

# The Potential of Sunflower Oil as Fat Replacer in Beef Sausages

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**Abstract.** This study was conducted to assess the proximate and sensory characteristics of beef sausages prepared with sunflower oil as fat replacer. The sausages were prepared using 7.5kg of minced beef divided into five batches of 1.5kg each. Each batch was spiced with mixed spices. Sunflower oil was included at 0%, 5%, 10%, 15%, and 20% to represent T0, T1, T2, T3 and T4 respectively. They were stuffed into natural casing, smoked for about 15 minutes at temperature of 105°C. Sausages were allowed to cool and then vacuum sealed in transparent polythene bags and refrigerated at -2°C for sensory and proximate analysis. Nine-point category scale was used for the sensory evaluation while the proximate analysis was conducted following methods of Association of Official Analytical Chemists (AOAC, 2000). The sensory data were analysed using Kruskal-wallis test whereas proximate data were analysed using Analysis of Variance (ANOVA) of GENSTAT version 12. Differences among treatments means were separated by Tukey pairwise comparison test at 5% level of significance. The result from texture indicate significant differences (<0.05) among treatment means, Significant differences existed between T0 and T4, but not between T1, T2 and T3. However, except for texture, there was no significant difference among the treatments for all the other parameters (colour, flavour intensity, flavour liking, juiciness and overall acceptability) measured. There were significant differences (P<0.05) for all the proximate parameters measured which were, moisture, fat, ash and protein. Although, the proximate composition of the products was affected as a result of the incorporation of sunflower oil, the changes did not cause any detrimental effect on the sensory characteristics and nutritional qualities of the products.  
**Keywords:** beef, proximate, sausage, sensory.

## 1 Introduction

Animal muscle tissue that is eaten is called meat [1]. It is crucial to people's general well-being and way of life, and it has a great influence on their eating patterns [2]. According to cultural and religious beliefs, as well as considerations like convenience and availability, domestic animals are the source of meat. Meat contains high biological value fats, vitamins, protein, and minerals [3]. [4], describes meat processing as the procedure that involves the

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addition of ingredients to meat to create specific products through the transformation of fresh meat using mechanical methods.

Meat processing results in the prolongation of shelf life, improvement of taste of meat and the creation of added value [5]. People frequently find themselves spending more time away from home for work as they prioritise improving their lifestyles, which leaves less time for cooking [6]. These challenges highlight the necessity of creating ready-to-eat or handy meat products in order to satisfy consumer desires. Sausages are a widely enjoyed and popular processed meat product, typically made with boneless meat, fat, water, spices, and sometimes additives and preservatives, all stuffed into casings.

While animal fats are traditional and provide desirable sensory properties, their high content of saturated fatty acids is a growing health concern. Therefore, there is a need to explore alternative lipid sources with improved fatty acid profiles that can mimic the functional and sensory roles of animal fat in sausages. According to [7], sunflower oil is a good source of vitamin E and polyunsaturated fatty acids such as, omega-6 fatty acids, linolenic acids and many more. Furthermore, antioxidants like beta-carotene and selenium, which can help guard against oxidative stress and cell damage, are abundant in sunflower oil [8]. However there is limited information on the potential of sunflower oil as fat replacer in beef sausages. It will therefore be prudent to test its potential as a fat replacer in beef sausages.

According to research, sunflower oil possesses anti-inflammatory qualities that may help lessen the chance of developing chronic illnesses like cancer and heart disease [7]. The aim of the study was to determine the nutritional qualities and sensory characteristics of beef sausages prepared with sunflower oil as fat replacer.

The specific objectives of the study were to determine the;

1. Sensory characteristics of the sausages.
2. Cooking yield of the sausages
3. Proximate composition of the sausages
4. The pH of the sausages

## **2 Materials and methods**

### **2.1 Study area**

The product formulation was carried out at the Meat Processing Unit of University for Development Studies (UDS), Nyanpkala campus and proximate analysis of the samples were carried out at the Savanna Agricultural Research Institute (SARI).

