

## Original Research Article

# Effect of selected oils on antioxidant and physicochemical properties of breakfast sausage

### ABSTRACT

**Aims:** The process of degradation converts fatty acid esters of oils into free fatty acids, by reaction with air, moisture and/or other materials. The main cause of rancidity of lipids is the oxidative deterioration of unsaturated fatty acids through a free-radical chain mechanism called lipid peroxidation. The aim of this study seek to evaluate the effect of selected oils on antioxidant and physicochemical properties of breakfast sausage.

**Methodology:** Breakfast sausage was prepared (g/100g: beef 65.0, corn flour 10.0, oil 10.0, others 13.0). Lard, was replaced with shea butter, olive oil or groundnut oil in a completely randomized design. Prepared sausages were subjected to iodine values, acid values, saponification values and physicochemical evaluation. Data were analysed using descriptive statistics and ANOVA at  $\alpha_{0.05}$ .

**Results:** The iodine value was higher in olive oil-based sausages and lowest in lard-based sausages. The acid value was significantly higher in lard-based sausages, having the highest acid value of (17.21) with least value in no oil-based sausage (8.63 Mgmg/KOH/g of oil). The saponification values were higher in the groundnut oil-based breakfast sausages (271.38 mg/KOH/g of oil) while the least saponification value was recorded in treatment A (126.23 Mgmg/KOH/g of oil). —Groundnut oil-based breakfast sausages had the highest dimensional shrinkage of 18.52%, while olive oil-based breakfast sausages had the least dimensional shrinkage of 8.53%. Breakfast sausages prepared with groundnut oil had the highest cooking loss of 33.22% while the breakfast sausages prepared with olive oil had the lowest cooking loss of 15.69%. The result obtained from this study shows that no oil-based sausages had the highest pH (6.26) while olive oil based sausage had the lowest pH (6.09).

**Conclusion:** Lard can be replaced in breakfast sausages with olive oil due to its high antioxidant and physicochemical properties.

**Keywords:** Lard, olive oil, shea butter, groundnut oil, antioxidant properties

### 1. INTRODUCTION

Consumers' perception of processed meat products are critical issues for the meat industry [1]. In recent years, consumers are increasingly conscious about healthy diet. However, most of the processed meat products contained high amounts of fat, which are related to chronic diseases such as obesity and cardiovascular heart diseases. Health organizations

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20 had suggested that intake of total dietary fat should be reduced, particularly saturated fatty  
21 acids and cholesterol, in order to prevent cardiovascular heart disease and other related  
22 diseases. Consumers now desired d for low or reduced animal fat products with high  
23 palatability and nutritional quality [2].

24 ~~Therefore,~~ demand for healthier meat and meat products with reduced levels of salt, fat and  
25 improved fatty acid profile has increased globally. Breakfast sausage containing less salt  
26 and animal fat ~~can helps~~ in reducing human dietary salt and cholesterol intake, thereby  
27 promoting health and wellness [3].

29 ~~According to [4] who stated that,~~ the economic development, quality of life, improvement and  
30 increasing concern about the health of modern life, the palatability and functionality of food  
31 are receiving attention as well as the ability to sustain life, and meat and meat products are  
32 becoming to the high-quality livestock product with intake convenience and a lot of functional  
33 materials in addition to the existing images of common protein foods [5]. In order to produce  
34 meat products with the functionality and safety, ~~it is realized that~~ the needs for the  
35 environment-friendly natural preservatives and food additives with superior cell function  
36 regulating effect [6,7] are important. The reduction or replacement of animal fat in meat  
37 products could be accomplished by changing the formulation by using plant-based oils i.e.  
38 using olive oils, groundnut oils and shea butter to replace lard.

40 The aim of this study therefore seek to evaluate the effect of selected oils on antioxidant and  
41 physicochemical properties of breakfast sausages.

