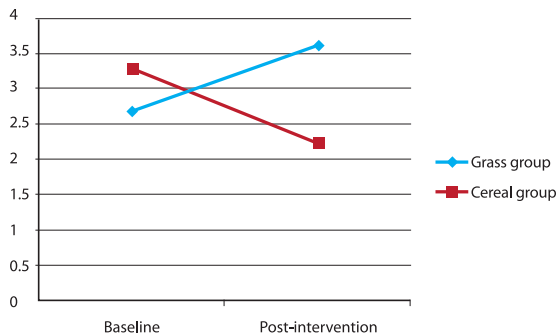


Figure 2 Changes in blood plasma composition of LCn-3 PUFA at baseline and post-intervention according to study group (% total fatty acids in blood plasma).

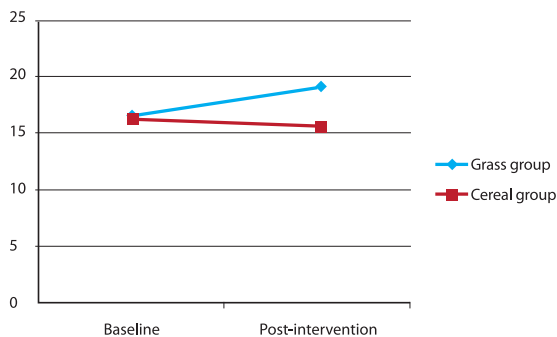


Figure 3 Change in blood platelet composition of LCn-3 PUFA at baseline and post-intervention according to study group (% total fatty acids in blood platelets).



Conclusion

These results demonstrate that moderate consumption of red meat from grass-fed animals can increase blood plasma and platelet LCn-3 PUFA concentrations among healthy individuals. This is thought to be a completely new finding, as the follow through from animal diet to human diet and human blood composition is a novel and original approach.

The approximate daily intake of red meat in this study of 67g/day (470g/week) was below the upper limit advised by the WCRF of 71g/day (500g/week) and represents an achievable intake, as results from the North South Ireland Food Consumption Survey (NSIFCS) indicate that 88% of the Irish population are already consuming red meat intakes of 51g/day. Dietary analysis showed that red meat was the primary component responsible for the rise in blood concentrations of LCn-3 PUFA within the group that consumed meat from grass-fed animals compared to the group that consumed meat from cereal-fed animals.

Overall the results of this study suggest that red meat from grass-fed animals can contribute important amounts of dietary LCn-3 PUFA to consumers of red meat, and that increasing the production of red meat from grass-fed animals may help to increase LCn-3 PUFA intakes within the consumer population of Ireland, which in turn would be beneficial for human health.



OBJECTIVE 4

ESTIMATES OF THE CONTRIBUTION OF RED MEAT TO TOTAL DIETARY INTAKES OF LCn-3 PUFA

Materials & Methods

The North South Ireland Food Consumption Survey (NSIFCS) was carried out in 1997-1999 and is the most up to date data source for habitual food intake for adults (aged 18-64 years) residing on the island of Ireland. Using available data for consumer food intakes from this survey and fatty acid data for fish and meat as contained in a major dietary database used by nutritionists, it was possible to create a crude estimate of current total LCn-3 PUFA intakes among the Irish population. Fatty acid data for beef, lamb and burgers (assumed to be beef burgers) were hypothetically replaced with data obtained from the human intervention study, where beef and lamb were collected from animals fed a strict finishing diet of grass or cereals only. These substitutions in the database allowed an estimation of LCn-3 PUFA intakes in a hypothetical situation where all red meat consumed was presumed to be from either grass-fed or cereal-fed animals.

Results

The ability of red meat to contribute important amounts of LCn-3 PUFA to the diet is of course dependent on the amount of red meat consumed. Table 5 presents estimated total LCn-3 PUFA intakes for Irish consumers based on intakes of contributing foods and their relevant concentration of LCn-3 PUFA. This table also shows the effect of consuming red meat from grass-fed or cereal-fed animals on total LCn-3 PUFA intakes. With the hypothetical consumption of red meat from grass-fed animals, the total intake of LCn-3 PUFA was estimated at 309 mg/day, approximately 8 mg/day greater than the intake of 301 mg/day which was estimated from the consumption of red meat from cereal-fed animals. Although this is a small amount, it nonetheless confirms that the animal diet has an impact on amounts of LCn-3 PUFA supplied by red meat consumption. Even with the hypothetical inclusion of red meat in the diet from grass-fed animals and the assumption of fish being consumed, total LCn-3 PUFA intakes are still well below the recommended 450mg/day. This heralds the need for further action to raise LCn-3 PUFA intakes closer to this recommendation.

