



Consumer preference and effect of correct or misleading information after ageing beef *longissimus* muscle using vacuum, dry ageing, or a dry ageing bag



Helena Stenström^{a,1}, Xin Li^{a,b,*}, Melvin C. Hunt^c, Kerstin Lundström^a

^a Swedish University of Agricultural Sciences, Uppsala BioCenter, Department of Food Science, P.O. Box 7051, SE-750 07 Uppsala, Sweden

^b Institute of Agro-Products Processing Science and Technology, Chinese Academy of Agricultural Sciences, 100193 Beijing, China

^c Department of Animal Sciences and Industry, Kansas State University, Manhattan, KS 66506, USA

ARTICLE INFO

Article history:

Received 8 January 2013

Received in revised form 22 July 2013

Accepted 19 October 2013

Available online 25 October 2013

Keywords:

Beef

Dry ageing

Dry ageing bag

Vacuum ageing

Consumer preference

Effect of information

ABSTRACT

The objective of this study was to determine which ageing treatment of beef was sensorially preferred by consumers and how their preference changed when given information about the ageing treatment used. *Longissimus thoracis et lumborum* from four young bulls were randomly assigned three ageing treatments: dry ageing, vacuum ageing and ageing in a highly moisture permeable bag (bag dry-ageing); each was aged at 1.6 °C for another 13 days. A preference test (171 consumers) with questions about overall liking, tenderness, and juiciness was performed. Thereafter, a deceptive test (61 consumers) was performed with two taste samples, the first taste sample with correct information about ageing treatment and the second with false information. In the preference test, consumers preferred dry ageing and bag dry-ageing to vacuum ageing. In the deceptive test, dry ageing was preferred, but the information given influenced preference.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Today, few people question whether meat should be aged; rather, the question is how long and by which method. Most beef sold in food stores is vacuum aged (aged in a vacuum bag, also called wet ageing) 7 to more than 21 days post mortem. Only a very small amount of meat is dry aged (no protective packaging), usually for 14 to 30 days post mortem.

A number of studies have compared wet ageing and dry ageing, focusing on weight loss and sensory preference (Campbell, Hunt, Levis, & Chambers, 2001; Laster et al., 2008; Oreskovich, McKeith, Carr, Novakofski, & Bechtel, 1988; Parrish, Boles, Rust, & Olson, 1991; Smith et al., 2008; Warren & Kastner, 1992). Dry-aged meat loses more weight during the process, especially moisture loss at ageing and weight loss at trimming, which makes it more expensive. Most dry-aged meat is sold by speciality shops, over the Internet, and to upscale restaurants and can be difficult to find in ordinary food stores.

One of the problems with dry ageing is the necessity for hygiene and ventilation in the chilling room. Meat that is aged unprotected has a high risk of microbial contamination. Effective ventilation is important also to form a dry protective surface that constitutes a protective barrier against microbial contamination in the later part of ageing (Campbell et al., 2001; Oreskovich et al., 1988; Warren & Kastner, 1992). A relatively new kind of bag, highly permeable to water vapour, is now available (TUBLIN® TUB-EX). The material in the bag functions as a breathable plastic, which simulates moisture loss of unpackaged cuts. In this way, the meat can develop the same positive sensory attributes as traditionally dry-aged meat while at the same time decreasing trim losses because it is protected from the environment. Only a few studies have compared traditional dry ageing with dry ageing in a bag (Ahnström, Seyfert, Hunt, & Johnson, 2006; DeGeer et al., 2009), and the results indicate no differences between these dry ageing methods.

In many countries, meat is produced from young bulls with little marbling. Vacuum ageing is the most common ageing method, so this method should be included in a comparison with dry-ageing. Thus, this study, used meat from young bulls and all three ageing methods. We hoped to discover, using sensory tests, whether consumers preferred beef that had been vacuum aged, dry aged, or aged in a highly water-permeable bag. In addition, we wanted to study how information about meat processing influenced consumers in their preferences after receiving misleading information.

* Corresponding author at: Swedish University of Agricultural Sciences, Uppsala BioCenter, Department of Food Science, Box 7051, SE-750 07 Uppsala, Sweden. Tel.: +46 18 671641 (Office); fax: +46 18 672995.

E-mail address: xinli.caas@gmail.com (X. Li).

