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Original article

The potential of soya oil and egg-yolk as sources of fat in beef sausages

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A B S T R A C T

A study was conducted to assess the effects of less-saturated fats [Egg yolk (EY) and soya oil (SO)] on characteristics and acceptability of beef sausages. Each of the fats was incorporated in beef sausages at three levels (5%, 10% and 15%), and compared with products formulated with only lean beef (Control). Fresh boneless beef was obtained and thoroughly trimmed of excess visible fats, and then minced. The minced beef was divided into portions of 4kg, and were randomly assigned to the fats. The fats were then mixed with the minced meats and allowed 15 minutes for the meat to absorb the fat. The products were formulated and evaluated for their sensory characteristics using BSI (1993) method, and storability by laboratory analyses. Addition of both fats up to 15% improved (P<0.001) tenderness and juiciness of the products. Increasing levels of EY caused a weakening of the product's flavour intensity, had no effect (P>0.05) on flavour liking and reduced acceptability of the EY3 products. Increasing levels of SO improved (P<0.001) flavour intensity, flavour liking and overall acceptability of the products. Both fats increased the unsaturated fatty acid contents of the products but had no significant (P>0.05) effect on product storability. Comparatively, inclusion of SO up to 15% in beef sausages was preferred (P<0.001) to that of EY. SO could be used up to 15% in beef sausages for improved sensory characteristics and acceptability.

1. Introduction

Products from meat processing firms are widely accepted by meat consumers due to the increasing demand for convenient meals, and also because meat is a source of high quality protein, high levels of available irons, essential fatty acids and the B-group of vitamins (Biesalski, 2005). Recently however, the patronage of meat and meat products has been adversely affected due to the establishment of a likely relationship between meat consumption and an increased risk of health disorders such as cancers of the colon and also coronary-heart diseases (Ferguson, 2010). Animal fat and for that matter saturated fatty acids have been recognized as influential factors in the pathogenesis of heart failure and cancers associated with the consumption of meat (Kratz, 2005; Lin *et al.,* 2004; Hongbao, 2006; Sharma *et al.,* 2011). Saturated fatty acids are very high in the fats of ruminant livestock and for that matter, cattle, resulting in beef fat appearing hard and unsuitable for further processing (Ambrosiadis *et al.,* 1996; Teye, 2010). The hardness of beef fat especially when it cools also results in a "greasy" mouth feel associated with eating fatty beef products; a situation that causes consumers to dislike such products (Warriss, 2010; Hoffman *et al.,* 2005). Technologically, the hard fat has high tendency of separating from the muscles to form fat-pockets in the casings of sausages. Elsewhere, the fats of pork and chicken are used to substitute for beef fat in comminuted beef products, as these have lower levels of saturated fatty acids and have better technological properties than beef fat (Ambrosiadis *et al.,* 1996). However, religious barrier against the consumption of pork hinders the use of pork fat in beef products especially in northern Ghana where over 70% of the human population consists of Moslems. Chicken fat cannot be obtained in adequate quantities in Ghana for use as substitute for beef fat. Consequently, beef sausages in northern Ghana are made using only lean beef without fat (Teye, 2010).

Fat is however, reported to play a major role in the texture, juiciness and flavour of comminuted meat products (Crehan *et al.,* 2000). Drewnowski (1992) reported that the sensory properties of fat make a diet flavourful, varied and rich. Troutt *et al.* (1992) also reported that fat acts as a reservoir for flavour compounds, and contributes to the texture and juiciness of the products. The absence of fat in beef sausages therefore contributes to the products becoming "dry and tough", as described by some consumers. There is the need to find alternative fats which are less saturated but have potentials of improving the sensory qualities of beef sausages.

Recent studies are focusing on increasing the unsaturated fatty acid contents of meat products, by substituting beef fat with non-beef fats in beef sausages (Choi *et al.,* 2010; Martin *et al.*, 2008; Mugeurza *et al.*, 2001).

Soya oil, like all vegetable oils, is relatively higher in unsaturated fatty acids (65%), compared with beef fat (46%), and therefore has fewer health concerns (Paneras and Bloukas, 1994). Its potential as fat substitute was realized when used as substitute for pork fat in low-fat frankfurters (Paneras and Bloukas, 1994). Vegetable oils are reported to have high levels of oleic and monounsaturated fatty acids, natural antioxidants and reduce cholesterol levels (Martin *et al.,* 2008; Mugeurza *et al.,* 2001). Rodriguez-Carpena *et al.* (2012) tested the potentials of sunflower and olive oils as substitutes for pork fat, and reported positive health implications of consuming such products. There is however, little information on the effects of soya oil as substitute for beef fat on characteristics of beef sausages.