### **2.2 Experimental design**

Sunflower oil was assigned to minced beef in a completely randomized design. Sunflower oil was added at 0, 5, 10, 15 and 20% per kilogram of beef for each treatment. All treatments were triplicated. Sunflower oil was added in order to assess the nutritional value and sensory attributes of beef sausages.

### **2.3 Sausage formulation**

On a kilogram basis sunflower oil was included at 0%, 5%, 10%, 15% and 20% per kg beef. To every treatment, the same amount of ice cubes and spices were added.

**Table 1.** Composition of Sausage

<b>Ingredients (Spices)</b>	<b>Quantity (g)/kg meat</b>
Black pepper	2
White pepper	2
Salt	15
“Adobo”	2
Phosphate	5
Ice	200
Chilli pepper	0.5

## 2.4 Sausage preparation

Six kilograms (6kg) of boneless beef were acquired from the UDS Meats Unit. The beef was trimmed of any visible fat and connective tissues, and then it was minced using a meat mincer (Talleres Ramon, Spain) through a 3 mm sieve plate.

A three-knife, 30-liter bowl chopper (Talleres Ramon, Spain) was used to thoroughly comminute the minced beef and spices. To maintain the temperature of the meat batter during comminution, crushed ice cubes were added. The process of comminution was continued until a desired consistency was obtained. After comminution, the meat batter was placed inside a hydraulic stuffer (Talleres Ramon, Spain) and stuffed into casings. It was manually linked to a length of about 8 cm. After that, the sausages were smoked for 15 minutes, until they reached a core temperature of 70°C. It was then cooled in cold water and hanged to dry. Before being subjected to sensory and laboratory analysis, the products were labelled, placed into transparent polythene bags, and vacuum sealed using an electronic vacuum sealer (Busch Ramon, Spain). They were then kept in a freezer at a temperature of -2 degrees Celsius [4]

## 2.5 Sensory analysis

After being removed from the freezer, the samples were thawed for two hours. After being thawed, samples were warmed at temperature of 70°C for fifteen minutes; they were cut into about 2 cm<sup>3</sup> pieces, wrapped in aluminum foil to keep them warm, and placed into coded containers for sensory analysis.

British Standard Institution (BSI, 1993) rules were followed in the training of the panelists. In a well-lit room, panelists used nine-point hedonic scale to assess the products. A total of twenty-five (25) trained panelists were used for the assessment of the products.

## 2.6 Proximate analysis

The proximate composition of the products was determined following the methods of Association of Official and Analytical Chemists (AOAC 2000). The following proximate parameters were determined: crude protein, crude fat, moisture and ash. The pH of the products was also determined.

## **2.7 Cooking loss of the beef sausages**

Following product formulation, the weight of three fingers from each treatment was measured and recorded. The samples were grilled for around 45 minutes at 105°C in an electric oven.

Cooking loss was estimated using the formula:

$$\text{Cooking loss} = \frac{\text{fresh sample weight} - \text{cooked sample weight}}{\text{fresh sample weight}} \times 100$$

## **2.8 Data analysis**

The sensory data were analysed using Kruskal Wallis Test of GENSTAT while the proximate data were analysed using One Way Analysis of Variance (ANOVA) of GENSTAT Version 16. Where significant differences were found, means were separated using Tukey pairwise comparison.

## **3 Results and discussion**

### **3.1 Sensory characteristics of the sausages**

Table 2 shows the findings about the consumer's choice for beef sausages prepared using sunflower oil. For texture, there was a significant difference (<0.05) between treatment means. Significant differences existed between T0 and T4, but not between T1, T2 and T3. However, except from texture, there was no significant difference (P>0.05) among the treatments for all other parameters measured.