¹ Present address: SIA Glass AB, Stenlövsvägen 33, SE-311 68, Slöinge, Sweden.

2. Materials and methods

2.1. Animals and sample collection

Four young bulls from the same farm were slaughtered at a small-scale slaughterhouse. Two of the animals were Swedish Holstein (SLB) and two were Swedish Red (SRB). The bulls (age 18–21 months) weighed between 334 and 386 kg. Conformation and fatness were graded according to the EUROP schemes modified to the Swedish system, in which 15 classes are used (for conformation score: E⁺ = best, P⁻ = poorest; for fatness score, 5⁺ = fattest, 1⁻ = leanest) (Commission of the European Communities, 2005; Swedish Board of Agriculture, 1998). The conformation score ranged from R to O, and for fatness, all four animals were classified 3. After slaughter, carcasses were chilled for 48 h, then the *longissimus thoracis et lumborum* (LTL) muscles from both sides of the carcass were removed from the 11th thoracic to the last lumbar vertebra (ca. 50 cm long sections). pH was measured manually 48 h post mortem on the right side between the 10th and 11th rib with a pH metre (Portamess® 913 X pH, Knick Berlin, Germany) equipped with a gel electrode (SE 104, Knick, Berlin, Germany). pH was also measured 15 days post mortem at the end of the ageing treatments.

2.2. Ageing treatments

Three ageing treatments were used: traditional dry ageing (no packaging); vacuum ageing (80 µm thick, polyamide/polyethylene with oxygen transmission rate of 50 cm³ / (m² * 24 h * atm) at 23 °C and 75% relative humidity and water-vapour transmission rate of 3 g/m²/24 h at 23 °C and 85% relative humidity; Amilen PA/PE 20/60, Finnvacuum, Helsinki, Finland); and ageing in a highly moisture-permeable bag (50 µm thick, polyamide mix with water vapour transmission rate 8000 g/15 µm²/24 h at 38 °C and 50% relative humidity; TUBLIN® Dry, TUB-EX ApS, Denmark). The treatments were assigned randomly to the eight LTL (see Table 1 for distribution of treatments). Three LTL were left on the bone to be traditionally dry aged. These were weighed and hung in a cooler (1.6 °C). The LTL assigned to be aged in vacuum or in highly permeable bags were cut into anterior and posterior sections, which were then packed in their respective bags, weighed, and placed with the fat side up on stainless steel gratings on shelves in the same chilling room as the LTL on the bone. Fat was left on each LTL during ageing. Day 15 post mortem, the dry-aged LTL were weighed (still on the bone) and boned.

2.3. Weight losses

Weight loss was measured during ageing and cooking by weighing all LTL sections directly after slaughter, after ageing, and after cooking. Weight loss was expressed in percentages for losses during ageing: (weight loss during ageing / weight before ageing) × 100; during cooking: (weight loss during cooking / weight before cooking) × 100. Because the dry-aged LTL was aged on the backbone, its weight loss was not comparable to the weight loss from the bag dry-aged or

vacuum-aged LTL. Trim losses were not recorded, but the subcutaneous fat was trimmed off. The intramuscular fat content was low and similar among the young bulls; intramuscular fat was estimated around 2%.

2.4. Sensory evaluation

The sensory evaluation was performed at a supermarket on a Thursday and a Friday from 3 to 7 p.m. Consumers were recruited on their way out of the supermarket and asked if they would like to participate in a study of Swedish beef.

The sensory evaluation consisted of two tests. On the first day of testing, a paired preference test was performed consisting of “attribute-by-preference questions” as described by Meilgaard, Civille, and Carr (2007). The purpose of this test was to find out which ageing treatment consumers preferred. Each of the 171 consumers tasted and evaluated two pairs of aged samples taken from the same animal and site (either the anterior or posterior loin sections) but opposite sides (contra lateral pairs). The consumers were given a questionnaire consisting of two sets of attribute-by-preference questions and were asked to choose which of the two samples they liked more, which was more tender and which was more juicy. The last part of the questionnaire had general questions about gender, age, and how often the consumer ate beef.

