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Buffalo meat composition as affected by different cooking methods

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ABSTRACT

Buffalo meat is considered in Italy as an alternative product for its good nutritional characteristics. The influence of three cooking methods (boiling, grilling and frying) on the chemical and lipid composition of buffalo meat was evaluated. All the treatments reduced the moisture and increased protein, ash and fat content. The increase in fat content was higher after frying due to the incorporation of fat from olive oil. Fried meat had lower saturated fatty acid content due to the incorporation of mono-unsaturated (C18:1) fatty acids from oil. The incorporation of oil fatty acids caused a decrease in conjugated linoleic acid relative content. Moreover, fried meat showed the highest levels of the unhealthy trans fatty acids. Therefore, frying was shown as the worst cooking methods regarding human health. Boiling and grilling increased thiobarbituric acid reactive substances, while frying had no effect on them.

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Keywords: Fatty acid; Grilling; Frying; Boiling; TBARS

1. Introduction

Human nutritionists are recommending a higher intake of polyunsaturated fatty acids (PUFA) and especially of n-3 fatty acids at the expense of n-6 fatty acids (Department of Health, 1994). Besides the beneficial effects of PUFA for human health, the conjugated linoleic acid (CLA) isomers have received much attention for their health promoting effects (Pariza et al., 2001). On the other hand, trans fatty acids have deleterious health effects (Stender and Dyerberg, 2004), and recommendations to decrease their intake have been promoted during the last decade (WHO, 2003).

The buffalo is mainly reared in Italy for milk production. That milk is used for the popular “mozzarella cheese” production. Nevertheless buffalo meat is considered in Italy as an alternative healthy product for its good nutritional characteristics (Ficco et al., 2007). In fact nowadays, there are encouraging sign of progress on marketing young buffalo meat for direct consumption in Asia, Italy, Eastern Europe and the Americas (Huerta-Leidenz et al., 2001).

Cooking of meat is essential to achieve a palatable and safe product (Tornberg, 2005). Moreover, it may affect basic traits related to consumer preferences, as flavour and tenderness

(Pietrasik et al., 2005). However, the nutritive value of buffalo meat can be affected by cooking methods. In general, heat (boiling, grilling and frying) is applied to meat in different ways to improve its hygienic quality by inactivation of pathogenic microorganisms and to enhance its flavour and taste, and increase shelf life (Bogner, 1998; Pokorny, 1999). During cooking, physicochemical reactions modify the food nutritional value. Cooking induces water loss in the food, increasing its lipid content, while only some fat is lost (García-Arias et al., 2003). Moreover, this effect is also dependent on the type of cooking (Ohta et al., 1988; Türkkan et al., 2008).

Therefore, the aim of this project was to study the influence of three cooking methods (boiling, grilling and frying) on the chemical and lipid composition of buffalo meat.

2. Material and methods

2.1. Sampling and cooking

Ten male buffalos were reared at the same experimental farm (C.R.A.-PCM, Rome, Italy) and under the same production system until they reached the slaughter weight (380 kg). The animals were slaughtered at the abattoir located in the same

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experimental farm, following the official methods. At the abattoir, four steaks from the cut end of the *longissimus thoracis* muscle were collected from the carcasses, trimmed of subcutaneous fat and assigned to one of the treatments (raw, frying, boiling or grilling), rotating steak location along the muscle to ensure equal representation of muscle location. The steaks were then vacuum packaged and aged for three days at 2 °C. Prior to cooking, steaks were cut in half to obtain two replicates from each animal. Common ways of cooking were used: frying, boiling and grilling. Olive oil was used for pan-frying (8.9% palmitic acid; 3.2% palmitoleic acid, 3.7% stearic acid; 64.5% oleic acid; 14.9% linoleic acid; 1.7% linolenic acid). The temperature of oil during the frying process was 180 °C and the internal temperature of the meat reached 84 ± 1.7 °C. For the boiling process, the samples were dipped into boiling water until 85 ± 3.2 °C internal temperature was reached. The grilling process was carried out with an electrically operated grill at 180 °C until an internal temperature of 89 ± 0.7 °C was reached. After the cooking processes, the samples were homogenised using a kitchen blender.

2.2. Meat quality analysis

Weight percentages of moisture, ash, fat and protein in the samples were determined according to AOAC (1990) methods. Protein content was measured by the block digestion method (UNE 55-020), moisture content was determined by drying at 102 °C for 24 h (ISO R-1442) and ashing was done at 550 °C for 24 h (ISO R-936). The intramuscular fat percentage was measured according to Soxhlet method (ISO R-1443) using a Foss Tecator AB Soxtec 2050.