43

## 44 2. MATERIALS AND METHODS

45

### 46 2.1 Meat ~~Source-source~~ and sausage preparation

47 Semi-membranous muscle from mature bull was purchased from the Jos abattoir. The meat

48 was cleaned; connective tissue and fats were trimmed to produce lean meat. The meat was

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49 kept in the refrigerator at  $4 \pm 1^{\circ}\text{C}$ , in order to reduce the microbial load, and for safety  
 50 purposes. Meat and fats were prepared separately through an automated meat mincer. The  
 51 meat was prepared through 6 mm plate and the fat through 4 mm plate. Then the rest of  
 52 the meat and the other ingredients were then thoroughly mixed and re-grand through a 4  
 53 mm plate as showed in table Tables 1, 2 and 3 to 3. The prepared sausages was  
 54 were stuffed into presoaked natural casing (pig intestine) that was presoaked in brine using  
 55 an automated stuffer. Sausage was subjected to grilling at  $80^{\circ}\text{C}$  until internal temperature of  
 56  $72^{\circ}\text{C}$  was reached to get the exact cooking time.

57 **Table 1:** The composition of sausages [1]. Sausage composition.  
 58

Ingredients (%)	A	B	C	D	E
Beef	65.00	65.00	65.00	65.00	65.00
Lard	10.00	—	—	—	—
Shear butter	—	10.00	—	—	—
Olive oil	—	—	10.00	—	—
Groundnut oil	—	—	—	10.00	—
Corn flour	10.00	10.00	10.00	10.00	10.00
Curing salt	2.00	2.00	2.00	2.00	2.00
Sugar	1.00	1.00	1.00	1.00	1.00
Binder (soya bean)	3.50	3.50	3.50	3.50	3.50
Phosphate	0.30	0.30	0.30	0.30	0.30
Ice water	4.00	4.00	4.00	4.00	4.00
Dry spices	2.00	2.00	2.00	2.00	2.00
Green spices	2.20	2.20	2.20	2.20	2.20
Total	100.00	100.00	100.00	100.00	100.00

59 **Table 2:** Composition of dry spices for breakfast sausages [1].  
 60  
 61

Spice	Inclusion level %
Black pepper	20.00
Nutmeg	7.00
Calabash nutmeg	3.00
Red pepper	20.00
Monosodium glutamate	15.00
Thyme	20.00
Curry powder	10.00
Total	100.00

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63 **Table 3:** Composition of green spices for breakfast sausage [1].

Spices	inclusion level %
Onion ( <i>Allium cepa</i> )	60
Ginger ( <i>Zingiber officinale</i> )	20
Garlic ( <i>Allium sativum</i> )	20
Total	100

64 **Source:** [1]

## 65 2.2 Determination of iodine values

66 The iodine value of a substance is the weight of halogens expressed as iodine absorbed by  
67 100 parts by weight of the substance. It was determined for each treatment sample by  
68 measuring 1\_g of the sample (m) into a 250\_mL conical flask. About 15\_mL of chloroform was  
69 added and 25\_mL of iodine-iodine bromide was poured gently into the flask. The content in  
70 the flask was shaken and covered then left in a dark cupboard for 30 mins. About 10 ml-mL  
71 of a 100 g/L solution of potassium iodide was added after 30 mins and titrated with 0.1M  
72 sodium thiosulphate, shaking vigorously until the yellow colour is almost discharged.  
73 Further, 5 ml-mL of starch solution was added and then titration continued till the purple  
74 black colour from starch addition is completely discharged ( $n_1$ ). A blank test was also carried  
75 out under the same condition ( $n_2$ ) and the iodine value was calculated using:using the  
76 following formula.

$$IV = \frac{1.269 (n_2 - n_1)}{m}$$

## 80 2.3 Determination of Acid-acid Valuesvalues

81 The acid value (AV) is the number that expresses, in milligrams the quantity of potassium  
82 hydroxide required to neutralise the free acids present in 1\_g of the substance. The acid  
83 value is often a good measure of the breakdown of the triacylglycerol into free fatty acids,

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84 which has an adverse effect on the quality of many lipids. About 5 g (w) of the samples were  
85 weighed into conical flask that is well labelled. Approximately 25 mL of equal volumes of  
86 ethanol and petroleum ether were poured into each conical flasks. One mL-milliliters of  
87 phenolphthalein was added and titrated with 0.1 M of Potassium potassium hydroxide until a  
88 stable pink colour (for 15 secs) was attained. The acid value was calculated by:— using the  
89 following formula.

