

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

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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, physicochemical evaluation and oxidative rancidity. 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 with least value in no oil-based sausage. The saponification values were higher in the groundnut oil-based breakfast sausage while the least saponification value was recorded in treatment A. Groundnut oil-based breakfast sausage 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). The oxidative rancidity was higher in lard-based sausage but lower in olive oil-based sausage.

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

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 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 helps** in reducing human dietary salt and cholesterol intake, thereby
27 promoting health and wellness [3].

28 According to [4] who stated that, the economic development, quality of life, improvement and
29 increasing concern about the health of modern life, the palatability and functionality of food
30 are receiving attention as well as the ability to sustain life, and meat and meat products are
31 becoming to the high-quality livestock product with intake convenience and a lot of functional
32 materials in addition to the existing images of common protein foods [5]. **In order to produce**
33 **meat products with the functionality and safety, the needs for the environment-friendly**
34 natural preservatives and food additives with superior cell function regulating effect [6,7] are
35 important.

36 The reduction or replacement of animal fat in meat products could be accomplished by
37 changing the formulation by using plant-based oils i.e. using olive oils, groundnut oils and
38 shea butter to replace lard.

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

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42 **2. MATERIALS AND METHODS**

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44 **2.1 Meat source and sausage preparation**

45 Semi-membranous muscle from mature bull was purchased from the Jos abattoir. The meat
46 was cleaned; connective tissue and fats were trimmed to produce lean meat. The meat was

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

55 **Table 1: composition of sausages [1]**

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

56 **A= Sausage with lard, b=Sausage with shea butter, C= Sausage with olive oil, D= Sausage**
 57 **with groundnut oil, E= Sausage with no oil.**

58 **Table 2: Composition of dry spices for breakfast sausages [1]**

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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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

60 **Source: [1]**61 **2.2 Determination of iodine values**

62 The iodine value of a substance is the weight of halogens expressed as iodine absorbed by
63 100 parts by weight of the substance. It was determined for each sample by measuring 1g of
64 the sample (m) into a 250mL conical flask. About 15mL of chloroform was added and 25mL
65 of iodine bromide was poured gently into the flask. The content in the flask was shaken and
66 covered then left in a dark cupboard for 30 mins. About 10 mL of a 100 g/L solution of
67 potassium iodide was added after 30mins and titrated with 0.1M sodium thiosulphate,
68 shaking vigorously until the yellow colour is almost discharged. Further 5mL of starch
69 solution was added and then titration continued till the purple black colour from starch
70 addition is completely discharged (n_1). A blank test was also carried out under the same
71 condition (n_2) and the iodine value was calculated using the following formula.

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

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75 **2.3 Determination of acid values**

76 The acid value (AV) is the number that expresses, in milligrams the quantity of potassium
77 hydroxide required to neutralise the free acids present in 1g of the substance. The acid value
78 is often a good measure of the breakdown of the triacylglycerol into free fatty acids, which
79 has an adverse effect on the quality of many lipids. About 5g (w) of the samples were

80 weighed into conical flask that is well labelled. Approximately 25mL of equal volumes of
81 ethanol and petroleum ether were poured into each conical flasks. One milliliters of
82 phenolphthalein was added and titrated with 0.1 M of Potassium hydroxide until a stable pink
83 colour (for 15 secs) was attained. The acid value was calculated by using the following
84 formula: Acid value= $(5.6) \frac{n}{w}$

85 2.4 Determination of saponification value

86 About 2mL of the oil sample was added to 20mL of Ethanolic potassium hydroxide in 500mL
87 round bottom flask. The flask with its content was refluxed for 30 minutes. Further 2ml of
88 phenolphthalein indicator was added and the hot solution was allowed to cool and later
89 titrated against 0.5M hydrochloric acid.

90 Procedure

- 91 1. Approximately 2g of the fat or oil was weighed into a 250mL conical flask.
- 92 2. 25mL of alcoholic potassium hydroxide solution (0.5 N) was added .
- 93 3. A reflux condenser was attached and heated with the flask contents on a boiling
94 water bath for 1 hour with occasional shaking.
- 95 4. 3 drops of phenolphthalein indicator was added to the hot solution. Excess
96 potassium hydroxide was titrated with the 0.5 N hydrochloric acid (VmL of
97 hydrochloric acid at end point represents S).
- 98 5. The above procedure but without sample was done for blank (VmL of hydrochloric
99 acid at end point represents B).
- 100 6. Saponification value was calculated using the formula below:

