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 sausage and lowest in lard-based sausage. The acid value was significantly higher in lard-based sausage, having the highest acid value of (17.2l) with least value in no oil-based sausage (8.63 Mg/KOH/g of oil). The saponification values were higher in the groundnut oil-based breakfast sausage (271.38 mg/KOH/g of oil) while the least saponification value was recorded in treatment A (126.23 Mg/KOH/g of oil). 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 sausage had the highest pH (6.26) while olive oil based sausage had the lowest pH (6.09).
Conclusion: Lard can be replaced in breakfast sausage 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

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

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

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

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

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

2. MATERIAL AND METHODS

2.1 Meat Source and sausage preparation

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

kept in the refrigerator at 4 ±1˚C, in order to reduce the microbial load, and for safety. Meat and fat were prepared separately through an automated meat mincer. The meat was prepared through 6mm plate and the fat through 4mm plate. Then the rest of the meat and the other ingredients were thoroughly mixed and re-grand through a 4mm plate as showed in table 1, 2 and 3. The prepared sausage was stuffed into presoaked natural casing (pig intestine) that was presoaked in brine using an automated stuffer. Sausage was subjected to grilling at 80 ^{0}C until internal temperature of 72^{0}C was reached to get the exact cooking time.

Table 1: Sausage composition

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

Source: [1]

Table 2: Composition of dry spices for breakfast sausage

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

Source: [1]

Table 3: Composition of green spices for breakfast sausage

Spices	**inclusion level %**
Onion (*Allium cepa*)	60
Ginger (*Zingiber officinale)*	20
Garlic (*Allium sativum*)	20
Total	100

Source: [1]

2.2 Determination of iodine values

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

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

2.3 Determination of Acid Values

The acid value (*AV) is* the number that expresses, in milligrams the quantity of potassium hydroxide required to neutralise the free acids present in 1g of the substance. The acid value is often a good measure of the breakdown of the triacylglycerol into free fatty acids, which has an adverse effect on the quality of many lipids. 5g (w) of the samples were weighed into conical flask that is well labelled. 25ml of equal volumes of ethanol and petroleum ether were poured into each conical flasks. One mL of phenolphthalein was added and titrated with 0.1 M of Potassium hydroxide until a stable pink colour (for 15 secs) was attained. The acid value was calculated by: Acid value= (5.6) $\frac{n}{w}$

2.4 Determination of Saponification Value

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

Procedure

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

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

Where:

B: ml of HCl required by Blank.

S: ml of HCl required by Sample

2.5 Cooking Loss

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

2.6 pH

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

2.7 Statistical Analysis

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

3. RESULTS AND DISCUSSION

3.1 Effect of selected oils on oxidative properties of breakfast sausage

The iodine value was higher in olive oil-based sausage while the value in lard-based sausage is the least. The iodine value is a measure of the relative degree of unsaturation in oils as determined by the uptake of appropriate halogen compounds. Because melting point and oxidative stability are related to the degree of unsaturation, iodine value provides an estimation of these quality factors. The greater the iodine value, the more the unsaturation and the higher the susceptibility to oxidation. In Table 4, it was observed that there were

significant differences in the iodine value of sausage made with different oil types. Olive oil based sausage was significantly different in iodine value when compared with other treatments. This could be due to higher levels of unsaturated fatty acids present in olive oil compared to others.

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

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

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

[abc] Means on the same row with different superscripts are significantly different ($p<0.05$)
A= Sausage with lard, B=Sausage with shea butter, C= Sausage with olive oil, D= Sausage with grountnut oil, E= Sausage with no oil.
SEM= Standard Error mean

3.2 Effect of selected oils on physicochemical properties of breakfast sausage

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

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

Cooking yield connote the changes in weight due to moisture loss, water absorption or fat gains/ losses during food preparation. The cooking yield of sausage depends on the cooking

temperature [12] cooking time [13], the ingredients [14] and the amount of the fat in the products. The effect of selected oils on cooking yield of breakfast sausage in this study ranges from 66.78% to 84.31%. The highest value was observed in olive oil based sausage which could be due to the level of reduction in cooking loss and dimensional shrinkage. This observation was previously reported for various frankfurters [15, 16, 17] patties [18. 19] and meatball [20] noted that reducing the animal fat content in meat products by replacement with vegetable oil reduced cooking loss. [16] demonstrated that processing yield was affected by locust bean/xanthan gum replacement. [21] reported that frankfurters containing rice bran fiber had significantly lower cooking loss than samples with no added fiber. Meat products appear to have improved water holding capacity and emulsion stability due to added dietary fiber and vegetable oil which leads to a higher cooking yield.

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

Table 5: Effect of selected oils on physical properties of breakfast sausage

	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

^{abc} Means on the same row with different superscripts are significantly different ($p<0.05$)

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

SEM= Standard Error mean

4. CONCLUSION

It can be concluded from the study that Lard can be replaced in breakfast sausage with olive oil due to its high antioxidant and physicochemical properties.

COMPETING INTERESTS

AUTHORS HAVE DECLARED THAT NO COMPETING INTERESTS EXIST.

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