90 Acid value=  $(5.6) \frac{n}{w}$

**Comment [SaA3]:** Please include a reference for the formula!

## 91 2.4 Determination of Saponification saponification Value value

92 About 2 mL of the oil sample was added to 20 mL of Ethanolic potassium hydroxide in  
93 500 mL-mL round bottom flask. The flask with its content was refluxed for 30 minutes.  
94 Further, 2 mL of phenolphthalein indicator was added and the hot solution was allowed to  
95 cool and later titrated against 0.5 M hydrochloric acid.

### 96 Procedure

- 97 1. Approximately 2 g of the fat or oil was weighed into a 250 mL conical flask.
- 98 2. 25 mL of alcoholic potassium hydroxide solution ( 0.5 N) was added .
- 99 3. A reflux condenser was attached and heated with the flask contents on a boiling  
100 water bath for 1 hour with occasional shaking.
- 101 4. 3 drops of phenolphthalein indicator was added to the hot solution. Excess  
102 potassium hydroxide was titrated with the 0.5 N hydrochloric acid (V mL of  
103 hydrochloric acid at end point represents S).
- 104 5. The above procedure but without sample was done for blank ( V mL of  
105 hydrochloric acid at end point represents B).
- 106 6. Saponification value was calculated using the formula below:

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107 Saponification value:  $\frac{56.1 (B - S) \times N \text{ of HCl}}{\text{Gram of sample used}}$   
108

109 Where: B: mL of HCl required by Blank, S: mL of HCl required by Sample

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## 110 | 2.5 Cooking ~~Loss-loss~~

111 | Cooking loss was determined according to the procedure described by [8].

## 112 | 2.6 pH

113 | The pH was determined by using a digital pH meter model PHS- 25 Microfield instrument  
114 | England according to the method described by [9]. The pH value of cooked sausage  
115 | samples was determined by weighing 10 grams of sample into a blender with 90 ml mL of  
116 | distilled water and homogenised until smooth slurry was formed. The digital pH meter was  
117 | placed in a buffer solution in order to allow equilibrium for two minute before placing it into  
118 | prepared slurry. An average of three readings taken gave the pH value.

119 |

## 120 | 2.7 Statistical ~~Analysis-analysis~~

121 | Data were subjected to analysis of variance using [10]. Means were separated using  
122 | Duncan's Multiple Range Test option of the same software.

**Comment [SaA6]:** Please state the statistical analysis insterad of the reference!

123 |

124 |

## 125 | 3. ~~\_\_\_~~ RESULTS AND DISCUSSION

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### 127 | 3.1 ~~Effect of selected oils on o~~Oxidative properties of breakfast sausages

128 | The iodine value was higher in olive oil-based sausages while the value in lard-based  
129 | sausages ~~is was~~ the least. ~~The iodine value is a measure of the relative degree of~~  
130 | ~~unsaturation in oils as determined by the uptake of appropriate halogen compounds.~~

**Comment [SaA7]:** Repetition!

131 | Because melting point and oxidative stability are related to the degree of unsaturation, iodine  
132 | value provides an estimation of these quality factors. The greater the iodine value, the more  
133 | the unsaturation and the higher the susceptibility to oxidation. In Table 4, it was observed  
134 | that there were significant differences in the iodine value of sausages made with different oil  
135 | types. Olive oil based sausages ~~was were~~ significantly different in iodine value when  
136 | compared with other treatments. This could be due to higher levels of unsaturated fatty  
137 | acids present in olive oil compared to others.