On the second day of testing, a paired preference test was performed where 61 consumers were given information about the ageing treatment of the taste samples. The purpose of this test was to see if consumer preferences changed when they were given either correct or false information about the samples they were tasting. Each consumer tasted and evaluated the same contra lateral pairs of LTL from the same animal and site twice, once with correct information and once with false information (“deceptive test”). Consumers were given a questionnaire and oral information about the questionnaire construction. The questionnaire consisted of five parts:

- Information about the differences between dry and vacuum ageing.
- Six questions about gender, age, how often the consumer ate beef, shopping habits and previous knowledge of ageing treatments.
- A taste sample with correct information about the ageing treatments (dry or vacuum).
- A second taste sample with false information about the ageing method, that is, the dry-aged sample was marked vacuum aged and the vacuum-aged sample was marked dry aged.
- Two questions about how much the respondent would pay vacuum or dry-aged beef and when they were prepared to buy.

2.5. Steak preparation

Before cooking, pH and temperature were measured, and each half loin was wrapped in aluminium foil. The beef was heated in a restaurant circitherm oven at 150 °C to an internal temperature of 68 °C. The four half loins derived from one animal were put together on one baking plate. Two baking plates were heat treated simultaneously. After heat treatment, the meat was put on a cold baking plate at room temperature for 1.5–2 h. Most of the meat juice lost during cooking was poured out before the meat was stored in a chilling room (5 °C) over night.

The next day, each half loin was slightly blotted to remove excess moisture and weighed. Meat to be used that day was sliced on a slicing machine into 3-mm thick slices and cut into ca 2 × 3 cm squares with no edges, visible fat, or tendons. The samples were put in plastic boxes marked with three digit codes for transportation to the supermarket.

In both tests, the samples were kept in cooled boxes and served at room temperature. Consumers were served two samples on each paper plate separated with a coloured line, and were asked to start with the left sample. In the preference test, the three digit number (all randomly selected) for each sample was written on the plates. In the second paired-sample, deception test, both the three digit number and ageing method (dry or vacuum) was written on the plate. Balanced

Table 1
Distribution of treatments for the two LTL muscles from 4 animals.

Animal	Side	Site	
		Anterior	Posterior
1	Right	Vacuum aged	Bag dry-aged
	Left	Dry aged	Dry aged
2	Right	Dry aged	Dry aged
	Left	Bag dry-aged	Vacuum aged
3	Right	Bag dry-aged	Vacuum aged
	Left	Dry aged	Dry aged
4	Right	Vacuum aged	Bag dry-aged
	Left	Bag dry-aged	Vacuum aged

serving, where both comparisons were served first or last the same number of times, was used within and between the servings.

2.6. Statistical analysis

The experimental design involved the random allotment of 3 ageing treatments to the loin sections from the left and right sides of 4 animals (Table 1). The experimental unit for pH and weight loss was a section; for the sensory test it was the response from each consumer and test. Statistical analysis was carried out with the Statistical Analysis System version 9.2 (SAS Institute Inc., Cary, NC, USA). The MIXED procedure was applied when calculating least squares means (LSM) and standard errors (SE), and the option PDIF was used for calculating significant differences between LSM. The statistical model for sample pH, ageing loss and cooking loss included ageing system as fixed effect and animal as random effect. For the consumer tests, chi-square tests were used for the statistical analyses. In the chi-square tests, we included the two comparisons that were done at the same time, thus either dry aged vs. vacuum aged, dry aged vs. bag dry-aged or vacuum aged vs. bag dry-aged. Those comparisons were made between contra-lateral loins obtained from the same animal and the same site of the loin. With this design, animal and site were considered and thus not included in any model, but it was not possible to compare all sensory treatments in the same statistical test. Loin from 1 to 3 animals were used in each comparison.

3. Results

3.1. pH and weight losses

pH 48 h post mortem varied between 5.30 and 5.53 (mean: 5.46, S.D.: 0.105). At 15 days post mortem, pH ranged from 5.53 to 5.61 in all loins with no differences among treatments (Table 2). Vacuum aged samples had less weight loss during ageing than bag dry-aged samples (0.8% versus 4.9%; $P < 0.001$; Table 2). Weight loss during dry ageing, 3.8%, was not comparable because ageing was done with LTL still attached to the backbone. No differences among treatments were found during cooking.

3.2. Sensory analysis

3.2.1. Preference test

The consumer panel (171 consumers) in the preference test consisted of 48.5% women and 51.5% men (Table 3); most were between 41 and 65 years old (42.7%), and most ate beef once a week (35.1%).