The total fatty acids were extracted, methylated and analysed by an adaptation of the method described by Aldai et al. (2006), which has been reported to be highly effective for PUFA analysis (Juárez et al., 2008). Separation and quantification of the fatty acid methyl esters was carried out using a gas chromatograph (GC, Agilent 6890N, Agilent Technologies Spain, S.L., Madrid, Spain) equipped with a flame ionisation detector automatic sample injector HP 7683, and using a HP-88 J&W fused silica capillary column (100 m, 0.25 mm i.d., 0.2 µm film thickness, Agilent Technologies Spain, S.L., Madrid, Spain). Nonadecanoic acid methyl ester (C19:0 ME) at 10 mg/ml was used as an internal standard. Individual fatty acid methyl esters were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Identification of *cis9-trans11* CLA isomer, was achieved by comparing its retention time with that of an authenticated standard from Matreya (>98% purity; Matreya, LLC, Pleasant Gap, USA). Fatty acids were expressed as a percentage of total fatty acids identified and grouped as follows: saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA) and PUFA. PUFA/SFA, n-6/n-3 ratios and trans fatty acid content were calculated.

Finally, the extent of lipid oxidation was assessed by the thiobarbituric acid substances (TBARS) method described by Bruna et al. (2001).

2.3. Statistical analysis

The effect of the heat treatment on the proximate and fatty acid composition and on the lipid oxidation parameters, was analysed by one-way analysis of variance (ANOVA). Post-hoc analysis was carried out using Tukey's test. Differences were considered to be significant when $P < 0.05$. Data were analysed using the Statistica 7.0 software package (StatSoft, 2006).

3. Results and discussions

3.1. Proximate composition and thiobarbituric acid content substances (TBARS)

Table 1 shows proximate composition (g/100 g meat) of buffalo meat before and after each of the three cooking methods. The effects of cooking temperature (80–100 °C) and time (30–60 min) on collagen solubility and tenderness of buffalo meat have been previously studied (Vasanthi et al., 2007). However, limited research is available to document changes in buffalo meat proximate composition and fatty acid profile with different cooking methods.

Changes in moisture, protein, ash and fat contents were found to be significant ($P < 0.001$) for all cooking methods. The treatments reduced the moisture and increased protein, ash and fat contents. As aforementioned, thermal treatments induce water loss in meat. The water is probably lost due to heat-induced protein denaturation during cooking, which causes less water to be entrapped within the protein structures held by capillary forces. In addition, cooking loss depends on the mass transfer process during thermal treatment and, therefore, different cooking methodologies will determine differences in water loss (Cheng and Sun, 2008). Moreover, the decrease in the moisture content has been described as the most prominent change that makes the protein, fat and ash contents increase significantly (García-Arias et al., 2003). Therefore, the subsequent increases in the other traits (protein, ash and fat contents) were related to that water loss, modifying their relative contents. In fact, higher water loss (moisture decrease) determined higher increases in the rest of components. In this way, frying lead to the highest moisture decrease, followed by grilling. Boiling showed the lowest water loss due to the incorporation of water during the cooking process. On the other hand, the increase in ash and fat content was higher after frying due to that water loss and to the incorporation of fat from olive oil.

TBARS content is commonly evaluated to determine lipid oxidation (Rey et al., 2001), which is related to meat quality deterioration and to the formation of potentially toxic compounds (Paniangvait et al., 1995) that have been shown to be

Table 1 – Proximate composition (g/100 g meat) of raw and cooked buffalo meat.

	Raw	Boiling	Grilling	Frying
Moisture	73.54 ± 0.215^a	63.79 ± 0.263^b	61.23 ± 0.301^c	56.50 ± 0.476^d
Protein	18.33 ± 0.082^d	26.87 ± 0.105^c	28.12 ± 0.102^b	29.73 ± 0.071^a
Ash	1.13 ± 0.007^d	1.32 ± 0.014^c	1.97 ± 0.024^b	2.27 ± 0.062^a
Fat	1.72 ± 0.153^c	3.20 ± 0.212^b	3.44 ± 0.177^b	6.30 ± 0.282^a

a, b, c, d: different letters in the same trait significant statistical differences ($P < 0.001$).