**Comment [SaA8]:** Quality factors such as?

138 The acid value indicates the amount of carboxylic acid group in a chemical compound such  
 139 as fatty acid or in a mixture of compounds. The higher the acid value, the higher the rancidity  
 140 level because as oil and fat become rancid; triglyceride are converted into fatty and glycerol.  
 141 The acid value of the five treatments were statistically significant from each other, with  
 142 treatment A, having the highest acid value of (17.28 Mgmg/KOH/g of oil), treatment B (15.03  
 143 Mgmg/KOH/g of oil), C (11.78 Mgmg/KOH/g of oil) and E (8.63 Mgmg/KOH/g of oil) had the  
 144 lowest acid value. Lard based sausages had the highest acid value of 17.28 Mgmg/KOH/g of  
 145 oil, with least value in no oil based sausage (8.63 Mgmg/KOH/g of oil). This could be due to  
 146 the higher amount of saturation of oil in lard.

147 The saponification values were statistically significant from each other. Treatment D had the  
 148 highest saponification value (271.38 mg/KOH/g of oil) while the least saponification value  
 149 was in treatment A (126.23 Mgmg/KOH/g of oil). Treatments B, C and E had saponification  
 150 values of 231.41, 198.45 and 176.72 Mgmg/KOH/g of oil, respectively. It was also observed  
 151 that the saponification value of the selected oils used for breakfast sausages were  
 152 statistically different from each other. Olive oil had the highest saponification value (271.38  
 153 Mgmg/KOH/g of oil) while lard based sausages had the lowest saponification value (126.23  
 154 Mgmg/KOH/g of oil). This could be due to the higher unsaturated fatty acids present in olive  
 155 oil compared to other oils.

157 **Table 4:** Effect of selected oils on oxidative properties of breakfast sausage.  
 158

PARAMETER	A	B	C	D	E	
Iodine value (mg iodine/100g of oil)	0.95 <sup>d</sup>	0.32 <sup>e</sup>	7.93 <sup>a</sup>	7.30 <sup>c</sup>	7.62 <sup>b</sup>	
Acid value (mg/KOH/g of oil)	23.23 <sup>a</sup>	15.03 <sup>c</sup>	11.78 <sup>d</sup>	17.28 <sup>b</sup>	8.63 <sup>e</sup>	1.33
Saponification value (mg/KOH/g of oil)	126.23 <sup>e</sup>	231.41 <sup>b</sup>	198.45 <sup>c</sup>	271.38 <sup>a</sup>	176.72 <sup>d</sup>	13.13

159 <sup>abc</sup> Means on the same row with different superscripts are significantly different (p<0.05)  
 160 A= Sausage with lard, B=Sausage with shea butter, C= Sausage with olive oil, D= Sausage with  
 161 groundnut oil, E= Sausage with no oil.  
 162 SEM= Standard Error mean

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Comment [SaA9]: You just describe your results. No further justification and elaboration. Include results from other studies too. You may compare their studies to support your data!

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164 **3.2 Effect of selected oils on physicochemical properties of breakfast**  
165 **sausages**

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166 Breakfast sausages prepared from groundnut oil had the highest dimensional shrinkage of  
167 18.52% while breakfast sausages prepared from olive oil had the least dimensional  
168 shrinkage of 8.53%. Dimensional shrinkage is as a result of cooking process, due to the  
169 denaturation of the meat proteins with loss of water and fat. In this study, dimensional  
170 shrinkage ranges from 8.53% to 18.52% (Table 5). Olive oil based sausage had the least  
171 dimensional shrinkage which could had been due the ability of olive oil to bound properly  
172 with water to form better emulsion stability compared to other vegetable oil based sausage.  
173