Most consumers did two independent tests, and the total number of answers was 327. If a consumer did not choose one of the sensory attributes, the answer was excluded from the statistical analysis but included in Table 4. As shown in Table 4, the consumer panel preferred dry aged and bag dry-aged LTL to vacuum-aged LTL. When dry aged and vacuum-aged LTLs were compared ($n = 57$), 67% of the consumers who

Table 2

pH and weight loss during ageing and cooking (%), least-squares means and standard error (SE).

	Treatment			Pooled SE	P-value
	Dry aged	Vacuum aged	Bag dry-aged		
pH	5.56	5.56	5.56	0.02	0.979
Weight loss during					
Ageing, %	3.8 ¹	0.8 ^a	4.9 ^b	0.13	<0.001
Cooking, %	30.3	30.7	27.2	1.65	0.127

Different letters (a, b) indicate significant differences ($P < 0.001$) between values within the same row.

¹ Significance was not calculated between dry ageing and vacuum and bag dry-ageing since dry ageing was performed with LTL still attached to the backbone.

Table 3

Information on consumers in the preference test ($n = 171$).

Information	% (number)
Gender	
Male	51.5 (83)
Female	48.5 (88)
Age (year)	
<19	7.6 (13)
19–25	9.4 (16)
26–40	24.6 (42)
41–65	42.7 (73)
>65	15.8 (27)
Beef consumption ^a	
>1/week	27.5 (47)
1/week	35.1 (60)
1/month	29.2 (50)
Never	1.2 (2)
Other	7.0 (12)

^a Question asked: how often do you eat whole beef (e.g. roast, steak, roast beef)?

showed a preference preferred dry ageing to vacuum ageing. Dry aged meat was also evaluated as more tender by 64% of the consumers ($P = 0.033$), but consumers found no differences in juiciness between the two ageing treatments. For dry aged and bag dry-aged LTL ($n = 155$), consumers found no significant differences for overall liking, tenderness, or juiciness. Of the consumers who showed a preference between bag dry-aged and vacuum aged beef ($n = 115$), 67% preferred bag dry-aged beef ($P = 0.001$), 71% found it more tender ($P = 0.001$), and 64% more juicy ($P = 0.004$).

3.2.2. Deceptive test

For the deceptive test, 61 consumers were recruited. Most were between 41 and 65 years old (57.4%), and 52.5% were women (Table 5). Most consumers ate whole beef either once a week (31.2%) or once a month (32.8%), and nearly all of them were either responsible (50.8%) or partly responsible (41.0%) for the food shopping in their households. Among the respondents, 68.9% did not know if they could buy dry-aged beef in their food shop, and 50.8% did not know the difference between dry and vacuum ageing before they participated in this study.

If consumers did not make a choice in the comparisons, their data were excluded from the statistical analysis. When consumers were served meat samples with information about ageing treatment (dry or vacuum), dry-aged beef was preferred ($P = 0.001$; Table 6). If they were served a dry-aged sample marked vacuum aged or a vacuum-aged sample marked dry aged, they showed no significant differences between treatments ($P = 0.109$), but more consumers (55.7%) chose

Table 4

Consumer preferences among treatments, % (number).

Ageing treatment	Flavour attribute		
	Overall liking ^a	Tenderness ^b	Juiciness ^c
Dry aged	64.9 (37)	63.2 (36)	54.4 (31)
Vacuum aged	31.6 (18)	35.1 (20)	43.9 (25)
No difference	3.5 (2)	1.8 (1)	1.8 (1)
P-value	0.010	0.033	0.423
Dry aged	51.6 (80)	48.4 (75)	52.3 (81)
Bag dry-aged	45.8 (71)	47.7 (74)	43.2 (67)
No difference	2.6 (4)	3.9 (6)	4.5 (7)
P-value	0.464	0.935	0.250
Bag dry-aged	65.2 (75)	70.4 (81)	62.6 (72)
Vacuum aged	32.2 (37)	28.7 (33)	35.7 (41)
No difference	2.6 (3)	0.9 (1)	1.7 (2)
P-value	0.001	0.001	0.004

For a–c, questions asked were:

^a Which sample do you like more?

^b Which sample do you consider to be more tender?

^c Which sample do you consider to be juicier?

Table 5
Information on consumers for the deceptive test (n = 61).

