



Scandinavian consumer preference for beef steaks packed with or without oxygen

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ABSTRACT

Beef steaks retail-packed with (80% O₂, 20% CO₂) or without oxygen (either skin-packed or gas-packed (69.6% N₂, 30% CO₂, 0.04% CO or 70% N₂, 30% CO₂)) were compared by consumers in Denmark ($n = 382$), Norway ($n = 316$) and Sweden ($n = 374$). Two pairs of two steaks – one steak packed in a high oxygen atmosphere and one packed without oxygen – were given to the consumers. They were instructed to prepare the steaks at home on two consecutive days, and two persons had to taste each steak. In Denmark, the oxygen-free packing was either gas packing with CO (69.6% N₂, 30% CO₂, 0.04% CO) or without CO (70% N₂, 30% CO₂), in Norway it was either gas packing with CO (69.6% N₂, 30% CO₂, 0.04% CO) or skin packing, and in Sweden it was either skin packing or gas packing without CO (70% N₂, 30% CO₂). The meat represented animals that were between 17 and 80 months old (Denmark) and young bulls (Norway and Sweden).

Consumers in all three countries clearly preferred steaks packed without oxygen, in terms of overall liking, willingness to pay and their preferred choice of one steak. Furthermore, they preferred the oxygen-free steaks in terms of both overall liking and liking of tenderness, juiciness and flavour. In Sweden, many consumers would pay more than usual for the skin-packed steak, and it was more often chosen as the preferred steak out of the four compared with gas-packed without oxygen. No difference was seen between the two oxygen-free packing methods in Denmark and Norway.

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1. Introduction

It is well known that packing beef in an atmosphere containing a high concentration of oxygen combined with CO₂ (MAP with high O₂) results in a red colour and an increased shelf-life (McMillin, 2008; Pietrasik, Dhanda, Shand, & Pegg, 2006; Tørngren, 2003). Consumers often associate the red colour with freshness (Jeyamkondan, Jayas, & Holley, 2000), and it is therefore a desirable packaging method for retail. However, the high oxygen content also accelerates the oxidation process (Møller, Nannerup, & Skibsted, 2005), thereby reducing tenderness and juiciness and increasing rancid and warmed-over flavours (Clausen, Jakobsen, Ertbjerg, & Nielsen, 2009; Grobbel, Dikeman, Hunt, & Milliken, 2008; Lund, Christensen, Fregil, Hviid, & Skibsted, 2008; Tørngren, 2003), thus reducing the overall eating quality of the meat.

Premature browning is another side effect of packing in a high oxygen atmosphere. The high oxygen atmosphere results in oxidation of the pigment to oxymyoglobin and metmyoglobin. The heat denaturation of the pigment results in a brown colour (a well-done appearance) already at a core temperature of 55 °C compared with the usual colour change at 65–68 °C – a phenomena called premature browning (Tørngren, 2003; Warren et al., 1996).

Gas packing without oxygen results in a higher juiciness and tenderness and less rancid flavours compared with packing in a high oxygen atmosphere, though the colour of the raw meat becomes purple like vacuum-packed meat. Packing meat with traces of oxygen results in discolouration (Pietrasik et al., 2006). If the aim is to pack in an oxygen-free atmosphere, an oxygen scavenger is therefore needed to minimise discolouration (Buys, 2004).

One way to combine the desired red colour with an acceptable eating quality of the meat could be to pack without oxygen but with a small amount of CO. These results in meat with a very high a^* value – even higher than meat packed in a high concentration of oxygen (De Santos, Rojas, Lockhorn, & Brewer, 2007; Krause, Sebranek, Rust, & Honeyman, 2003). Today, CO is not allowed in Europe but is accepted in USA. Previously, it was legal in Norway, but Norway has since banned the use of CO in compliance with EU rules.

Packing in a high oxygen atmosphere has a positive effect on the appearance of the fresh meat, but it also has some negative effects on the eating quality. This has been shown using instrumental measurement and sensory profiling with trained assessors. However, it is not known if the differences are large enough to be detected by ordinary consumers when cooking their steaks at home and, if the differences are detected, whether they have any influence on their preference.

The aim of the study was to investigate, by a pairwise comparison, Scandinavian consumer liking of beef steaks packed with or without oxygen.

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2. Materials and methods

The experiment was conducted in Denmark (in Roskilde, a large town near the capital, Copenhagen), Sweden (in Stockholm, the capital) and Norway (in Oslo, the capital). The meat tested in each location originated from the individual countries.

The overall design of the experiment was the same in all three countries. Consumers got a package with two pairs of steaks. They were asked to prepare and have two people tasting and evaluating the steaks at home one pair per day. Each pair consists of one steak gas-packed in high oxygen atmosphere, the other packed without oxygen – either skin packing, gas packing with N₂ and CO₂ or gas packing with N₂ and CO₂ but also added CO. The packaging methods without oxygen differ between the two pairs while the gas packing was the same.

Longissimus dorsi from both sides of beef carcasses were cut into 2 cm thick steaks. The steaks from one side were gas-packed in a high oxygen atmosphere, while the steaks from the other side were packed without oxygen (Table 1). The meat was packed on Mondays (all gas packing both with and without oxygen) or Tuesdays (skin packing) and was picked up by the consumers on Thursdays. The consumers were given a short oral and written introduction. The consumers were instructed to fry the steaks as they would normally fry beef steaks and to eat the two pairs on two separate days between Friday and Monday, giving at least 5 days' packing in the high oxygen atmosphere.