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174 Breakfast sausages prepared from groundnut oil had the highest cooking loss of 33.22%  
175 while the breakfast sausages prepared from olive oil had the lowest cooking loss of 15.69%.  
176 Breakfast sausages prepared from olive oil had the highest cooking yield of 84.31% while  
177 breakfast sausages prepared from groundnut oil had the least cooking yield of 66.78%.  
178 Breakfast sausages prepared from shea butter and groundnut oil are also not significantly  
179 different in their pH value. Cooking loss measures the water binding capacity of sausage  
180 which was affected by moisture, protein and fat content as well as processing methods.  
181 Cooking loss is an important factor because it is responsible for the appearance and  
182 juiciness of meat products [11]. Cooking loss in this study ranges from 15.69% to 33.22%  
183 (Table 5). Olive oil based sausage had the least cooking loss which could be due to the high  
184 cooking yield and ability to bound with water for emulsion stability.  
185

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186 Cooking yield connote the changes in weight due to moisture loss, water absorption or fat  
187 gains/ losses during food preparation. The cooking yield of sausage depends on the cooking  
188 temperature [12] cooking time [13], the ingredients [14] and the amount of the fat in the  
189 products. The effect of selected oils on cooking yield of breakfast sausages in this study  
190 ranges from 66.78% to 84.31%. The highest value was observed in olive oil based sausage  
191

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192 which could be due to the level of reduction in cooking loss and dimensional shrinkage. This  
 193 observation was previously reported for various frankfurters [15, 16, 17] patties [18, 19] and  
 194 meatball [20] noted that reducing the animal fat content in meat products by replacement  
 195 with vegetable oil reduced cooking loss. [The study by \[16\]](#)–demonstrated that processing  
 196 yield was affected by locust bean/xanthan gum replacement. [Another study by \[21\]](#) reported  
 197 that frankfurters containing rice bran fiber had significantly lower cooking loss than samples  
 198 with no added fiber. Meat products appear to have improved water holding capacity and  
 199 emulsion stability due to added dietary fiber and vegetable oil which leads to a higher  
 200 cooking yield.

201 The pH of breakfast sausages as affected by selected vegetable oil was carried out to  
 202 determine the acidity or alkalinity. [The pH values greater than 7](#) are alkaline while pH values  
 203 less than 7 are said to be acidic. The result [obtained from this study shows](#) showed that no  
 204 oil based sausages had the highest pH (6.26) as shown in Table 5 while olive oil based  
 205 sausage had the lowest pH (6.09). This could be due to high concentration of free fatty acid  
 206 present in the oil based sausage  
 207

208 **Table 5:** Effect of selected oils on physical properties of breakfast sausages.  
 209

	A	B	C	D	E	SEM
Dimensional shrinkage%	11.34 <sup>c</sup>	10.27 <sup>d</sup>	8.53 <sup>e</sup>	18.52 <sup>a</sup>	12.92 <sup>b</sup>	0.91
Cooking loss %	20.30 <sup>c</sup>	22.95 <sup>b</sup>	15.69 <sup>e</sup>	33.22 <sup>a</sup>	15.96 <sup>d</sup>	1.71
Cooking Yield %	79.79 <sup>c</sup>	77.05 <sup>d</sup>	84.31 <sup>a</sup>	66.78 <sup>e</sup>	84.04 <sup>b</sup>	1.71
pH	6.09 <sup>c</sup>	6.13 <sup>b</sup>	6.09 <sup>c</sup>	6.11 <sup>b</sup>	6.26 <sup>a</sup>	0.02

210 <sup>abc</sup> Means on the same row with different superscripts are significantly different (p<0.05)  
 211 A= Sausage with lard, b=Sausage with shea butter, C= Sausage with olive oil, D= Sausage with  
 212 groundnut oil, E= Sausage with no oil.  
 213 SEM= Standard Error mean  
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216 **4. CONCLUSIONS**

217 It can be concluded from the study that [the Lard-lard](#) can be replaced in breakfast sausages  
218 with olive oil due to its high antioxidant and physicochemical [properties](#).

**Comment [SaA10]:** Further studies? More continuation? Please state!

219  
220 **COMPETING INTERESTS**

221 [AUTHORS HAVE DECLARED THAT NO COMPETING INTERESTS ~~EXIST~~](#).

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