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# The effect of diet and DHA addition on the sensory quality of goat kid meat

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ABSTRACT

To enhance the nutritional quality of meat, dietary strategies have been developed to manipulate the fatty acid profiles of muscle tissue. Fatty acids affect meat attributes, including hardness, colour and lipid stability, and flavour. Little research has been done, however, on the effects of dietary omega-3 polyunsaturated fatty acid (PUFA) supplementation on the sensory characteristics of meat. To address this issue, six diets were fed to goat kids: goat's milk, powdered whole cow's milk, powdered whole cow's milk plus docosahexaenoic acid (DHA) (low dose), milk replacer, milk replacer plus DHA (low dose), and milk replacer plus DHA (high dose). A descriptive, semi-trained sensory evaluation and a consumer triangular test were performed to analyse the resulting meat. High doses of omega-3 PUFA produced meat with unusual odours, unpleasant flavours, and low overall appreciation scores. Low doses of DHA maintained a positive sensory perception.


## 1. Introduction

To enhance the nutritional quality of meat, nutritional strategies have been developed to manipulate the fatty acid profile of muscle tissue (Wood et al., 2003). Among essential fatty acids, those enriched in marine oil products are particularly important for maintaining human health and alleviating certain pathological conditions (Moghadasian, 2008). Two dietary fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are critical for the optimal performance of multiple body systems; these fatty acids are primarily derived from fish oil and other marine food products (Moghadasian, 2008).

In ruminant meat, concentrations of polyunsaturated fatty acids (PUFA) are low because of biohydrogenation in the rumen (Wachira et al., 2002). Despite ruminal hydrogenation, several studies have indicated that dietary supplementation with n-3 fatty acids (popularly known as omega-3 fatty acids) modifies the fatty acid profile of meat and improves the meat's nutritional qualities (Raes, DeSmet, & Demeyer, 2004). Fatty acids in muscle tissue affect several aspects of meat quality, including hardness, colour and lipid stability, and flavour (Wood et al., 2003). In addition, PUFA are preferentially deposited in phospholipids, which are the primary determinants of a meat's flavour (Mottram & Edwards, 1983). As a result, changes to fatty acid profiles potentially have large effects on meat characteristics. The susceptibility of fatty acids to oxidation in tissues depends on the levels of unsaturated fatty acids and antioxidants (Gladine, Rock, Morand, Bauchart, & Durand, 2007).

Goat kids are pre-ruminant animals, as the rumen develops over time. They process food in an essentially mono-gastric fashion, and thus, the fatty acid composition of the diet affects the meat properties more directly than in adult goats (Yeom, Van Trierum, Hache, Lee, & Beynen, 2002). As a result, dietary manipulations affect intramuscular n-3 fatty acid levels more efficiently in young animals (Raes et al., 2004). However, most studies examining n-3 PUFA supplementation have focused on meat from animals that are several weeks old (Díaz et al., 2011; Nute et al., 2007; Radunz et al., 2009), whereas newborn animals have received little attention. Also, despite an extensive body of literature that documents the effects of dietary n-3 PUFA on the fatty acid profiles of ruminant meats, there is very little information concerning the effects of n-3 supplementation on the sensory characteristics of meat. Only a few studies, such as Nute et al. (2007) in lambs and Díaz et al. (2011) in goat kids, have reported odour and flavour data. In these cases, both fishy and rancid were used to describe the meat's odour and flavour, characteristics that only increased with storage.

Powdered whole cow's milk could be an inexpensive alternative (under certain circumstances) feed source that is fed to a wide variety of livestock and that may result in improved artificial rearing. To our knowledge, the effect of cow's milk on the sensory characteristics of goat kid meat has not been examined.

The aim of our study was to characterise the sensory changes to goat kid meat that result from n-3 PUFA supplementation and powdered cow's milk. In addition, a consumer triangular test was used to determine if consumers could discriminate between meats derived from different diets. In particular, it was important to

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determine whether consumers could detect n-3 PUFA supplementation, which often results in unpleasant odours and flavours.

## 2. Material and methods

### 2.1. Animals, diets, and sampling

This study was conducted on the experimental farm of the Veterinarian Faculty of Las Palmas de Gran Canaria University (Arucas, Spain), and the experimental procedures were approved by the Ethical Committee of this University. Sixty Majorera goat kids (males and females) were separated from their mothers at birth, dried, and their umbilical cords disinfected. They were weighed and randomly assigned to one of six experimental groups. Kids were bottle-fed pooled colostrum that was prepared pre-partum, according to Castro, Capote, Álvarez, and Argüello (2005). After the fourth feeding, kids began receiving their experimental diets. All diets (except for goat milk) consisted of 16% (w/w) dry matter (DM). The six diets were: 1) goat's milk (GM) from the farm; 2) cow's milk (CM) derived from powdered whole cow's milk; 3) commercial milk replacer (MR) (Bacilactol Cabritos, Saprogal, La Coruna, Spain; 95.5% DM, 23.6% crude protein, and 22.7% ether extract); 4) MR supplemented with a low dose of n-3 PUFA (DHA-gold©, Martek Biosciences, Columbia, MD, USA) (15.1% MR and 0.9% DHA) (MR-LD-DHA); 5) MR supplemented with a high dose of DHA (14.2% MR and 1.8% DHA) (MR-HD-DHA); and 6) CM supplemented with a low dose of n-3 PUFA (15.1% CM and 0.9% of DHA) (CM-LD-DHA). Goat kids were fed these diets until their body weight reached 8 kg, when they were slaughtered according to welfare practices (European Communities, 1986).