Data from the NSIFCS show that 66% of the Irish population are consumers of fish of all different types. It is probable that the proportion of those who consume oily fish is even lower, based on the knowledge that in the UK only 27% of the population are known to be oily fish consumers. Given the possibility of a low oily fish intake, taken together with the fact that a greater proportion of the Irish population consume meat than fish, a separate hypothetical situation was presumed where the contribution of meat to total LCn-3 PUFA intakes was estimated in the absence of fish in the diet (Table 6). In this situation, red meat (beef, lamb and burgers) from grass-fed animals has the potential to supply 41% of the total daily LCn-3 PUFA intake compared with 29% supplied by red meat from cereal-fed animals.



Red meat consumption (beef, lamb and burgers) from grass-fed animals compared to cereal-fed animals would allow greater intakes of LCn-3 PUFA to be consumed in amounts of 4.5 mg/day, 2.3 mg/day and 1.5 mg/day respectively for beef, lamb and burgers (89%, 38% and 89% more in terms of percentage difference). It is acknowledged that this study presents a crude estimate of LCn-3 PUFA intakes based on fatty acid data that were only available for beef steaks, beef mince and lamb loin medallion. Other cuts of red meat consumed may possess a different fatty acid composition.

Table 5 Estimated daily intake of LCn-3 PUFA within the Irish consumer population including the contribution from red meat produced from grass-fed and cereal-fed animals.

	Grass-fed				Cereal-fed	
	% ¹	Intake (g/d)	Concentration LCn-3 PUFA ² (mg/g)	Intake LCn-3 PUFA (mg/d)	Concentration LCn-3 PUFA ² (mg/g)	Intake LCn-3 PUFA (mg/d)
Fish & fish products	66	35	7.36	257.60	7.36	257.60
Total meat	99	197	-	51.13	-	42.89
Beef	80	39	0.24	9.84	0.13	5.04
Lamb	38	23	0.36	8.21	0.26	5.93
Burgers	27	13	0.24	3.10	0.13	1.64
Bacon & Ham	92	33	0.06	1.98	0.06	1.98
Pork	42	27	0.20	5.38	0.20	5.38
Poultry	89	37	0.60	22.02	0.60	22.02
Sausages	64	16	0.00	0.00	0.00	0.00
Meat Products	30	10	0.09	0.90	0.09	0.90
Total LCn-3 PUFA intake				308.73		300.49

¹ % of consumers of food product within total population from NSIFCS

² Concentrations of LCn-3 PUFA for fish and meat obtained from dietary database and beef, lamb and burgers from previously collected data, where only the fatty acid composition of lean tissue is presented



Table 6 Estimated contribution of red meat from grass-fed and cereal-fed animals to total LCn-3 PUFA intakes where meat is the major dietary source of LCn-3 PUFA.

	Intake ¹ (g/d)	Grass-fed		Cereal-fed		Difference	
		Intake LCn-3 PUFA ² (mg/d)	% ³	Intake LCn-3 PUFA ² (mg/d)	% ³	Intake LCn-3 PUFA ² (mg/d)	%
Beef	39.1	9.5	18.7	5.0	11.8	4.5	89.3
Lamb	22.8	8.2	16.1	5.9	13.8	2.3	38.4
Burgers	12.7	3.1	6.1	1.6	3.8	1.5	89.0
Bacon & Ham	33.0	1.9	3.9	1.9	4.6	-	-
Pork	26.9	5.4	10.5	5.4	12.5	-	-
Poultry	36.7	22.0	43.1	22.0	51.3	-	-
Sausages	16.1	0.0	0.0	0.0	0.0	-	-
Meat Products	10.0	0.9	1.8	0.9	2.1	-	-
Total meat	197.3	51.1		42.9		8.2	19.2

¹ Consumer intakes from NSIFCS

² Concentrations of LCn-3 PUFA for fish and meat obtained from dietary database and beef, lamb and burgers from previously collected data, where only the fatty acid composition of lean tissue is presented

³ % contribution to total daily LCn-3 PUFA intake from meat



SUMMARY OF FINDINGS

This study included an extensive fatty acid analysis of red meat produced over a complete year, a farm feeding regime survey, a human dietary intervention study and an update in current estimates of LCn-3 PUFA intakes among consumers of red meat in the Irish population.