101

102 Saponification value: $\frac{56.1 (B - S) \times N \text{ of HCl}}{\text{Gram of sample used}}$
103

104 Where:

105 B: mL of HCl required by Blank.

106 S: mL of HCl required by Sample

107 **2.5 Cooking loss**

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

109 **2.6 pH**

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

117 **2.7 Analysis of oxidative rancidity**

118 Thiobarbituric acid value (TBA) was estimated by modified methods of [22]. It measures the
119 lipid peroxidation or rancidity. Three mls each of glacial acid and 1% TBA solution were
120 added to test tubes appropriately labelled blank and tests. 0.6ml of distilled water was added
121 to the blank, while 0.6ml of the homogenised sample was added to each of the tests tubes.
122 These were thoroughly mixed, incubated in a boiling water bath for 15 minutes, then allowed
123 to cool, after which they were centrifuged and their supernatants collected. The supernatant
124 from the blank was used to zero the spectrophotometer (preset at 532nm) before reading the
125 absorbance of the supernatant from the test solutions.

126 The amount of TBARS was expressed as milligrams of malondialdehyde per gram of
127 sample.

$$128 \quad \text{TBA} = \frac{\text{O.D} \times \text{V} \times 1000}{\text{A} \times \text{v} \times \text{I} \times \text{Y}}$$

131 **Where:**

132 O.D = Absorbance of test at 532nm.

133 $V =$ Total volume of the reaction mixture = 6.6mL
134 $A =$ Molar extinction coefficient of the product, and according Buege and Aust (1978) is equal
135 to 1.56×10^5
136 $l =$ Length of light path =1cm.
137 $Y =$ mg of tissue in the volume of the sample used.
138 $v =$ volume of tissue extract used =0.6ml

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140 **2.8 Statistical analysis**

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

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144 **3. RESULTS AND DISCUSSION**

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146 **3.1 Oxidative properties of breakfast sausage**

147 The iodine value was higher in olive oil-based sausage while the value in lard-based
148 sausage was the least. Because melting point and oxidative stability are related to the
149 degree of unsaturation, iodine value provides an estimation of these quality factors. The
150 greater the iodine value, the more the unsaturation and the higher the susceptibility to
151 oxidation. In Table 4, it was observed that there were significant differences in the iodine
152 value of **sausages** made with different oil types. Olive oil based sausages **were** significantly
153 different in iodine value when compared with other treatments. This could be due to higher
154 levels of unsaturated fatty acids present in olive oil compared to others.

155 The acid value indicates the amount of carboxylic acid group in a chemical compound such
156 as fatty acid or in a mixture of compounds. The higher the acid value, the higher the rancidity
157 level because as oil and fat become rancid; triglyceride are converted into fatty and glycerol.

158 The acid value of the five treatments were statistically significant from each other, with
159 treatment A, having the highest acid value of (17.28 mg/KOH/g of oil), treatment B (15.03
160 mg/KOH/g of oil), C (11.78 mg/KOH/g of oil) and E (8.63 mg/KOH/g of oil) had the lowest
161 acid value. Lard based sausage had the highest acid value of 17.28 mg/KOH/g of oil, with

162 least value in no oil based sausage (8.63 mg/KOH/g of oil). This could be due to the higher
163 amount of saturation of oil in lard.

164 The saponification values were statistically significant from each other. Treatment D had the
165 highest saponification value (271.38 mg/KOH/g of oil) while the least saponification value
166 was in treatment A (126.23 mg/KOH/g of oil). Treatments B, C and E had saponification
167 values of 231.41, 198.45 and 176.72 mg/KOH/g of oil respectively. It was also observed that
168 the saponification value of the selected oils used for breakfast sausage were statistically
169 different from each other. Olive oil had the highest saponification value (271.38 mg/KOH/g
170 of oil) while lard based sausage had the lowest saponification value (126.23 mg/KOH/g of
171 oil). This could be due to the higher unsaturated fatty acids present in olive oil compared to
172 other oils.