**Table 2.** Sensory characteristics of beef sausages

Parameters	T0	T1	T2	T3	T4	S. E. D	P-value
Colour	5.100	4.700	4.950	4.850	5.450	1.202	0.333
Texture	4.250 <sup>a</sup>	4.350 <sup>ab</sup>	4.950 <sup>ab</sup>	5.100 <sup>ab</sup>	5.750 <sup>b</sup>	1.677	0.019
Juiciness	4.700	5.350	5.600	5.100	4.750	1.592	0.372
Flavour intensity	5.600	6.150	5.950	5.650	5.650	1.295	0.624
Flavour liking	5.600	5.950	6.050	6.200	6.150	1.389	0.803
Overall acceptability	6.250	5.750	6.500	6.300	6.400	1.357	0.640

Note: <sup>abc</sup>=Means on the same row with the different superscript are significantly different ( $p < 0.01$ ), S. E. D= Standard Error of Difference

There were no marked differences observed among treatments for colour. The addition of sunflower oil did not significantly change the colour of the sausages. This is consistent with the findings of [9], who stated that oil from plants does not usually affect the colour of meat, except when used in large amounts or in conjunction with colour additives. Improvement in texture was noted with increased levels of sunflower. As seen in table 3, treatment T4 had the best texture and this was due to the sunflower oil’s lubricating effects and fat globule modification. Also, the differences in juiciness were not statistically significant, although some treatments had higher scores. This indicates that the addition of sunflower oil did not markedly affect the juiciness of the products.

The flavour intensity was not affected by sunflower oil incorporation. Due to its mild flavour, sunflower oil did not adversely affect taste, as evidenced by the similar ratings given to all treatments. The addition of sunflower oil to sausage recipes, especially in larger amounts, can make the texture better without changing the taste, smell, or overall acceptability of the sausage.

### 3.2 Proximate composition of the beef sausages

The beef sausages had moisture content between 64.49% and 75.24%. Comparing T1 and T2 to T0 and T4, T1 and T2 had a lot more moisture ( $P < 0.05$ ). The addition of sunflower oil may have changed the product's ability to hold water, which could explain the increase in moisture retention. Oil emulsification often helps meat products hold onto water better by stabilising the interactions between water, fat, and protein.

**Table 3.** Proximate composition of the beef sausages

Parameters	T0	T1	T2	T3	T4	S.E.D	P-value
Moisture	65.04 <sup>c</sup>	75.24 <sup>a</sup>	73.19 <sup>a</sup>	68.31 <sup>b</sup>	64.49 <sup>c</sup>	0.714	<0.001
Fat	12.57 <sup>a</sup>	7.127 <sup>b</sup>	7.52 <sup>b</sup>	11.77 <sup>a</sup>	12.81 <sup>a</sup>	0.809	0.002
Ash	3.710 <sup>b</sup>	4.440 <sup>b</sup>	3.795 <sup>b</sup>	5.545 <sup>a</sup>	3.626 <sup>b</sup>	0.246	0.002
Protein	10.42 <sup>c</sup>	12.15 <sup>c</sup>	18.01 <sup>b</sup>	29.21 <sup>a</sup>	9.83 <sup>c</sup>	1.098	<0.001

Note: <sup>abc</sup>=Means on the same row with different superscripts are significantly different ( $p < 0.01$ ), S.E.D= Standard Error of Difference.

Sunflower oil is a liquid oil that is high in unsaturated fatty acids. It may make stable emulsions that hold moisture better than solid fats. The fat content was between 7.13% and 12.81%. T1 and T2 had a lot less fat than the control (T0), T3, and T4. [10] reported that replacing pork back fat with vegetable oils like sunflower oil lowers the total fat content because oil is less dense and binds differently than solid fat. Also, using plant oils may help make lipid profiles healthier, which is in line with what customers want in low-fat or healthier meat products.

The range of the ash content, which represents the total mineral content, was 3.63% to 5.55%. Compared to all other treatments, T3 had a noticeably higher ash content. This might have to do with the particular formulation or ingredient interaction in T3, perhaps as a result of additional seasoning ingredients, binders, or extenders that contributed more minerals.

The kind and number of additives or substitutes used in meat formulations have an impact on the amount of ash. Depending on their natural mineral makeup, vegetable-based ingredients or modified formulations can affect the amount of ash [11]. Better nutritional quality in terms of essential minerals may also be indicated by a higher ash level.