Fatty acid composition of beef and lamb

- Both season and reported finishing diet were found to be important determinants of the fatty acid composition of beef and lamb.
- Red meat produced in the summer and autumn months was higher in both LCn-3 PUFA and CLA.
- It will be important for future research to investigate how the frequency of grass finishing of animals could be increased over the farming year in order to maximize quantities of these fatty acids within red meat produced.

Farm feeding regime survey

- Grass finishing is commonplace among red meat producers in Northern Ireland, particularly in the summer months; however these data are potentially limited by a low response rate to the questionnaire.
- These data will be valuable in future efforts to promote grass feeding among producers.

Human intervention study

- For the first time the effect of human consumption of red meat produced from different animal diets was investigated.
- Beef and lamb produced from animals fed grass for six weeks prior to slaughter contained significantly greater concentrations of LCn-3 PUFA compared to that produced from animals fed cereals, and consumption of this meat allowed significantly greater incorporation of LCn-3 PUFA into plasma and platelets in healthy subjects.
- It remains unknown whether amounts of LCn-3 PUFA provided by red meat consumption would be sufficient to cause beneficial effects on consumer health and this presents an area for necessary future research.

Contribution of red meat to total dietary intakes of LCn-3 PUFA

- The current estimated total intake of LCn-3 PUFA is 309 mg/d with the assumption that red meat consumed is produced from strictly grass-fed animals.
- In Ireland, 88% of the population consumes red meat, 66% consume fish and from UK data possibly only 27% consume oily fish. Among consumers who do not consume fish, the significance of red meat and its contribution of LCn-3 PUFA becomes greater.



IMPLICATIONS FOR THE INDUSTRY

Future research is required to investigate the potential for increased production of beef and lamb from grass-fed animals in order to attempt to exploit LCn-3 PUFA concentrations in the meat. Ultimately the co-operation of producers will be required; therefore educating the producer on the importance of the animal diet on the fatty acid profile of meat produced will be a key factor in achieving this. Consideration should also be given to the management of relevant aspects of the production system other than the animal diet, which may also influence fatty acid composition of the meat. It will be important to carry out further intervention studies with red meat from grass-fed animals to investigate the impact of an increase in LCn-3 PUFA concentrations on biological mechanisms. Finally, it will also be important to determine the opportunity to exploit higher omega-3 red meat produced from grass-fed animals as a marketable product based on consumer attitudes toward purchasing such a product. There are currently food products in the market place that are promoted as high in omega-3s, such as fat spreads and eggs.

In conclusion this project has added new findings to knowledge on concentrations of LCn-3 PUFA found in red meat and has demonstrated the importance of grass finishing of animals in achieving higher concentrations. This project has originally shown that higher concentrations of LCn-3 PUFA in red meat, when consumed in moderate quantities, will increase the LCn-3 PUFA status of humans. There is thus likely to be a human health benefit from consuming grass-fed red meat, and because of the high proportion of the population that consumes red meat, a consequent benefit to the health of the population. With further research it may be possible to increase the LCn-3 PUFA content of meat above levels reported by this study, which would in turn allow red meat to contribute greater amounts of LCn-3 PUFA to consumers.

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PUBLICATIONS THAT HAVE ARISEN FROM THIS PROJECT

McAfee A J, Duffy E, Cuskelly G J, Wallace J M W, Bonham M P, Moss B W & Strain J J (2009). Finishing diets used in beef and lamb production in Northern Ireland: results of a questionnaire survey. *Proceedings of the British Society of Animal Science, Southport, April 2009 (Abstract)*.

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