Information	% (number)
Gender	
Male	47.5 (29)
Female	52.5 (32)
Age (year)	
<19	4.9 (3)
19–25	3.3 (2)
26–40	23.0 (14)
41–65	57.4 (35)
>65	11.5 (7)
Beef consumption ^a	
>1/week	23.0 (14)
1/week	31.2 (19)
1/month	32.8 (20)
Never	1.6 (1)
Other	11.5 (7)
Responsibility for shopping ^b	
Yes	50.8 (31)
Partly	41.0 (25)
No	8.2 (5)
Availability in shop ^c	
Yes	23.0 (14)
No	8.2 (5)
Do not know	68.9 (42)
Knowledge about ageing ^d	
Yes	41.0 (25)
No	50.8 (31)
Do not know	8.2 (5)

For a–d, questions asked were:

^a How often do you eat whole beef (roast, steak, roast beef)?

^b Are you responsible for food purchases in your household?

^c Is it possible to buy dry aged beef in any of the food shops you usually do your food shopping in?

^d Did you know the difference between dry and vacuum ageing before you participated in this study?

vacuum aged meat marked as dry aged. As many as 59% of the consumers were fooled by the marking, i.e., they chose the sample marked dry aged (or vacuum aged) at both taste tests (data not shown). Fewer consumers (41%) chose the same treatment in both taste comparisons. That is, if he/she preferred the dry-aged sample in the first taste comparison, he/she choose the sample marked vacuum aged in the second comparison.

When asked how much they were prepared to pay for dry and vacuum-aged beef (Table 7), only 14.8% of consumers were prepared to pay more than the average price for beef that was dry aged, and 1.6% were prepared to pay more for vacuum-aged beef. Interestingly, 44.3% answered that they were prepared to pay the average price for dry-aged beef whereas only 26.2% answered the same for vacuum-aged beef. More consumers (57.4%) were prepared to pay less than the average price for vacuum aged than for dry-aged beef (29.5%). As seen in Table 8, consumers preferred dry-aged beef for weekend (54.1%) and formal (52.5%) dinners.

Table 6
Consumer preferences in the deceptive test^a, % (number).

	Overall liking
<i>First taste sample (correct marking)</i>	
Dry aged	72.1 (44)
Vacuum aged	26.2 (16)
No difference	1.7 (1)
P-value	0.001
<i>Second taste sample (wrong marking)</i>	
Dry aged marked vacuum aged	36.1 (22)
Vacuum aged marked dry aged	55.7 (34)
No difference	8.2 (5)
P-value	0.109

^a Question asked: which sample do you like more?

Table 7
Frequency of consumers (%) prepared to pay more, about the same, or less than the average price for dry and vacuum aged beef^a (n = 61).

	Treatment	
	Dry aged	Vacuum aged
<i>Prepared to pay</i>		
More	14.8	1.6
About the same	44.3	26.2
Less	29.5	57.4
Did not answer	11.5	14.8

^a Question asked: how much are you prepared to pay for dry and vacuum aged beef?

4. Discussion

Weight losses during ageing were, as expected, lower for vacuum-aged than for bag dry-aged samples. Because the dry-aged LTL had the lumbar vertebra attached during ageing, weight loss for this treatment was not fully comparable, but numerically, dry and bag dry-aged had the same general range of weight loss compared to vacuum-aged samples. These results confirm Ahnström et al. (2006), who showed that dry and bag dry-aged strip-loin steaks did not differ in weight loss after 14 days of ageing. The same study also found that during 21 days of ageing, dry-aged strip-loins lost more weight (water loss and trim loss) than loins aged in a dry bag for the same period (Ahnström et al., 2006). Also DeGeer et al. (2009) found positive effects on yields for dry ageing in a bag compared with traditional dry ageing. As with our results, Hodges, Cahill, and Ockerman (1974) found only small weight losses during vacuum ageing. As expected, significantly higher losses occurred in dry-aged beef during ageing than vacuum-aged beef, not only in our study but in others (Laster et al., 2008; Minks & Stringer, 1972; Oreskovich et al., 1988; Parrish et al., 1991; Smith et al., 2008; Warren & Kastner, 1992).

In the preference test, the consumer panel consisted of an even number of males and females, most from 41 to 65 years old and most ate whole beef once a week or once a month. Consumers in this panel can be assumed to be average beef consumers, not only because of the even distribution of men and women but also because they ate whole beef rather often.

