Chemical and lipid composition of buffalo meat 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. That increase in fat content was higher after frying due to the incorporation of fat from olive oil. The lipid fraction proportions were affected by boiling, in which phospholipids increased, and by frying, in which glycerides increased. Grilling had no effect on lipid fraction proportions. Fried meat had lower saturated fatty acid content in all the lipid fractions considered due to the incorporation of mono-unsaturated (C18:1) and poli-unsaturated fatty acid (C18:2) from oil. That incorporation of oil fatty acids caused a decrease of n-3 fatty acids and conjugated linoleic acid relative content. Grilling decreased trans fatty acid content in the free fatty acid fraction, and frying did it in the glycerides fraction. Boiling and grilling increased thiobarbituric acid reactive substances, while frying had no effect on them.

Introduction
Human nutritionists are recommending a higher intake of polyunsaturated fatty acids (PUFAs) 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).
Buffalo meat is considered in Italy as an alternative healthy product for its good nutritional characteristics. However the nutritive value of buffalo meat can be affected by cooking methods. The effects of different cooking methods on nutritive values of different meats have been previously studied (Vasanthi *et al.,* 2007).
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.

Material and methods
Sampling and cooking
Ten male buffalos were reared at the same farm and under the same production system until they reached the slaughter weight (380 kg). At the abattoir, samples from *longissimus dorsi* muscle were collected, sliced, packed and aged for three days at 2ºC.
The samples were cooked by frying, boiling, and grilling. Olive oil was used for pan-frying. The temperature of oil during the frying process was 180ºC and the internal temperature of the meat reached 84±1.7ºC. For the boiling process, the samples were dipped into boiling water until 85±3.2ºC internal temperature was reached. The grilling process was carried out with an electrically operated grill at 180ºC until an internal temperature of 89±0.7ºC was reached. After the cooking processes, the samples were homogenised using a kitchen blender.
Meat quality analysis
AOAC methods (1990) were used for moisture, protein and ash determinations. The lipids were extracted and purified according to the method of Folch *et al*. (1957). Total intramuscular lipids were separated into neutral lipids (glycerides), free fatty acids (FFAs) and polar lipids (phospholipids) according to the method described by Pinkart *et al.* (1998). Contents of fractions were quantified, and the results were expressed as a percentage of the total weight obtained. The fatty acid composition of each fraction was determined by gas liquid chromatography of methyl esters, prepared in basic conditions (KOH:methanol) for glycerides and phospholipids and acidic conditions (H_2SO_4:methanol) for the FFAs. The gas chromatograph was a Varian 3900 equipped with a flame ionization detector and the column was an Agilent HP-88 column (Agilent Technologies Spain, S.L., Madrid) (100 m, i.d. 0.25 mm x 0.2 μm). Fatty acid proportions from the three

fractions were expressed as percentage of the total fatty acids. Finally, the extent of lipid oxidation was assessed by the thiobarbituric acid substances (TBARS) method described by Bruna *et al.* (2001).

Statistical analysis

Significant differences between means of experimental data were determined by ANOVA using Statistica 7.0 software (StatSoft Inc., www.statsoft.com).

Results and discussions

Table 1 shows proximate composition, lipid fraction percentage and TBARS content. 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 content. That increase in fat content was higher after frying due to the incorporation of fat from olive oil. The lipid fraction proportions ($P<0.001$) were affected by boiling, in which glycerides decreased and phospholipids increased, and by frying, in which glycerides increased and phospholipids decreased. The decrease of glycerides fraction during boiling may be due to the thermal hydrolysis and the increase of that fraction during frying was due to the incorporation of triglycerides from olive oil. That increase in the amount of phospholypids leads to a decrease in the percentage of the other two fractions. Regarding to FFAs content, the levels found after the three cooking methods were lower than those of raw meat. It may be due to the migration of FFAs from muscle to other locations, as water or oil. The loss of volatile FFA and the deactivation of enzymes occurred during heating may also explain the decrease of FFAs.

Boiling and grilling increased thiobarbituric acid reactive substances ($P<0.001$), while frying had no effect on them. The increase in the TBARS values after boiling and baking could be due to the high temperature. 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).