Egg-yolk also contains almost all of the fats in an egg. The levels of unsaturated and polyunsaturated fatty acids in the yolk sum up to 64% hence might be safer for consumption, compared with beef fats (Layman and Rodriguez, 2009). Its effect on characteristics of beef sausage is yet to be discovered. This study was aimed at investigating the effects of soya oil and egg yolk as sources of fat, on characteristics and acceptability of beef sausages.

2. Materials and methods

The study was conducted at the Meat Processing Unit and Laboratories of the University for Development Studies (UDS), Tamale, Ghana.

Fresh clean chicken eggs were obtained from the local market, broken and the yolk manually separated from the albumen. The yolk was refrigerated at 1°C for later use.

Refined soya oil ("Akoma" Brand) was obtained from an oil extraction company in Techiman, Ghana. The sausages were formulated at three levels (5%, 10% and 15%) each of egg yolk and soya oil. There were a total of 7 treatments: The soya oil products were named SO^5, SO^{10} and SO^{15}; while the egg yolk products were named EY^5,

EY^{10} and EY^{15}; these were compared with products formulated with lean beef only (Control). The control products were formulated with lean beef only, because that is how "Ghanaian beef sausages" are formulated.

2.1. Sausage formulation

A single factor Completely Randomized Design was adopted in this study. Fresh boneless lean beef was obtained from the Meat Processing Unit of UDS, cut into smaller sizes and minced using a 5mm-sieve table top mincer (Talleres Rommon, Spain). The minced beef was apportioned into groups of 4kg, and assigned randomly to the various levels of substitute fats. The substitute fats were mixed with the minced beef with an electronic mixer (Talleres Rommon, Spain) for 5 minutes, to enable the fat to be absorbed by the minced meat (Hoogenkamp, 1987; Claus, 1991). The following ingredients were added in equal amounts (g/kg) to the various formulations of sausage meat: 13.0g curing salt, 0.5g red chillies, 1.0g black pepper, 1.0g white pepper and 2.0g "adobo" (mixed spices). Crushed ice was added during comminution to control temperature and also improve consistency of the meat batter. The mixture was comminuted in a 3-knife bowl chopper (Talleres Ramon, Spain) until a meat-batter temperature of 17°C was attained. The meat batter was immediately stuffed into natural casings, using a hydraulic stuffer (Talleres Ramon, Spain) and manually linked into similar length of about 10cm. The sausages were hung on smoking racks and smoked for an hour, after which they were scalded to a core temperature of 70°C, then cooled in cold water and hung on the racks again for excess water to drain. The products were packed in transparent polythene bags and vacuum-sealed with a table top vacuum sealer (Talleres Rommon, Spain), labelled and refrigerated at 2°C for sensory, chemical and microbiological analyses. The products were formulated in three (3) batches.

2.2. Sensory evaluation

A total of 20 panellists, aged between 18 and 25years (12 males, 8 females) were randomly selected and trained according to the British Standard Institution (1993) guidelines of panellist selection and training, to evaluate the products. The refrigerated sausages were thawed and warmed in an oven (Turbofan, Blue seal, UK), sliced into uniform sizes (about 2cm in length) and wrapped with coded aluminium foils and presented to the panellists. Each panellist was provided with water and pieces of bread to serve as neutralizers between the products. An eight-point category scale was used to rate the sensory characteristics of the products as recommended by Keeton (1983):

Internal colour: 1=extremely pale red; 2=very pale red; 3=moderately pale red; 4=slightly pale red; 5=slightly dark red; 6=moderately dark red; 7=very dark red; 8=extremely dark red

Juiciness: 1=extremely dry; 2=very dry; 3=moderately dry; 4=slightly dry; 5=slightly juicy; 6=moderately juicy; 7=very juicy; 8=extremely juicy

Texture: 1=extremely coarse; 2=Very coarse; 3=moderately coarse; 4=slightly coarse; 5=slightly smooth; 6=moderately smooth; 7=Very smooth; 8=extremely smooth