Protein content ranged from 9.83% (T4) to 29.21% (T3), with significant variation across treatments. The highest protein values were found in T3 and T2, which were noticeably higher than those in T0, T1, and T4. This implies that either by incorporating protein-rich ingredients or by reducing the dilution of fat and moisture, the formulation in T3 and T2 may have a higher protein concentration.

Improved protein concentration as fat content drops is the reason for high protein levels in sunflower oil treatments [6]. Furthermore, it has been shown that substituting oils for saturated fats improves protein gel formation and binding, strengthening the meat matrix's structural integrity [12].

**Table 4.** Cooking loss of the sausages

Parameter	T0	T1	T2	T3	T4	S.E.D	P-Value
<b>Cooking loss</b>	28.150	26.350	28.451	28.540	28.60	1.553	0.056

### 3.3 Cooking loss of the beef sausages

The cooking loss result is presented in Table 4. It indicates no significant differences ( $P > 0.05$ ) among the treatment means, despite slight numerical variations between the control (T0) and the sunflower oil-substituted treatments (T1–T4). Cooking loss in meat products generally reflects the combined loss of water and fat during heat treatment and is influenced by factors such as fat type, the water-binding capacity of the protein matrix, and processing conditions [15]. Beef fat, being rich in saturated fatty acids, is solid at room temperature and

contributes to the formation of a stable fat–protein network during heating. This structural matrix assists in trapping water and fat within the sausage, thus potentially reducing cooking loss [15]. In contrast, sunflower oil is predominantly composed of unsaturated fatty acids, mainly linoleic acid, and remains liquid at room temperature. The liquid nature of sunflower oil could make it more prone to migration during cooking, which may theoretically increase cooking loss. However, in the present study, the lack of significant differences suggests that the processing and formulation methods particularly effective emulsification were sufficient to stabilize sunflower oil within the meat matrix. Previous studies have reported that properly emulsified vegetable oils, including sunflower oil, can replicate the binding properties of animal fats, maintaining gel strength, water fat binding capacity, and cooking yield in emulsified meat products [8].

### 3.4 pH of the beef sausages

Table 5 below shows the pH of beef sausages prepared with and without sunflower oil. There was a significant difference ( $P < 0.05$ ) between T0 and T4 but not T1, T2, and T3. The role of low pH in meat and meats products is its effect on inhibition of bacterial growth and development. Lower pH of meats products creates an acidic medium making it inappropriate for bacterial growth and reproduction.

**Table 5.** pH of the beef sausages prepared with and without sunflower oil

Parameter	T0	T1	T2	T3	T4	S.E.D	P-value
pH	5.6250 <sup>bc</sup>	5.7100 <sup>b</sup>	5.5400 <sup>c</sup>	5.5750 <sup>c</sup>	5.9750 <sup>a</sup>	0.2665	<0.001

Note: <sup>abc</sup>=Means on the same row with different superscripts are significantly different ( $p < 0.001$ ). S.E.D= Standard Error of Difference

## 4 Conclusion

The present study explored the use of sunflower oil as a fat replacer in beef sausage formulation and evaluated its effects on sensory characteristics, cooking loss, proximate composition, pH, and cost of production. The findings revealed that incorporating sunflower oil at varying levels influenced the quality attributes of the sausages to different extents. Texture was significantly improved at higher sunflower oil inclusion levels, particularly at 20%, without negatively affecting juiciness, flavour, or overall acceptability, indicating that consumers found these products equally desirable. The proximate analysis showed that sunflower oil inclusion affected moisture, fat, ash, and protein content significantly. Specifically, oil incorporation led to increased moisture retention and decreased fat content at certain levels, with the highest protein content observed in the 15% sunflower oil treatment. Additionally, the pH values varied significantly, with higher oil levels leading to slight increase in pH. Overall, the use of sunflower oil in beef sausage production offers potential nutritional and sensory benefits. It can be used effectively to enhance the nutritional profile of sausages without compromising consumer acceptability.

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