After chilling, carcasses were split down the dorsal midline. The left and right sides were divided into five primary cuts (neck, flank, ribs, shoulder, and long-leg) and two minor cuts (kidney and tail), as described by Colomer-Rocher, Morand-Fehr, and Kirton (1987). *Quadriceps* and *Longissimus dorsi* were dissected, vacuum packed, and stored at −18 °C until analysis.

### 2.2. Sensory evaluation

#### 2.2.1. Preparation of the samples

Before sensory evaluation, samples were thawed at 4 °C over 24 h. *Quadriceps* and *Longissimus dorsi* were used for semi-trained sensory evaluation and consumer sensory evaluation, respectively. After removing external fat and connective tissue, the meat was cut into $2\times2\times1$ cm$^3$ pieces, wrapped in aluminium foil, and cooked on a pre-heated double hot-plate grill at 200 °C for 1 min. Samples were immediately given to the taste panellists one at a time.

#### 2.2.2. Semi-trained sensory evaluation

Sensory evaluations were performed by a nine-member sensory panel at Las Palmas de Gran Canaria University, which frequently participates in meat sensory analyses. Although panel members were generally familiar with sensory analysis methods, training sessions were performed until all members of the panel were comfortable analysing the specific meat attributes that were critical to this study. Evaluations were based on quantitative descriptors in a completely balanced block. The panel evaluated ten attributes using a 10-cm unstructured line scale, with space reserved for supplementary remarks concerning each sample and parameter. A total of 36 samples (from 60 animals) were assessed in 12 sessions. The order of sample presentation was randomised in the test. The sensory analyses were performed in rooms that met norm ISO 8589:2010 specifications, including the absence of noise and odour, white walls, and adequate temperature and humidity levels. Each sample was placed on an odour-free serving plate with a three-digit random code and served to a panel member under red light. Panel members were provided unsalted breadsticks and room-temperature water to cleanse their palates between samples.

**Table 1**
Definitions of the descriptors used in the sensory analysis of goat kid meat, according to Resconi et al. (2010) with modifications.

| Descriptor | Definition |
|---|---|
| Overall odour[a] | Odour intensity of cooked goat kid |
| Strange odour[a] | Intensity of abnormal odours |
| Tenderness[b] | Ease of chewing with the molars |
| Juiciness[c] | Liquid expelled by the sample during chewing |
| Fibrousness[d] | Amount of fibres perceived during chewing |
| Overall flavour[a] | Flavour intensity of cooked goat kid |
| Rancid flavour[a] | Flavour intensity of expired product |
| Liver flavour[a] | Flavour intensity of this organ |
| Fat flavour[a] | Flavour intensity of fat or oil |
| Overall appreciation | Final score summing all parameters |

[a] 0 = not detected, whereas 100 = very intense.
[b] 0 = very tough, whereas 100 = very tender.
[c] 0 = very dry, whereas 100 = very juicy.
[d] 0 = very low, whereas 100 = very high.

The semi-trained panel described ten meat attributes, which included overall odour, strange odour, tenderness, juiciness, fibrousnesses, overall flavour, rancid flavour, liver flavour, fat flavour, and overall appreciation (see Table 1). Resconi, Campo, Font i Furnols, Montossi, and Sañudo (2010) developed this list, but we replaced acid flavour with overall appreciation. We included this modification based on Resconi et al. (2010), who studied the effect of various finishing diets (i.e., different pasture-to-concentrate proportions) on the sensory qualities of beef. In addition, acid flavour is primarily affected by maize feeding (Larick & Turner, 1990), which is not a variable in this study. Although many authors reject the overall appreciation category when using a trained sensory panel (Köster, 1990), this parameter has been extensively used in the past (Rodrigues & Teixeira, 2009) and functions to condense all sensory parameters into a single value.

#### 2.2.3. Consumer triangular test

Ninety-five untrained consumers, who were unaware of the experimental conditions, analysed 300 *Longissimus dorsi* muscle samples from 36 animals. Samples were prepared in the same way as for the sensory evaluation (section 2.2.1). Three chops (two from the same treatment condition and one from a different treatment) were presented to each person on a plate with a code, in accordance with Spanish guidelines (Norma UNE-EN ISO 4120:2004). Panellists received these samples in individual cabins under controlled environmental conditions and red light. Taking into account the limited meat available, at least six comparisons between each pair of treatments were performed. Moreover, panellists were invited to discriminate between samples and to indicate which attributes were most critical to their decision. Panel members were provided unsalted

**Table 2**
For each panellist, the residual variance, scaling factor, and the variation percentage that is explained by the first two principal components are shown.

| Panellist | Residual | Scaling factor | F1 | F2 |
|---|---|---|---|---|
| 1 | 2.950 | 0.617 | 53.963 | 11.099 |
| 2 | 2.399 | 0.974 | 62.544 | 8.634 |
| 3 | 2.194 | 2.357 | 78.668 | 6.532 |
| 4 | 4.414 | 0.874 | 48.181 | 32.262 |
| 5 | 5.682 | 0.822 | 71.040 | 7.629 |
| 6 | 3.285 | 1.286 | 84.908 | 3.194 |
| 7 | 5.081 | 0.932 | 78.086 | 2.875 |
| 8 | 4.338 | 2.549 | 50.667 | 14.922 |
| 9 | 2.350 | 1.362 | 60.110 | 24.946 |

F1: First principal component of the generalised Procrustes analysis (GPA); F2: Second principal component of the GPA.