173 Table 4: Effect of selected oils on oxidative properties of breakfast sausage

PARAMETER	A	B	C	D	E	SEM
Iodine value (mg iodine/100g of oil)	0.95 ^d	0.32 ^e	7.93 ^a	7.30 ^c	7.62 ^b	0.92
Acid value (mg/KOH/g of oil)	23.23 ^a	15.03 ^c	11.78 ^d	17.28 ^b	8.63 ^e	1.33
Saponification value (mg/KOH/g of oil)	126.23 ^e	231.41 ^b	198.45 ^c	271.38 ^a	176.72 ^d	13.13

174 ^{abc} Means on the same row with different superscripts are significantly different (p<0.05)
175 A= Sausage with lard, B=Sausage with shea butter, C= Sausage with olive oil, D= Sausage with
176 groundnut oil, E= Sausage with no oil.
177 SEM= Standard Error mean
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179 **3.2 Physicochemical properties of breakfast sausages**

180 **Breakfast sausages** prepared from groundnut oil had the highest dimensional shrinkage of
181 18.52% while breakfast sausages prepared from olive oil had the least dimensional
182 shrinkage of 8.53%. Dimensional shrinkage is as a result of cooking process, due to the
183 denaturation of the meat proteins with loss of water and fat. In this study, dimensional
184 shrinkage ranges from 8.53% to 18.52% (Table 5). Olive oil based sausage had the least

185 dimensional shrinkage which could had been due the ability of olive oil to bound properly
186 with water to form better emulsion stability compared to other vegetable oil based sausage.
187 Breakfast sausages prepared from groundnut oil had the highest cooking loss of 33.22%
188 while the breakfast sausages prepared from olive oil had the lowest cooking loss of 15.69%.
189 Breakfast sausages prepared from olive oil had the highest cooking yield of 84.31% while
190 breakfast sausages prepared from groundnut oil had the least cooking yield of 66.78%.
191 Breakfast sausages prepared from shea butter and groundnut oil are also not significantly
192 different in their pH value. Cooking loss measures the water binding capacity of sausage
193 which was affected by moisture, protein and fat content as well as processing methods.
194 Cooking loss is an important factor because it is responsible for the appearance and
195 juiciness of meat products [11]. Cooking loss in this study ranges from 15.69 to 33.22%
196 (Table 5). Olive oil based sausage had the least cooking loss which could be due to the high
197 cooking yield and ability to bound with water for emulsion stability.
198 Cooking yield connote the changes in weight due to moisture loss, water absorption or fat
199 gains/ losses during food preparation. The cooking yield of sausage depends on the cooking
200 temperature [12] cooking time [13], ingredients [14] and the amount of the fat in the
201 products. The effect of selected oils on cooking yield of breakfast sausage in this study
202 ranges from 66.78 to 84.31%. The highest value was observed in olive oil based sausage
203 which could be due to the level of reduction in cooking loss and dimensional shrinkage. This
204 observation was previously reported for various frankfurters [15, 16, 17] patties [18, 19] and
205 meatball [20] noted that reducing the animal fat content in meat products by replacement
206 with vegetable oil reduced cooking loss. The study by [16] demonstrated that processing
207 yield was affected by locust bean/xanthan gum replacement. Another study by [21] reported
208 that frankfurters containing rice bran fiber had significantly lower cooking loss than samples
209 with no added fiber. Meat products appear to have improved water holding capacity and
210 emulsion stability due to added dietary fiber and vegetable oil which leads to a higher
211 cooking yield.

212 The pH of breakfast sausages as affected by selected vegetable oil was carried out to
 213 determine the acidity or alkalinity. The pH values greater than 7 are alkaline while pH values
 214 less than 7 are said to be acidic. The result showed that no oil based sausages had the
 215 highest pH (6.26) as shown in Table 5 while olive oil based sausage had the lowest pH
 216 (6.09). This could be due to high concentration of free fatty acid present in the oil based
 217 sausage

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219 **Table 5:** Effect of selected oils on physical properties of breakfast sausages