Meat flavour intensity: 1=extremely weak; 2=very weak; 3=moderately weak; 4=slightly weak; 5=slightly strong; 6=moderately strong; 7=very strong; 8=extremely strong

Flavour liking/ acceptability: 1=Dislike extremely; 2=Dislike very much; 3=Dislike moderately; 4=Dislike slightly; 5=Like slightly; 6=Like moderately; 7=Like very much; 8=Like extremely

2.3. Chemical analyses of products

The sausages were analyzed in triplicates for lipid per-oxidation (peroxide value), moisture, crude protein and fat contents according to the methods of the AOAC (1999). In addition, the Iodine Value (IV) of the fatty acids in the products was determined according to the methods of the ISO (1996).

2.4. Statistical analyses

The data obtained were analyzed using the General Linear Model (GLM) of Analysis of Variance (ANOVA) of the Minitab Statistical Package, version 15 (MINITAB, 2007). Where significant differences were found, the means were separated using Tukey Pair Wise comparison, at 5% level of significance.

3. Results and discussion

3.1. Sensory characteristics of products

The sensory characteristics of the products are presented in Table 1. There was no significant difference (P> 0.05) in the colour of the products (Table 1). The colour of the product varied between 3.80 and 4.10, thus the product appeared slightly pale red. Though the product colour was not significantly different, it was observed that the exudates from the EY products were pinkish, while that of the SO products was creamy. The EY and SO products however, had significantly (P<0.001) improved texture and juiciness. As was expected, these characteristics improved with increasing EY/SO inclusions. Several studies reported an increased juiciness and smoother consistency of meat products with higher fat contents (Berry and Wergin, 1993; Troy *et al.,* 1999). Serdaroglu and Rmencioglu (2004) reported that meatballs with higher fat levels were significantly tender than those with lower fat levels. Fat acts as a lubricant to muscle cells, to prevent excessive drying and shrinkage, and hence the tenderness of such products (Lawrie and Ledward, 2006). Several studies reported that fat plays a major role in improving water holding capacity and binding properties, by forming rheological and structural properties that trap moisture in the products to improve juiciness (Hughes *et al.,* 1997; Pietrasik and Duda, 2000). The improved texture and juiciness of the fat-substituted products is advantageous, because texture is regarded as the most important sensory attribute affecting meat acceptability (Warkup *et al*., 1995). Tenderness has also been identified as the most critical eating quality characteristics, which determines whether consumers are repeat buyers (Colmenero, 2000).

The fat substitutes had no significant (P>0.05) effects on flavour intensity of the products as compared with the control; but the SO products had significantly (P<0.001) higher flavour intensity than the EY products. Overall acceptability of the EY products decreased with EY inclusion level. The decrease was however, not significant (P<0.05) in the EY^5 and EY^{10} products, but was significantly (P<0.001) low in the EY^{15} products. The SO products however, had enhanced (P<0.001) flavour intensity, flavour liking and overall acceptability. These parameters increased (P<0.001) from SO^5 to SO^{15}. Fat is reported to improve the sensory characteristics and acceptability of meat and meat products (Crehan *et al.,* 2000; Drewnowski, 1992). It was therefore expected that the acceptability of the EY products would be enhanced, but that was not the case. The EY was seemingly flavourless in nature, and therefore, its addition to the products diluted the flavour intensity, making them appear bland. This might have resulted in the reduced acceptability of the EY products.

Table 1
Sensory characteristics of products.

Parameters	Control	EY^5	EY^{10}	EY^{15}	SO^5	SO^{10}	SO^{15}	SED	SIG
Colour	3.90	4.00	3.80	3.90	3.90	3.80	4.10	0.19	ns
Texture	3.20^c	3.40^c	4.60^b	5.40^a	3.30^c	4.10^b	5.60^a	0.15	***
Juiciness	4.50^c	5.30^{bc}	5.80^b	6.60^a	4.50^c	5.90^b	6.70^a	0.15	***
Meat flavour intensity	4.40^c	3.40^d	3.40^d	3.30^d	4.50^c	5.60^b	6.60^a	0.14	***
Flavour liking	4.90^{bc}	4.30^c	4.00^c	4.20^c	5.10^b	6.20^a	6.40^a	0.18	***
Overall Acceptability	4.70^c	4.50^{cd}	4.20^{cd}	3.90^d	4.40^{cd}	6.20^b	7.00^a	0.17	***

[abcd]Means in the same row with common superscripts are not significantly different; SED=standard error of difference; Sig=significance; ns= not significantly different, ***= (P< 0.001).