Table 1. Proximate and lipid fraction composition (%) and TBARS content (mg malonaldehyde/kg meat) of raw and cooked buffalo meat

	Raw	Boiled	Grilled	Fried	Sig
Moisture	73.54±0.215a	63.79±0.263b	61.23±0.301c	56.50±0.476d	***
Ash	1.13±0.007d	1.32±0.014c	1.97±0.024b	2.27±0.062a	***
Protein	18.33±0.082d	26.87±0.105c	28.12±0.102b	29.73±0.071a	***
Fat	1.72±0.153c	3.20±0.212b	3.44±0.177b	6.30±0.282a	***
Glycerides	52.54±0.402b	41.63±0.360c	54.31±0.443b	62.53±0.559a	***
FFA	17.44±0.276a	13.66±0.290b	14.29±0.395b	13.61±0.437b	***
Phospholipids	30.01±0.978b	44.70±1.256a	31.39±1.102b	23.85±0.770c	***
TBARS	1.32±0.010c	1.50±0.053b	1.92±0.081a	1.39±0.031c	***

Sig.: Significant differences; *** = $p<0.001$

Table 2 shows the fatty acid composition in the three lipid fractions. Fried meat had lower SFA content ($P<0.001$) in the three fractions due to the incorporation of MUFA (C18:1) and PUFA (C18:2) from oil. That incorporation of oil fatty acids caused a decrease of n-3 fatty acids and CLA relative contents ($P<0.001$). Grilling decreased trans fatty acid content ($P<0.001$) in the FFAs fraction. Frying decreased trans fatty acid percentage in the glycerides fraction. Möllenken (1998) concluded that trans fatty acids would be difficult to form unless a severe cooking condition was used. Therefore, if trans fatty acids were not formed during frying, the decrease of its percentage would be again explained by the incorporation of other fatty acids from oil.

Table 2. Fatty acid indices (% of total fatty acids) of glycerides, free fatty acids and phospholipids fractions of raw and cooked buffalo meat

	Raw	Boiled	Grilled	Fried	Sig
	Glycerides				
SFA	49.78±0.182b	52.07±0.446a	52.46±0.246a	40.84±0.342c	***
MUFA	46.74±0.291b	43.69±0.439c	43.47±0.338c	53.69±0.280a	***
PUFA	3.53±0.116c	3.97±0.147b	3.80±0.190bc	5.71±0.179a	***
CLA	0.34±0.049a	0.30±0.013a	0.31±0.031a	0.06±0.005b	***
n6/n3	6.66±1.160c	8.63±0.878b	7.68±0.529bc	27.90±1.802a	***
Trans	1.00±0.101a	1.11±0.095a	1.17±0.114a	0,57±0,045b	***
	Free Fatty Acids				
SFA	90.62±0.808a	89.02±2.088a	90.75±1.436a	84.08±0.529b	***
MUFA	5.24±0.414b	6.59±1.371b	5.67±0.971b	11.5±0.261a	***
PUFA	4.11±0.561ab	4.33±0.778a	3.55±0.382b	4.54±0.407a	**
CLA	0.17±0.073a	0.10±0.018b	0.09±0.275b	0.01±0.002c	***
n6/n3	8.08±0.239a	6.84±0.397b	6.79±1.452b	6.70±1.556b	***
Trans	1.37±0.278a	1.55±0.473a	0.76±0.243b	1.56±0.107a	***
	Phospholipids				
SFA	39.76±0.952a	35.57±0.349b	39.31±0.609a	36.44±0.797b	***
MUFA	19.74±0.883	19.81±0.467	19.45±0.460	20.25±0.620	ns
PUFA	40.49±1.579b	44.52±0.579a	41.31±0.712ab	43.07±1.109a	***
CLA	0.11±0.002a	0.13±0.034a	0.09±0.009a	0.07±0.057b	***
n6/n3	8.49±1.469	8.15±0.769	10.39±1.782	8.66±1.003	ns
Trans	0.50±0.074a	0.35±0.046b	0.46±0.076ab	0.44±0.053ab	*

Sig: Significant differences. ns = p>0.05; * = p<0.05; ** = p<0.01; *** = p<0.001

Conclusions

All the cooking methods evaluated changed proximate composition, oxidation parameters and fatty acid profile of the 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. Fatty acid profile was greatly affected by cooking methods. There were significant increases in PUFAs of glycerides, phospholipids and FFA in meat after frying. However CLA and n-3 fatty acid relative content decreased, leading to a worse n-6/n-3 ratio. No trans fatty acid formation was observed for any culinary treatment.

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