In the preference study, vacuum ageing and dry and bag dry-ageing showed significant differences for overall liking and tenderness, whereas no differences for any of the sensory attributes were found between dry and bag dry-ageing. This showed that the respondents prefer dry-aged beef over vacuum aged, supporting the conclusions of Ahnström et al. (2006) that bag dry-ageing can be an alternative to traditional dry ageing. In comparisons between dry and vacuum-aged beef, Warren and Kastner (1992) found that dry ageing had a positive influence on flavours such as beefy and brown/roasted with a decrease in sour, bloody, and metallic flavours. Unlike these results, other studies have shown small (Minks & Stringer, 1972) or no (Laster et al., 2008; Richardson, Nute, & Wood, 2008; Smith et al., 2008; Troy, 1999) flavour differences between dry and vacuum-aged beef. For overall liking and tenderness, vacuum ageing was preferred according to Sitz, Calkins,

Table 8
Frequency of consumers (%) who would choose dry and vacuum aged beef for weekday, barbeque, weekend, or formal dinner^a (n = 61).

	Treatment			
	Dry aged	Vacuum aged	Both dry and vacuum aged	None
<i>Choice for</i>				
Weekday dinner	29.5	29.5	4.9	36.1
Barbeque dinner	37.7	23.0	6.6	32.8
Weekend dinner	54.1	16.4	9.9	19.7
Formal dinner	52.5	13.1	9.8	24.6

^a Question asked: when (for what occasion) would you buy dry or vacuum aged beef?

Feuz, Umberger, and Eskridge (2006), who used a consumer panel, and Parrish et al. (1991), who used both a trained and a consumer panel. For tenderness, Warren and Kastner (1992) and Troy (1999) found no differences between dry-aged and vacuum aged beef, whereas Richardson et al. (2008) found that dry-aged beef was more tender than vacuum aged. For juiciness, some studies found no differences between dry-aged and vacuum-aged beef (Laster et al., 2008; Parrish et al., 1991; Sitz et al., 2006; Troy, 1999), whereas Richardson et al. (2008) reported that dry-aged beef was juicier than vacuum aged.

Consumers in the deceptive test can be assumed to be average beef consumers for the same reasons as for the preference test. In this study, the consumers were served two plates, each with two samples to taste. On the first plate, the dry age and vacuum-aged beef was correctly marked, but on the second plate, the samples were falsely marked (the dry-aged beef was marked vacuum aged, and the vacuum-aged beef was marked dry aged). When the taste samples were marked with the correct information about ageing treatment, most consumers (73%) preferred dry-aged LTL. In the preference study where no information about treatment was given, 67% preferred dry-aged LTL. However, when the samples with false information were served, 61% preferred the vacuum-aged sample marked dry aged. This shows that consumers were confused by the labelling, and several changed their preference to the vacuum-aged sample marked dry aged. Still 41% of the consumers were consistent in their choice, which probably means they really preferred the taste of either dry-aged or vacuum-aged samples. The effects of labelling on consumer's choice of meat was clearly delineated by Dransfield, Zamora, and Bayle (1998), who studied how consumer selection of sirloin steaks was influenced by eating quality, nominal price, and labelling. Without knowing the eating quality, higher priced steaks were preferred by about one third of consumers. The proportion increased when the steaks were labelled with information about breed and tenderness. After tasting the meat, the actual meat quality was most important, followed by price and labelling. This contrasts the study by Scholderer, Bredahl, Brunsø, Claudi-Magnussen, and Lindahl (2004), where pork chops labelled "free-range" or "organic" were consistently perceived as having higher eating quality than pork chops labelled "conventional" or unlabelled pork chops, independent of the actual meat type consumers had tasted. The organic pork chops used in that study were consistently perceived to have slightly lower eating quality than the conventional pork, after adjustment for information effects.

Additional questions showed that half of the consumers (51%) did not know the difference between dry and vacuum ageing before they participated in the study, and most (69%) did not know whether they could purchase dry-aged beef in their grocery store. Smith et al. (2008) also noted that the term dry ageing is relatively unknown. On the other hand, the term 'ageing' is generally recognized and considered positive (Smith et al., 2008). Tenderness, which increases during ageing (Campbell et al., 2001; Miller et al., 1997; Mitchell et al., 1991; Smith et al., 2008), is the most important sensory factor (Feuz, Umberger, Calkins, & Sitz, 2004; Shackelford et al., 2001), and consumers are willing to pay extra for guaranteed tender beef products (Boleman et al., 1997; Dransfield et al., 1998; Shackelford et al., 2001). Hence, producers selling well aged and/or dry-aged beef most probably will be favoured if they inform consumers of the beef ageing treatment, what it means, and how it affects the quality of the meat.