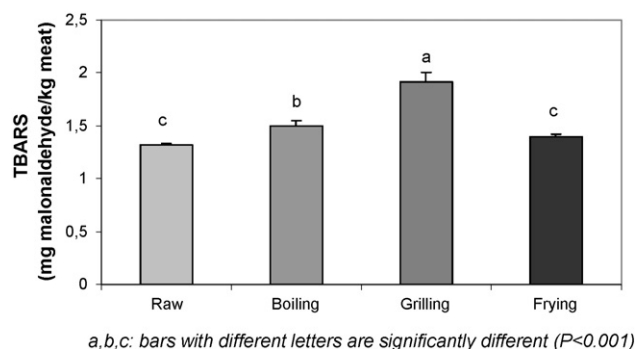


Fig. 1 – Thiobarbituric acid substances (TBARS) content (mg malonaldehyde/kg meat) of raw and cooked buffalo meat.

linked to the development of cardiovascular and other degenerative diseases (López-Bote et al., 1997). Boiling and grilling increased TBARS ($P < 0.001$), while frying had no effect on them (Fig. 1). The increase in the TBARS values after boiling and grilling could be due to the high temperature that promoted lipid peroxidation, increasing malonaldehyde levels. However, during frying the malonaldehyde eventually formed could be lost either by dissolution in the frying oil or due to formation of adducts with proteins (Weber et al., 2008).

3.2. Changes in fatty acid composition

Table 2 shows the fatty acid composition in buffalo intramuscular fat. The most represented fatty acids in the lipids extracted from raw buffalo meat, in descending order of concentration, were oleic, stearic and palmitic acids (C18:1n-9c, C18:0 and C16:0, respectively), followed at a considerable distance by linoleic, palmitoleic and myristic acids (C18:2n-6c, or LA, C16:1n-7 and C14:0, respectively), totaling around 95.9% of the total fatty acids.

Most of the fatty acids and indices were modified by the three cooking methods ($P < 0.001$). For the three cooking methods the relative content of total PUFA increased and a general decrease in SFA was observed. This observation may be explained by the fact that SFA and MUFA are largely represented in neutral lipids and are more prone to migration (Enser et al., 1996). The decrease in SFA after boiling and grilling was related to the decrease in C18:0 relative content. On the other hand, boiled buffalo meat had higher MUFA relative content than raw meat, while grilled buffalo meat showed the lowest MUFA levels due to decrease in C18:1 fatty acid relative content. Moreover, fried buffalo meat had the lowest SFA content due to the incorporation of MUFA (C18:1) from oil. Therefore, fried meat showed the highest levels of MUFA among all the studied types. However, the incorporation of oil fatty acids caused a decrease in CLA and n-3 fatty acids relative contents, even if C20:5n-3 (EPA) fatty acid increased after frying. Grilling caused an increase of C20:3n-6 and C20:4n-6 fatty acids, increasing the n-6/n-3 ratio. Grilled meat had the highest PUFA relative content. The increase in PUFA after grilling has been also reported by other authors in beef (Scheeder et al., 2001; Correia and Biscontinini, 2003) and hamburgers (Rodriguez-Estrada et al., 1997), and it has been related to triglycerides unsaturated fatty acid drip losses (Scheeder et al., 2001; Cobos et al., 2008).

Grilling had no significant effect on trans fatty acid content. However, boiling and, especially, frying increased trans fatty acid percentage in buffalo meat. Möllenken (1998) concluded that trans fatty acids would be difficult to form unless a severe cooking condition was used.

Some authors (Duckett and Wagner, 1998) consider that changes in fatty acid composition that occur during cooking may be overlooked when only total lipid extracts are analysed. In fact, the thermal hydrolysis, the migration of fatty acids from muscle to other locations, the loss of volatile fatty acids and the deactivation of enzymes occurred during heating may

Table 2 – Fatty acid composition (%) of raw and cooked buffalo meat.