3.2. Proximate composition of products

The moisture, crude protein and fat contents of the products are presented in Table 2. The fat contents of the SO and EY products increased significantly (P<0.001) from 6.34 to 13.47 (Table 2). However, the rate of increase did not reflect the quantity of SO/EY added during product formulation. This might be due to losses experienced during cooking of the products. Serdaroglu and Rmencioglu (2004) reported that fat retention decreased with an increase in fat levels in meatballs, and that high fat retentions were observed in products with the least fat contents. As fat content increases in a product, the mean free distance between fat droplets decreases, and this phenomenon causes fat coalescing and then leaking out from the product (Tornberg *et al.,* 1989). This might have accounted for the relatively lower fat contents than what was added during formulation of products.

The moisture content of the SO products reduced significantly (P<0.001) with an increase in SO/EY inclusions. The moisture content was however, marginally lower in the EY^5 and EY^{10} products, but significantly (P<0.001) lower in the EY^{15} products. With reference to Table 2, the fat content of the SO products appeared higher than the EY products. According to Serdaroglu and Rmencioglu (2004), moisture content reduces when fat level increases in a product. This is because during meat comminution, the muscle proteins form matrices that trap moisture and fat (Xiong, 1997). The higher the fat content of the product, the less the muscle proteins that would be available to bind water, and that could have accounted for the lower moisture contents in the products with higher fat levels. It was expected that the lower moisture contents of the SO and EY products might result in significantly lower juiciness in those products, but contrary to expectation, juiciness was highest in SO^{15} and EY^{15} products. This might be due to the fat serving as a barrier to prevent rapid loss of moisture from the EY and SO products during storage, compared with the control products.

Table 2

Proximate composition of products.

Parameters	Control	EY1	EY2	EY3	SO1	SO2	SO3	SED	Sig.
Moisture	76.88^{a}	75.80^{a}	75.36^{a}	74.80^{b}	74.10^{b}	72.80^{c}	70.54^{d}	0.12	***
Crude Protein	19.41^{a}	19.30^{ab}	18.41^{b}	18.20^{b}	18.75^{ab}	17.27^{b}	17.17^{b}	0.43	**
Fat	6.34^{d}	7.60^{c}	9.57^{bc}	10.83^{b}	7.96^{c}	10.14^{b}	13.47^{a}	0.07	***

^{abc}Means in the same row with common superscripts are not significantly different. SED=standard error of difference, Sig= significance, **= (P<0.01), ***= (P<0.001)

3.3. Aerobic Plate Counts (APCs) of products

The APCs of the products are presented in Fig. 1. The APCs of the control products were significantly (P<0.05) higher than the SO and EY products over the storage period. The EY products in turn had higher APCs than the SO products (Fig 1). This observation could be ascribed to the relatively higher moisture contents of the control and EY products, compared with the SO products (Table 2). Moisture creates conducive environment for microbial reproduction and survival, and therefore high moisture contents favour their activities (Lawrie and Ledward, 2006). As moisture content in food products increases, the salt concentration decreases, and water activity (a_w) increases (Colmenero, 2000). Water activity is the free water available in the product for microbial activities.