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

220 ^{abc} Means on the same row with different superscripts are significantly different (p<0.05)
 221 A= Sausage with lard, b=Sausage with shea butter, C= Sausage with olive oil, D= Sausage with
 222 groundnut oil, E= Sausage with no oil.
 223 SEM= Standard Error mean
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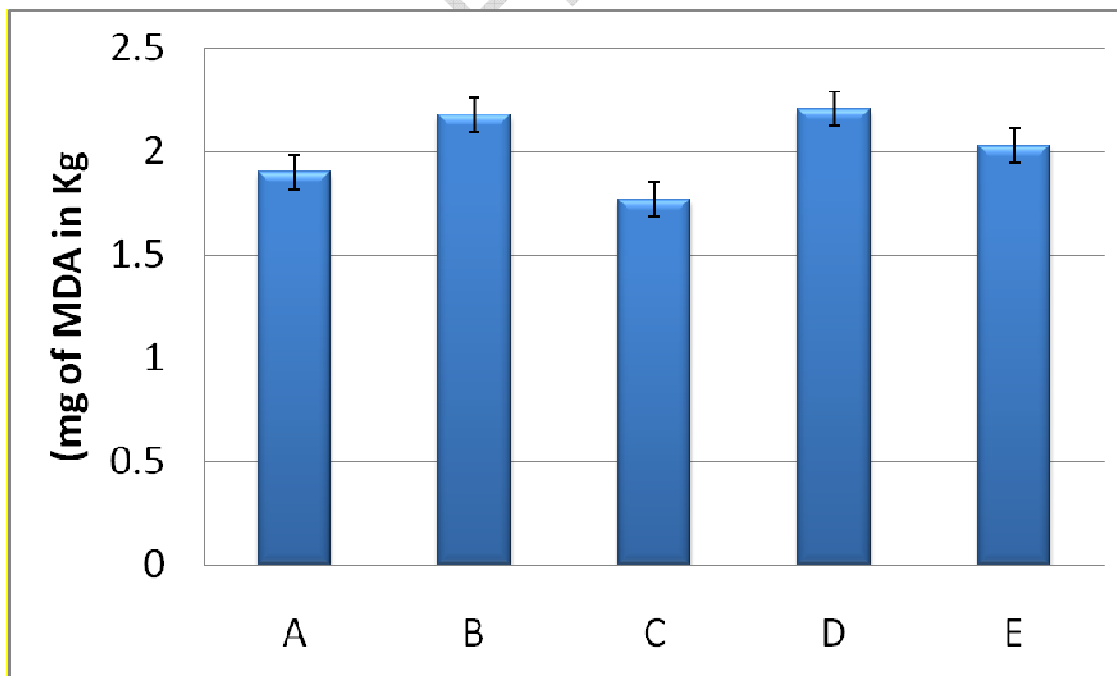
225 3.3 Oxidative rancidity properties of breakfast sausages

226 Oxidative rancidity properties of breakfast sausages as affected by different vegetable oil as
 227 lard replacer is represented in Figure 1. The oxidative rancidity score of breakfast sausages
 228 was higher (P<0.05) in treatment D followed by treatment B with least score in treatment C.
 229 The oxidative rancidity properties of oil based breakfast sausage denote how susceptible a
 230 produce is to lipid oxidation which determines amount of microbial loads and spoilage. The
 231 oxidative rancidity of olive oil based breakfast sausages had least value compared to other
 232 oil based sausages as shown Figure 1. This could be due to the amount of unsaturated fatty
 233 acid (mono unsaturated fatty acid and polyunsaturated fatty acid) present in olive oil.
 234 Oxidative rancidity values were higher for samples obtained with vegetable oil pre-emulsion,

235 almost double with respect to control samples. Similar results were communicated by other
236 researches too [23, 24], which only confirms the higher vulnerability to oxidation of
237 unsaturated fatty acids in vegetable oils. For low fat frankfurters, [24] reported oxidative
238 rancidity values significantly higher for all samples with vegetable oil in comparison to control
239 samples with no added vegetable oils. These results were in agreement with [25] who found
240 that among those in which pork back fat was substituted with various vegetable oils, low-fat
241 frankfurters with olive oil had the lowest TBA values, while those with soybean oil had the
242 highest due to their free fatty acid composition. [25] described the effects of replacing pork
243 back fat with olive oil on the processing and quality characteristics of sausages. Olive oil
244 increased TBA values compared with the control, and those containing higher amounts of
245 olive oil had higher TBA values. [26, 27] demonstrated that replacing beef fat with olive oil
246 and hazelnut oil improved the quality characteristics of fermented sausages.

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252 **Figure 1: Effect of oil on oxidative rancidity of breakfast sausage**

253 A= Sausage with lard, b=Sausage with shea butter, C= Sausage with olive oil,
254 D= Sausage with groundnut oil, E= Sausage with no oil.

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4. CONCLUSIONS

259 It can be concluded from the study that the lard can be replaced in breakfast sausages with
260 olive oil due to its high antioxidant and physicochemical properties. The reason for the
261 resistance of olive oil to rapid deterioration at elevated temperatures is its fatty acid
262 composition and the presence of natural antioxidants, such as tocopherols, squalene and
263 Δ^5 -avenasterol. The polar antioxidants found in olive oil may also make a contribution to the
264 increased stability to thermal oxidation and polymerisation.

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COMPETING INTERESTS

268 **AUTHORS HAVE DECLARED THAT NO COMPETING INTERESTS.**

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