DEVELOPMENT OF HEALTHIER NORTH AFRICAN FRESH BEEF SAUSAGE (*MERGUEZ)*

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Abstract – This study evaluates the nutritional and sensory characteristics of fresh beef sausage (merguez) reformulated in order to improve fat content and reduce sodium levels. Fat improvement was performed by replacing beef fat with olive oil stabilized in a konjac matrix (OKM). Sodium reduction was performed by replacing the partially added sodium chloride with a salt mixture (MS) containing potassium, calcium and magnesium chloride. Four formulations were elaborated, a control sample (C), and three reformulated samples, two with 75% substitution of beef fat by OKM (RF and RFMS) and one with 100% substitution by OKM (LF). Sodium replacement by MS was performed only in RFMS samples. The reformulation strategy achieved reductions between 31.3% and 43.8% of total fat in merguez. Olive oil contribution was between 24% to 36%. Sodium was decreased by 40% in RFMS. The reformulation strategy improved the composition and nutritional properties in healthier fresh merguez products and did not negatively affect the sensory characteristics.

Key Words – Merguez reformulation, Konjac with olive oil as fat substitute, Sodium reduction by replacing sodium chloride by a mixture of salts

I. INTRODUCTION

Merguez is a North African type of fresh sausage made with either beef or lamb or both and is widely consumed worldwide, including in Europe. This kind of fresh sausage usually presents some negative health concerns related to their high fat (over 20%), saturated fatty acids (SFA) and salt (3.6%) contents [1]. Like other meat products, merguez can be reformulated to achieve healthier lipid compositions. Konjac glucomannan (E-425) has been used as a fat analogue in various meat products [2, 3] in order to reduce calories and SFA contents by replacing beef fat used in these products. Olive oil is a high source of monounsaturated fatty acids (MUFA) which has been incorporated to Konjac matrix in order to enhance the nutritional properties of the meat product [3].

Excessive salt intake increases blood pressure and is a major risk of serious health problems including cardiovascular disease, diabetes, and kidney disease for certain sensitive sectors of the population [4, 5]. There are several strategies for reducing sodium in processed meat; one of the most common is the replacement of all or some parts of the added sodium chloride (NaCl) with other salts, usually combinations of potassium chloride (KCl), calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$). This approach has been widely used for different types of meat products [4-8] but not in fresh meat products as merguez sausage.

Therefore, the aim of this research is to evaluate the nutritional and sensory characteristics of merguez sausage reformulated in order to improve the fat content by replacing beef fat by olive oil stabilized in a konjac matrix and to reduce sodium by replacing sodium chloride by a mixture of salts containing potassium, calcium and magnesium chloride.

II. MATERIALS AND METHODS

Materials and konjac gel preparation

Fresh post-rigor meat and beef fat were obtained from a local market. The following ingredients were used: konjac flour, pre-gelled cornstarch, i-carrageenan and $Ca(OH)_2$. Other ingredients and additives used were olive oil, sodium chloride, potassium chloride, magnesium chloride, calcium chloride and various condiments and spices including coriander, fennel, paprika, hot pepper, mint and a commercial preparation of Harissa. Konjac matrix (fat analogue) was prepared with 20% of olive oil (OKM) as described by Triki *et al.* [2].

Experimental design and merguez sausage manufacture

Four formulations (Table 1) were elaborated with the same beef meat content of 55%. They were designed as following: A control sample (C) prepared with normal beef fat (29%) and normal sodium chloride (NaCl) content (1.4%). Three reformulated samples: RF was prepared by replacing 75% of beef fat by the same proportion of OKM and normal NaCl content. RFMS was prepared also by replacing 75% of beef fat by the same proportion of OKM however, 50% of NaCl was replaced by a mixture of salts (MS) (Table 1). Finally LF was prepared by replacing 100% of beef fat by the same proportion of OKM with normal NaCl content (Table 1). Sausages were made as described by Triki *et al.* [2].

Table 1 Formulation (%) of fresh merguez sausages.

	OKM	NaCl	MS		
			KCl	$CaCl_2$	$MgCl_2$
C	-	1.4	-	-	-
RF	21.75	1.4	-	-	-
RFMS	21.75	0.7	0.35	0.20	0.15
LF	29	1.4	-	-	-

*All formulations contain 55% of beef meat.

Proximate analysis

Sample moisture and ash contents (%) were determined [9] in triplicate in all fresh merguez sausage formulations. Protein content (%) was measured in quadruplicate with a LECO FP-2000 Nitrogen Determinator. Fat content (%) was determined in triplicate according to Bligh *et al.* [10].

Mineral contents

Ca, Mg, Na, K and Fe (mg/100g) were determined in fresh merguez sausages as reported by Serrano *et al.* [11] on an atomic absorption spectrophotometer (Perkin-Elmer, model 5100, Norwalk, Connecticut. USA) and determined in triplicate.

Sensory evaluation

Merguez sausages were assessed by a 20 member panel and were determined as described by Triki *et al.* [2]. The panelists evaluated the sausages on the following parameters on a scale from 0-10: juiciness, firmness and general acceptability. The sensory analysis was carried out three times.

Statistical analysis

One-way analyses of variance (ANOVA) to evaluate the statistical significance ($P<0.05$) of the effect of merguez sausage formulation was performed by SPSS 19.0 software.

III. RESULTS AND DISCUSSION

The protein content of the control sample (C) was higher ($P<0.05$) than those of the reformulated sausages, with no differences ($P>0.05$) between them (Table 2). Since all formulations were prepared with the same meat content (Table 1), these differences must be mainly due to the low contribution of protein from the beef fat as a consequence of reformulation (Table 1) [2]. No quantitative relevant variations in ash content (2.3–2.5%) between formulations were observed (Table 2).