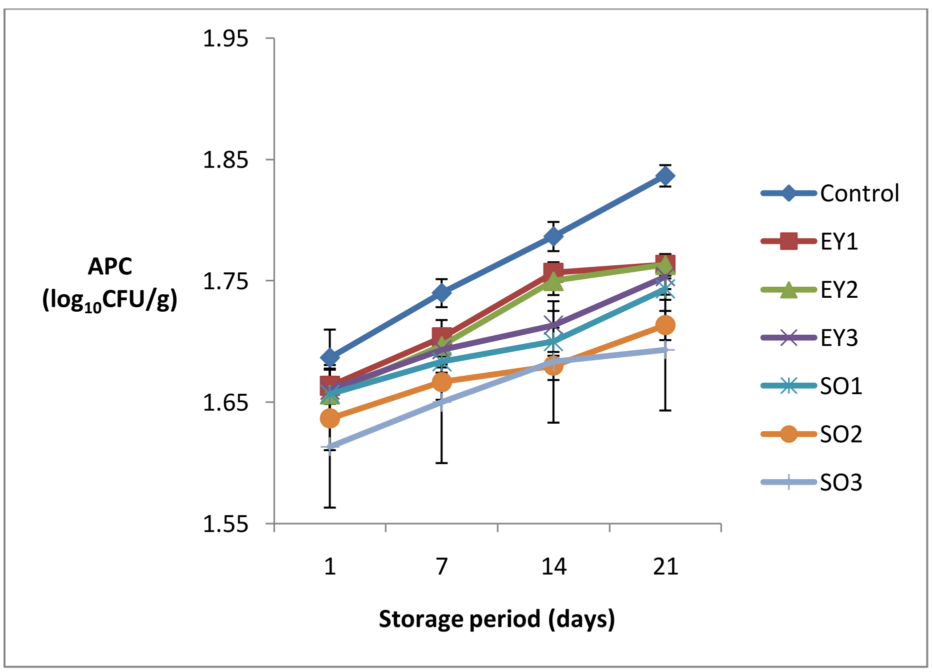

Fig. 1. Aerobic Plate Counts of products.

Papadima and Bloukas (2004) reported a high water activity with correspondingly high microbial counts during storage of traditional Greek sausages. Lower a_w (below 0.5) in a product suppresses microbial growth and development (Warriss, 2010), and might have contributed to the relatively lower microbial counts in the SO and EY products, as these had lower moisture contents.

The APCs in all the products however, were significantly lower than the maximum permissible limit of product acceptability, which is $7\log_{10}$ CFU/g product (ICMSF, 1986), an indication that the products are safe for consumption even after 21 days of storage.

3.4. Iodine value of fatty acids in the products

The iodine value, which is the degree of unsaturation of fatty acids in the products, is presented in Fig. 2. The iodine value of the fats was higher (P<0.001) in the SO and EY products than in the control products. The SO products in turn had higher IVs than the EY products. The higher the iodine value of a product, the higher the unsaturated fatty acids present in the fats (Padmanaban and Sarkar, 2010). This observation is as expected because vegetable oils and egg yolk are reported to have higher levels of unsaturated fatty acids than beef fat (Liu *et al.,* 1991; Paneras and Bloukas, 1994; Layman and Rodriguez, 2009), and hence their higher iodine values than the control products.

Having meat products with higher levels of unsaturated fatty acids is good news to the consumer, because excessive intake of dietary saturated fatty acids has been associated with the development of hypertension, cardio-vascular diseases and obesity (Bruhn *et al.,* 1992). These fats are high in cholesterol which are deposited in veins and arteries, and consequently hinder the flow of blood through them (Hongbao, 2006). A diet containing fats of the unsaturated fatty acids on the other hand, has been shown to be beneficial in the prevention of atherosclerosis and coronary heart diseases (Wolfram, 2003 and Russo, 2009). Long-term diets containing monounsaturated fatty acids have been shown to reduce platelet aggregation and decrease plasma LDL-cholesterol levels (Smith *et al.*, 2003).

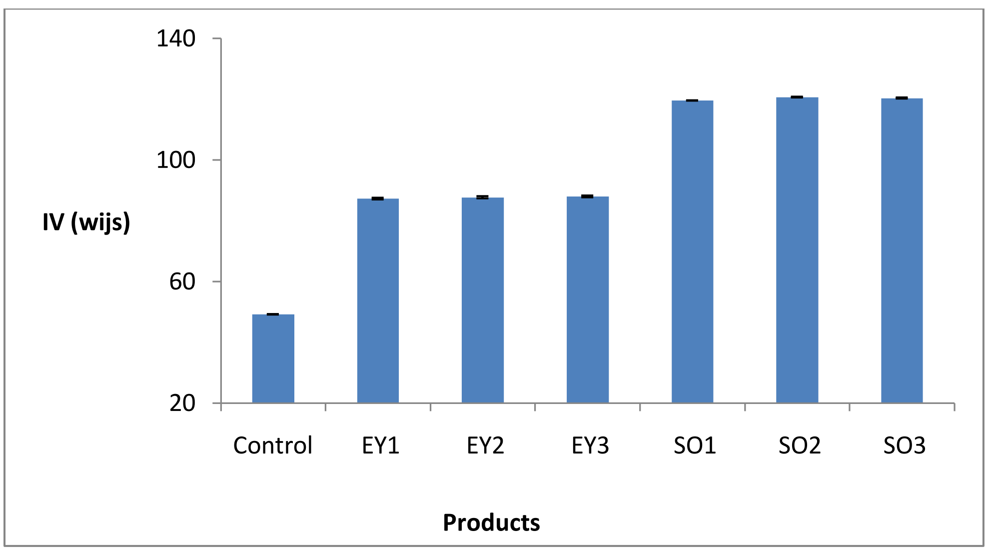

Fig. 2. Iodine value of fatty acids in products.