Most consumers were responsible (51%) or partly responsible (41%) for food shopping in their households, and they also ate beef once a week (31%) or once a month (33%), which indicates that they have some idea about beef prices and when it is suitable to cook and eat beef. When asked how much they would be prepared to pay (more, about the same or less than the average price for beef), 44% answered that they would pay about the average price for dry-aged beef, whereas only 26% answered the same for vacuum-aged beef. For dry-aged beef, 30% said that they would pay less than the average price, whereas 57% answered the same for vacuum-aged beef. Only 15% were willing to

pay more for dry-aged beef, and 2% for vacuum-aged beef. These results indicate that the consumers think that beef is overall too expensive. A conclusion we can draw from this question is that consumers are prepared to pay more for dry-aged beef than vacuum aged, which is expected since most consumers preferred the dry-aged beef. Other research has shown that consumers will pay more for better quality beef and that higher price has a positive influence on the expected quality (Acebrón & Dopico, 2000; Dransfield et al., 1998).

Four questions were asked about when and for what occasion (Table 8) consumers would buy dry and/or vacuum-aged beef: for weekend and weekday dinners, for a barbecue, or for a more formal dinner with friends and/or family. Dry-aged beef numerically was the most popular for weekend dinner (54%) and a more formal dinner with family and/or friends (53%). For barbecue, the consumers would buy dry-aged beef (38%). For barbecuing 33% did not make any choice and for weekday dinners, 36% did not make any choice, which could mean they would not buy beef for these occasions. These results are quite logical; beef is expensive and therefore eaten when you want a treat for yourself, or your family or friends. Success in barbecue is more likely with a marbled meat such as entrecote, and for a weekday dinner, most consumers choose less expensive pieces of meat.

5. Conclusions

In the two sensory tests in this study, dry aged and bag dry-aged beef are preferred over vacuum aged beef, and a dry-aged label positively influences a consumer's choice of LTL. Dry ageing of beef brings out pleasant flavours, and ageing is recognized as a positive term. However, dry aged meat is less available and considered a speciality, a value-added product, so it is more expensive. It does provide consumers the feeling of premium class and exclusivity. To compensate for the high price for a dry-aged product, relevant information is of special importance.

Acknowledgment

We would like to thank Åsa Lagerstedt Norström, Lisbeth Johansson and Maria Lundesjö Ahnström for their help with planning and performing this study. The authors also thank Tub-Ex ApS, Denmark, for their help in this study.

References

- Acebrón, L. B., & Dopico, D. C. (2000). The importance of intrinsic and extrinsic cues to expected and experienced quality: An empirical application for beef. *Food Quality and Preference*, 11, 229–238.
- Ahnström, M. L., Seyfert, M., Hunt, M. C., & Johnson, D. E. (2006). Dry aging of beef in a bag highly permeable to water vapour. *Meat Science*, 73, 674–679.
- Boleman, S. J., Boleman, S. L., Miller, R. K., Taylor, J. F., Cross, H. R., Wheeler, T. L., Koohmaraie, M., Shackelford, S. D., Miller, M. F., West, R. L., Johnson, D.D., & Savell, J. W. (1997). Consumer evaluation of beef of known categories of tenderness. *Journal of Animal Science*, 75, 1521–1524.
- Campbell, R. E., Hunt, M. C., Levis, P., & Chambers, E. (2001). Dry-aging effects on palatability of beef longissimus muscle. *Journal of Food Science*, 66, 196–199.
- Commission of the European Communities (2005). Council regulation determining the community scale for the classification of carcasses of adult bovine animals. Council Regulation 2005/0171. Brussels: Commission of the European Communities.
- DeGeer, S. L., Hunt, M. C., Bratcher, C. L., Crozier-Dodson, B.A., Johnson, D. E., & Stika, J. F. (2009). Effects of dry aging of bone-in and boneless strip loins using two aging processes for two aging times. *Meat Science*, 83, 768–774.
- Dransfield, E., Zamora, F., & Bayle, M. C. (1998). Consumer selection of steaks as influenced by information and price index. *Food Quality and Preference*, 9, 321–326.
- Feuz, D.M., Umberger, W. J., Calkins, C. R., & Sitz, B. (2004). U.S. consumers' willingness to pay for flavor and tenderness in steaks as determined with an experimental auction. *Journal of Agricultural and Resource Economics*, 29, 501–516.
- Hodges, J. H., Cahill, V. R., & Ockerman, H. W. (1974). Effect of vacuum packaging on weight loss, microbial growth and palatability of fresh beef wholesale cuts. *Journal of Food Science*, 39, 143–146.
- Laster, M.A., Smith, R. D., Nicholson, K. L., Nicholson, J.D. W., Miller, R. K., Griffin, D. B., Harris, K. B., & Savell, J. W. (2008). Dry versus wet aging of beef: Retail cutting yields and consumer sensory attribute evaluation of steaks from ribeyes, strip loins, and top sirloins from two quality grade groups. *Meat Science*, 80, 795–804.

- Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2007). *Affective tests: Consumer tests and in-house panel acceptance tests*. In: *Sensory evaluation techniques* (4th ed.) Boca Raton, FL: CRC Press.
- Miller, M. F., Kerth, C. R., Wise, J. W., Lansdell, J. L., Stowell, J. E., & Ramsey, C. B. (1997). Slaughter plant location, USDA quality grade, external fat thickness, and aging time effects on sensory characteristics of beef loin strip steak. *Journal of Animal Science*, 75, 662–667.
- Minks, D., & Stringer, W. C. (1972). The influence of aging beef in vacuum. *Journal of Food Science*, 37, 736–738.
- Mitchell, G. E., Giles, J. E., Rogers, S. A., Tan, L. T., Naidoo, R. J., & Ferguson, D.M. (1991). Tenderizing, ageing, and thawing effects on sensory, chemical, and physical properties of beef steaks. *Journal of Food Science*, 56, 1125–1129.
- Oreskovich, D. C., McKeith, F. K., Carr, T. R., Novakofski, J., & Bechtel, P. J. (1988). Effects of different aging procedures on the palatability of beef. *Journal of Food Quality*, 11, 151–158.
- Parrish, F. C., Boles, J. A., Rust, R. E., & Olson, D.G. (1991). Dry and wet aging effects on palatability attributes of beef loin and rib steaks from three quality grades. *Journal of Food Science*, 56, 601–603.
- Richardson, R. I., Nute, G. R., & Wood, J.D. (2008). Effect of wet vs. dry ageing on eating quality of beef from traditional breeds. *Proceedings 54th International Congress of Meat Science and Technology, Cape Town, South Africa*.
- Scholderer, J., Bredahl, L., Brunsø, K., Claudi-Magnussen, C., & Lindahl, G. (2004). *Organic pork: Consumer quality perceptions*. Aarhus School of Business (Project paper no 01/04, ISSN 09072101).
- Shackelford, S. D., Wheeler, T. L., Meade, M. K., Reagan, J. O., Byrnes, B.L., & Koohmaraie, M. (2001). Consumer impressions of tender select beef. *Journal of Animal Science*, 79, 2605–2614.
- Sitz, B.M., Calkins, C. R., Feuz, D.M., Umberger, W. J., & Eskridge, K. M. (2006). Consumer sensory acceptance and value of wet-aged and dry-aged beef steaks. *Journal of Animal Science*, 84, 1221–1226.
- Smith, R. D., Nicholson, K. L., Nicholson, J.D. W., Harris, K. B., Miller, R. K., Griffin, D. B., & Savell, J. W. (2008). Dry versus wet aging of beef: Retail cutting yields and consumer palatability evaluations of steaks from US choice and US select short loins. *Meat Science*, 79, 631–639.
- Swedish Board of Agriculture (1998). *Directions of classifications of carcasses from the Swedish Board of Agriculture*. SJVFS 127, Swedish Board of Agriculture, Jönköping (in Swedish).
- Troy, D. J. (1999). Enhancing the tenderness of beef. *Dublin. The National Food Centre, Research report no 11* (ISBN 1841700104).
- Warren, K. E., & Kastner, C. L. (1992). A comparison of dry-aged and vacuum-aged beef strip loins. *Journal of Muscle Foods*, 3, 151–157.