Table 2 Proximate analysis (%) of fresh merguez sausages.

	C	RF	RFMS	LF
Moisture	62 ± 0.7^{a}	69 ± 0.2^{b}	70 ± 0.3^{c}	73 ± 0.6^{d}
Fat	16 ± 0.7^{d}	11 ± 0.1^{c}	10 ± 0.3^{b}	9 ± 0.4^{a}
Protein	16 ± 0.8^{b}	14 ± 0.2^{a}	13 ± 0.5^{a}	13 ± 0.7^{a}
Ash	2.4 ± 0.0^{b}	2.5 ± 0.0^{c}	2.3 ± 0.1^{a}	2.4 ± 0.0^{b}
% Fat reduction	-	31.3	37.5	43.8
% Olive oil*	-	24.5	25.8	35.7

Means ± standard deviation. Different letters in the same row indicate significant differences ($P<0.05$).
*Calculated on the basis of formulation (20% of OKM added is olive oil).

As expected partial (RF) and total (LF) replacement of beef fat with konjac materials (OKM) affected ($P<0.05$) fat proportions of the sausages (Table 2). Fat contents were 16% in control samples (C) and ranged between 9 and 11% in the reformulated samples (Table 2) with a reduction between 31.3% and 43.8% of the total fat (Table 2). Olive oil contribution was between 24.5% (RF) and 35.7% (LF) comparing to control samples manufactured with only beef fat. Olive oil is a vegetable oil with the highest level of monounsaturated fatty acids (MUFA) and has attracted attention as supplementary

ingredient to animal fat replacers for processed meat products. It has also a high biological value due to its naturally occurring antioxidants including vitamin E and K, carotenoids and polyphenols. Olive oil is also reported to help prevent breast and colon cancer [12].

Table 3 Mineral content (mg/100 g) of fresh merguez sausages.

	C	RF	RFMS	LF
Na	631±12^{b}	644±12^{b}	386±16^{a}	773±25^{c}
K	321±19^{b}	313±12^{b}	519±5.7^{c}	272±6.7^{a}
Ca	26.5±0.7^{a}	34.9±1.5^{c}	100±4.5^{d}	31.8±0.3^{b}
Mg	23.3±0.0^{b}	23.2±1.1^{ab}	41±1.0^{c}	21.5±0.4^{a}
Fe	2.4±0.1^{b}	2.2±0.2^{b}	2.3±0.1^{b}	1.4±0.1^{a}

Means ± standard deviation. Different letters in the same row indicate significant differences (P<0.05).

As expected, mineral values of RFMS samples were affected (P<0.05) by the reformulation (Table 3). For this sample, sodium content presented a reduction of 40% comparing with RF samples which means an important advance in terms of health and nutritional considerations as recommended by public health and regulatory authorities [13, 14]. A 2:1 ratio intake of potassium to sodium (K/Na) may lower the mortality risk from cardiovascular disease by 50% [4]. The reformulated fresh merguez sausages with reduced salt samples (RFMS) reformulated in our study presented a ratio of 1.34 of K/Na, close to the 2:1 recommended.

This reformulation strategy also allowed an increase (P<0.05) of potassium levels by 39.7%. Potassium is fundamental in a significant number of body processes, including fluid balance, protein synthesis, nerve conduction, energy production, muscle contraction, synthesis of nucleic acids and heart rate regulation [13].

Calcium and magnesium levels displayed the same behaviour as potassium levels in RFMS samples and were increased by 186.7% and 76.7%, respectively. Meat and meat products are generally poor in calcium, procuring 4-21 mg/100 g in beef meat [15] whilst its high importance for human growth and heath. 100 g of the reduced sodium merguez sausages (RFMS) can provide 7–10% of the total calcium daily intake (1000–1300 mg) as well as 11-17% of total magnesium daily intake (240–360 mg). Health benefits of magnesium include alleviating or preventing osteoporosis, heart attacks, hypertension, etc. No clear differences were observed in iron levels between formulations (Table 3) similar to the amounts reported by Triki *et al.* [2]. The iron provided by merguez represents 15% of the RDA (14 mg/day).

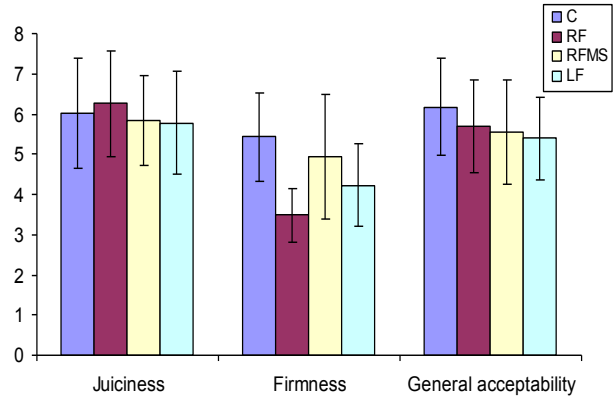

Figure 1. Sensory evaluation of fresh merguez sausages.

As shown in figure 1, no significant differences were observed in sensory parameters (juiciness, firmness and general acceptability) as affected by formulation. In fact, fat and salt reformulations did not result in any limitations in the sensory appreciation. However other authors [16] have observed that salt and fat reductions reduce the perceived saltiness and palatability and also weaken the overall flavour in meat products. The results found in our study may be explained by NaCl partial replacement by other salts and by using a large amount of spices in the formulation of these products, which could mask some sensorial changes associated with the formulation [2].

IV. CONCLUSION

The reformulation strategy used in this study resulted in a very important reduction in fat and sodium contents as well as an improvement of lipid (olive oil) and mineral profile of fresh merguez sausage with satisfactory sensory properties. Therefore, this processing strategy is suitable and highly recommended for use in the development of healthier fresh merguez sausages.

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