3.5. Per-oxide value (POV) of products

The POVs of the products were determined on days 7, 14 and 21 of storage to determine their storability in terms of lipid per-oxidation. The results are presented in Fig. 3.

The POVs of the SO and EY products were significantly (P<0.05) higher than the control products, but the levels observed in this study were significantly (P<0.001) lower than 25 millequivalent/kg product, which is considered as the limit of acceptability in food products (Evranuz, 1993; Narasimhan *et al.,* 1986). Several authors reported higher lipid per-oxidation in meat products formulated with vegetable oils (Choi *et al.,* 2010).

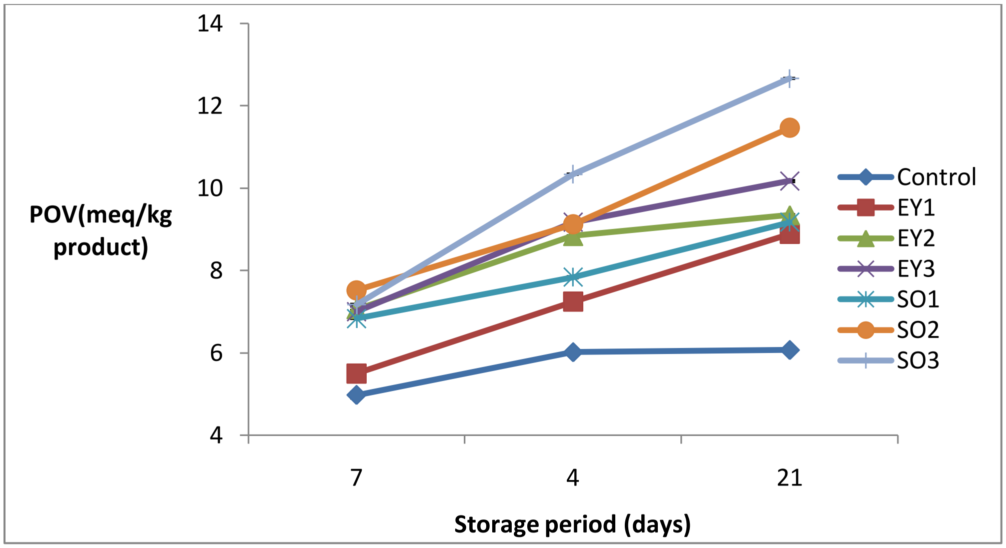

Fig. 3. Peroxide values of products in storage.

It was expected that the addition of less-saturated fatty acids to the products would result in rapid lipid per-oxidation, because Warriss (2010), reported that lipid per-oxidation progresses at faster rates in fats rich in unsaturated fatty acids, than those high in saturated fatty acids. The unsaturated and polyunsaturated fatty acids present in these, react with oxygen to form fatty acid hydro-peroxides. Hydro-peroxides are unstable, and breakdown into various compounds which can produce off-flavours; leading to a stale, rancid flavour in foods (Kerler and Grosch, 1996). Rodriguez-Carpena (2012), however reported that vegetable fats contain natural anti-oxidant called α-tocopherol, which inhibits lipid per-oxidation. This might have resulted in the per-oxide values of the SO products being significantly lower than the maximum permissible limit although the SO products had significantly higher iodine values than the EY and control products.

4. Conclusion

Soya oil, up to 15% inclusions, improved texture, juiciness and general acceptability of beef sausages. Egg yolk on the other hand improved texture and juiciness, but had reduced flavour intensity and acceptability of the products. The SO and EY improved the level of unsaturated fatty acids, but had no adverse effect on storability of products, indicating that the use of EY and SO would not compromise the storability of beef sausages. SO products were highly preferred to EY products and therefore, the use of soya oil up to 15% in beef sausages is recommended for improved marketability of beef products.

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