The two steaks that were evaluated on the same day were from the same animal, and all four steaks were from the same position on the loin (Fig. 1). The steaks were all cut into two halves after frying, and two different consumers in the same family evaluated the half steaks.

The evaluation questionnaire was divided into two halves with one steak being evaluated on the left side and the other on the right side.

The consumers first evaluated how much they liked the steaks using a 10 cm unstructured continuous scale ranging from “do not like at all” to “like very much”.

The following questions were then asked:

- How is the steak fried? Too red, satisfactory or too much?
- How well-done is the steak (put a cross on a continuous line with photos of steaks cooked to different degrees of doneness)?
- What do you think of the tenderness, juiciness and taste/flavour (all on a 10 cm unstructured continuous scale from “very bad to “very good”)?
- How much would you pay for this steak compared with what you normally pay (less, as usual, more)?

After all four steaks had been evaluated, the consumers were asked to choose which of the four steaks they most preferred.

2.1. Denmark

Right and left *longissimus dorsi* were excised the day after slaughter, vacuum-packed and aged until 14 days post mortem at 2 °C. The animals were between 17 and 80 months old and

weighed between 239 and 315 kg. The pH at 14 days post mortem was between 5.5 and 5.8. Twenty steaks were cut from each loin.

The steaks from the first 10 animals were packed in modified atmosphere containing either 80% O₂/20% CO₂ or 70% N₂/30% CO₂. The loins from the next 10 animals were packed in modified atmosphere containing either 80% O₂/20% CO₂ or 69.6% N₂/30% CO₂/0.4% CO (Fig. 1, Table 1). Apet trays M71-51A (O₂ permeability: max. 2 cm³/m² × 24 × bar, Færch plast) with Topseal™ MAP AF 57 film (O₂ permeability: min. 100 cm³/m² × 24 × bar, Færch plast) were used.

The consumers were recruited from the town of Roskilde and its surroundings. They were all regular consumers of beef. Two hundred households were recruited. Two persons per household participated, giving a total of 400 consumers. The response rate was 96%, with 382 consumers equally divided between males and females. The consumers were divided into three age groups: 85 consumers were aged between 18 and 30 years, 148 were aged between 31 and 55 years, and 129 consumers were aged between 56 and 92 years. Seven consumers were younger than 18 years, and 13 consumers did not give their age.

2.2. Norway

Right and left *longissimus dorsi* were hot-boned and packed in Pivac. The meat was aged until 15 days post mortem at 2 °C. The animals were all young bulls weighing between 220 and 320 kg. The pH at 14 days post mortem was between 5.5 and 5.8. Eighteen steaks were cut from each loin.

The steaks from the first 10 animals were gas-packed in modified atmosphere containing either 80% O₂/20% CO₂ or skin-packed (gas packing trays M71-51A, O₂ permeability: max. 2 cm³/m² × 24 × bar, Færch plast, with Topseal™ MAP AF 57 film, O₂ permeability: min. 100 cm³/m² × 24 × bar, Færch plast. Skin packing PS EVOH PE approx. 700 μ as tray while Skinfresh top 100 was used as cover). The loins from the next 10 animals were gas-packed in modified atmosphere containing either 80% O₂/20% CO₂ or 69.6% N₂/30% CO₂/0.4% CO (Table 1).

The consumers were recruited from Oslo. They were all regular consumers of beef. One hundred and eighty households were recruited. Two persons per household participated, giving a total of 360 consumers. The response rate was 88%, with 316 consumers equally divided between males and females. The consumers were divided into three age groups: 82 consumers were aged between 18 and 30 years, 151 consumers were aged between 31 and 55 years, and 62 consumers were aged between 56 and 92 years. Eight consumers were younger than 18 years, and 13 consumers did not give their age.

2.3. Sweden

Right and left *longissimus dorsi* were excised the day after slaughter, vacuum-packed and aged at 2 °C until 11 days post mortem for the skin-packed steaks and 17 days post mortem for the gas-packed steaks. The animals were all young bulls weighing between 275 and 332 kg. The pH at packing was between 5.6 and 5.7. Twenty steaks were cut from each loin.

Table 1
Packing methods for the three countries.

	Comparison 1		Comparison 2	
	Oxygen-free	High oxygen	High oxygen	Oxygen-free
Denmark	70% N ₂ /30% CO ₂ (gas/no ox)	80% O ₂ /20% CO ₂ (high ox)	80% O ₂ /20% CO ₂ (high ox)	69.6% N ₂ /30% CO ₂ /0.4% CO (gas/no ox/CO)
Norway	Skin-packed (skin)	80% O ₂ /20% CO ₂ (high ox)	80% O ₂ /20% CO ₂ (high ox)	69.6% N ₂ /30% CO ₂ /0.4% CO (gas/no ox/CO)
Sweden	70% N ₂ /30% CO ₂ (gas/no ox)	80% O ₂ /20% CO ₂ (high ox)	80% O ₂ /20% CO ₂ (high ox)	Skin-packed (skin)

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