



Research Article

Utilization of Wheat Germ Flour in the Processing of Beef Sausage

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Abstract

The term sausage is derived from the Latin word (salsus) meaning salt or literally translated, refers to chopped or minced meat preserved by salting. In this study beef sausage was processed by additions of different replacement levels of meat by Wheat Germ Flour (WGF) replacement levels were: 0% (as control) 10% and 15%. The processed beef sausage was packaged in foam trays, over-wrapped with Polyvinyl Chloride (PVC) and stored refrigerated at $4^{\circ}\text{C} \pm 1$ for up to 7 days. Several variables were determined using subjective and objective measurements, to evaluate the effects of replacement levels and storage periods on the quality attributes of the processed beef sausage. The measured parameters included: Water Holding Capacity (WHC), pH, Peroxide Value (PV), storage loss and cooking loss of beef sausage. The evaluation was conducted immediately after processing, three and seven days' post processing day. Results demonstrated that there were no significant differences ($p > 0.05$) in PV and storage loss, among the samples from the different replacement levels due to the Storage period. Fifteen % replacement level sample had the highest ($p < 0.05$) on water binding capacity and Lower ($p > 0.05$) PV and pH values. Water holding capacity is increased with the increase of replacement levels. WGF act as binder in beef sausage production and could be a good substitute to others plant binders which are used as meat binder or extenders.

Keywords: Peroxide Value; Polyvinyl Chloride; Wheat Germ; WHC

Introduction

Sausage may be roughly divided in to two general groups: raw sausage and heat processed sausage. According to the methods applied in their manufacture, raw sausages may further be subdivided in to two categories: fresh sausage and fermented sausages. Similarly, heat processed sausage are classified in smoked pre-cooked sausage, emulsion type sausages and cooked sausages. A - Fresh sausages are made from fresh meats. B - Fermented sausages are made from cured or uncured, fermented and often smoked meats but they are not heat processed in any way, they are divided into semidry and dry sausages. C - Smoked precooked sausages are mostly cured, non-fermented products, their shelf life is increased by heating due to partial reduction of their moisture content; they are usually finally cooked before consumption. D - Emulsion type sausages comprise ready-to-eat products made from comminuted and well-homogenized cured meats, fatty tissue, water and seasonings, usually smoked and slightly cooked. E - Cooked sausages are ready-to-serve products, basically made from previously cooked fresh or exceptionally cured raw materials, subjected to final cook-

ing after stuffing, with or without additional smoking [1]. Reformulations in meat products seek to reduce fat, while maintaining product acceptance without affecting its appearance, smell, and flavor ensuring that these products can be considered functional foods, in some cases. Consequently, several scientific studies have developed and proposed meat products with minimum levels of fat. However, it is well known that the modification of this component reduces the sensory quality of the final product, mainly its texture and acceptance, but meat products can be formulated with low fat content by incorporating functional ingredients, such as dietary fibers.

Meat and meat products are highly perishable materials so sanitation and cooling is essentials in handling, marketing and processing of meat. The sanitation in the Sudan, in general is very poor with regard to slaughtering, handling, marketing and processing of meat, except for very few meat plant and slaughter houses. Generally, meat products are widely consumed throughout the world; but unfortunately, their cost is high. To reduce this cost there is increasing interest in use of various non-meat proteins especially plant protein. Non-meat protein includes vegetable protein soya beans, cereal and legume protein and are often referred to in the trade name as "Meat Extenders" or "Meat Substitutes" [2]. Lin and

Zayas [3] reported that increasing cost of animal protein sources has encouraged researchers to study alternative protein sources, to be used in comminuted meat products, because of their lower formulation cost. Wheat germ is a by-product of wheat milling, and recently, it has attracted much attention due to its unique nutritional value. It contains 42% to 45% carbohydrate, 25% to 30% protein, 16% simple sugars, 4% to 5% minerals (total ash) and 10% to 12% lipid [4]. The objectives of this study to evaluate the effects of partial replacement of meat by wheat germ flour on the quality characteristics of beef sausage.

Material and Methods

Materials

Food Materials: Meat loins and round were obtained from Animal Production Research Center Kuku. The beef meat was stored frozen at $-11 \pm 1^\circ\text{C}$ in freezer at Regional Training Center for Meat Quality, Grading and Meat Technology, Elkadaro. Wheat germ was obtained from Seen flour mills stored frozen. Spices, salt

and sugar were obtained from local market of Khartoum North. The additional fat needed in the formulation was obtained from the local market. Uniform rendered fat free of protein was used.

Chemicals and Reagents: Chemicals and reagent used were brought from the central lab stores of Khartoum University, sodium nitrite and ascorbic acid, were obtained from Looly Company, Khartoum.

Casings: Cellulose casings 23 mm in diameter were obtained from Looly Company, Khartoum.

Methods

Raw Materials Preparation

Meat Preparation: Stored beef was allowed to thaw and sliced then ground through a 0.75 In, plate using a meat grinder. Ground beef was stored refrigerated at $4^\circ\text{C} \pm 1$, for about 20 hr., a sample was taken to be analyses for protein fat and moisture content following [5] (Table 1).