	Raw	Boiling	Grilling	Frying
C14:0	1.20 ± 0.06 ^a	1.03 ± 0.02 ^b	1.11 ± 0.07 ^{a,b}	0.51 ± 0.01 ^c
C16:0	23.3 ± 0.03 ^a	22.9 ± 0.24 ^a	22.7 ± 0.15 ^a	17.9 ± 0.21 ^b
C16:1	1.32 ± 0.01 ^a	1.15 ± 0.12 ^b	1.02 ± 0.08 ^b	1.34 ± 0.14 ^a
C18:0	29.1 ± 0.13 ^a	25.4 ± 0.35 ^b	26.4 ± 0.01 ^b	17.6 ± 0.27 ^c
C18:1n-11t	0.77 ± 0.01 ^c	1.26 ± 0.10 ^b	0.65 ± 0.04 ^c	2.09 ± 0.07 ^a
C18:1n-9c	33.6 ± 0.12 ^c	34.4 ± 0.06 ^b	32.8 ± 0.11 ^d	49.6 ± 0.04 ^a
C18:2n-6c	5.82 ± 0.09 ^c	8.32 ± 0.13 ^a	8.75 ± 0.02 ^a	6.52 ± 0.16 ^b
C20:0	0.13 ± 0.01 ^b	0.06 ± 0.02 ^c	0.16 ± 0.01 ^a	0.14 ± 0.05 ^b
C20:1	0.17 ± 0.02 ^c	0.17 ± 0.01 ^c	0.21 ± 0.01 ^b	0.34 ± 0.01 ^a
C18:3n-3	0.16 ± 0.01	0.14 ± 0.03	0.14 ± 0.02	0.13 ± 0.03
9c-11t CLA	0.22 ± 0.01 ^b	0.26 ± 0.01 ^{a,b}	0.28 ± 0.02 ^a	0.16 ± 0.01 ^c
C20:3n-6	0.26 ± 0.01 ^b	0.02 ± 0.00 ^c	0.43 ± 0.01 ^a	0.21 ± 0.01 ^b
C20:3n-3	0.53 ± 0.02 ^b	0.61 ± 0.10 ^a	0.39 ± 0.05 ^c	0.31 ± 0.08 ^c
C20:4n-6	0.38 ± 0.10 ^b	0.10 ± 0.01 ^c	1.11 ± 0.09 ^a	0.53 ± 0.14 ^b
C20:5n-3	0.04 ± 0.00 ^d	0.20 ± 0.01 ^b	0.10 ± 0.02 ^c	0.33 ± 0.05 ^a
C22:4n-6	0.18 ± 0.01 ^b	0.03 ± 0.00 ^d	0.23 ± 0.01 ^a	0.13 ± 0.01 ^c
C22:5n-3	0.10 ± 0.02 ^b	0.14 ± 0.01 ^a	0.15 ± 0.01 ^a	0.08 ± 0.01 ^b
SFA	54.6 ± 0.21 ^a	50.7 ± 0.09 ^b	51.4 ± 0.06 ^b	36.5 ± 0.34 ^c
MUFA	37.3 ± 0.14 ^c	39.0 ± 0.08 ^b	36.3 ± 0.07 ^d	54.3 ± 0.04 ^a
PUFA	7.95 ± 0.07 ^d	10.1 ± 0.01 ^b	12.1 ± 0.14 ^a	9.06 ± 0.30 ^c
PUFA/SFA	0.14 ± 0.01 ^c	0.20 ± 0.01 ^b	0.23 ± 0.01 ^a	0.24 ± 0.01 ^a
n-6/n-3	8.27 ± 0.54 ^b	8.35 ± 0.90 ^b	15.3 ± 0.85 ^a	8.93 ± 0.95 ^b
Trans FA	0.92 ± 0.13 ^c	1.37 ± 0.15 ^b	0.79 ± 0.11 ^c	2.33 ± 0.21 ^a

SFA: saturated fatty acids; MUFA: mono-unsaturated fatty acids; PUFA: polyunsaturated fatty acids; and FA: fatty acids.

a, b, c, d: different letters in the same trait significant statistical differences ($P < 0.01$).

be responsible of many of the observed changes. Therefore, it could be interesting to study the changes of fatty acid profiles in the three lipid fractions (phospholipids, free fatty acids and glycerides).

4. Conclusions

All the cooking methods evaluated changed proximate composition, oxidation parameters and fatty acid profile of buffalo meat. Changes in proximate composition were more prominent in fried meat. Only boiled and grilled meat had increased levels of TBARS, indicating oxidative changes, but they did not reach threshold levels for preventing human consumption. The fat content in fried samples significantly increased due to absorption of fat by the meat, and it affected its fatty acid profile. A decrease in SFA relative content was observed for the three cooking methods. The effect was greater for frying due to the incorporation of MUFA from oil. However, the fat absorption decreased the relative content of some healthy fatty acids, as CLA. Moreover, fried meat showed the highest levels of the unhealthy trans fatty acids. Therefore, even if olive oil incorporated MUFA into buffalo meat, frying was shown as the worst cooking methods regarding human health.

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