Material	Protein%	Fat%	Moisture content%	Ash %	Cured Fiber %	carbohydrate	pH
Beef meat	22.6	3.2	71	0.98	-	0.3	6.29
Wheat germ	27.2	9.3	10.35	2.17	2.53	48.3	6.17

Table 1: Proximate analysis and pH of beef meat and wheat germ.

Wheat Germ Preparation: Stored wheat germ was ground, to form Wheat Germ Flour (WGF). Then a sample was taken and analyzed for protein, fat and moisture content, following [5] (Table 1).

Calculation for Sausage Formulation: The experiment designed to produce sausage with the following specification, protein 15%, fat 20% moisture, 58.3% added starch 4.7%, salt 1.5%, and spices 0.5% (Tables 2, 3). Three batches with three replacements of meat by wheat germ were used every batch weight 2000g

components	%	Weight in grams
Protein	15	300
Fat	20	400
Starch	4.7	94
Water	58.3	1160
Salt	1.5	30
spices	0.5	10

Table 2: Sausage Formula.

Ingredient	Replacement level of meat*		
	0% protein	10% protein	15% protein
Beef meat	1327.43	1194.7	1128.32
Wheat germ	-	110.3	165.44
Starch	94	94	94100
Fat	357.52	355.15	94
Water	217.53	300.34	341.3
Salt	30	30	30
Sugar	10	10	10
Black pepper	3	3	3
Nutmeg	2	2	2
Cinnamon	2	2	2
Garlic	2	2	2
Sodium nitrite	0.13	0.12	0.11
Vitamin C	0.62	0.55	0.52

* Replacement level of meat by wheat germ on the protein to protein bases

Table 3: Sausage formulation for all treatments.

$$\text{Therefore, protein required} = \frac{15 \times 2000}{100} = 300\text{g}$$

$$\text{Fat required} = \frac{20 \times 2000}{100} = 400\text{g}$$

$$\text{Water required} = \frac{58.3 \times 2000}{100} = 1166\text{g}$$

$$\text{Starch required} = \frac{4.7 \times 2000}{100} = 94\text{g}$$

$$\text{Salt required} = \frac{1.5 \times 200}{100} = 30\text{g}$$

$$\text{Spices required} = \frac{0.5 \times 200}{100} = 10\text{g}$$

Sodium nitrite 100ppm.

Vitamin C 0.466g /kg

First Replacement Level

Wheat germ 0% so the required protein was 100% from meat beef therefore beef require = $\frac{300 \times 100}{22.6} = 1327.43$

$$\text{Fat in } 1327.43\text{g beef} = \frac{3.2 \times 1327.43}{100} = 42.48$$

$$\text{Fat to be added} = 400 - 42.48 = 357.52$$

$$\text{Moisture in } 1327.43\text{g beef} = \frac{71 \times 1327.43}{100} = 942.47$$

Moisture from starch = 6

Total moisture = 948.47

$$\text{Moisture to be added} = 1166 - 948.47 = 217.53$$

Required sodium nitrite = 0.13g

Required Vitamin C = 0.62g

Second Replacement Level

Wheat germ 10% so the required protein was 90% from beef and 10% from wheat germ

$$\text{There for beef required} = \frac{300 \times 90}{22.6} = 1194.7$$

$$\text{Wheat germ required} = \frac{300 \times 10}{27.2} = 110.3$$

$$\text{Fat in 1194.7g beef} = \frac{3.2 \times 1194.7}{100} = 38.23$$

$$\text{Fat in 110.3 wheat germ} = \frac{6 \times 110.3}{100} = 6.62$$

Total fat = 44.85

$$\text{Fat to be added} = 400 - 44.85 = 355.15$$

$$\text{Moisture in 1194.7g beef} = \frac{71 \times 1194.7}{100} = 848.24$$

$$\text{Moisture in 110.3g wheat germ} = \frac{10.35 \times 110.3}{100} = 11.42$$

Moisture in 100g starch = 6

Total moisture = 865.66

$$\text{Moisture to be added} = 1166 - 865.66 = 300.34$$

Sodium nitrite to be added = 0.12g

Vitamin C to be added = 0.56g

Third Replacement

Wheat germ 15% so the required protein in 85% from beef 15% from wheat germ.

$$\text{Therefore, beef required} = \frac{300 \times 85}{22.6} = 112.32$$

$$\text{Wheat germ required} = \frac{300 \times 15}{27.2} = 165.44$$

$$\text{Fat in 1128.32g beef} = \frac{3.2 \times 1128.32}{100} = 36.11$$

$$\text{Fat in 165.44g wheat germ} = \frac{6 \times 165.44}{100} = 9.95$$

$$\text{Fat to be added} = 400 - 46.04 = 353.96$$

$$\text{Moisture in 1128.32g beef} = \frac{71 \times 1128.32}{100} = 801.11$$

$$\text{Moisture in 165.44g wheat germ} = \frac{10.35 \times 165.44}{100} = 17.12$$

Moisture in 100g starch = 6.

Total moisture = 824.23

$$\text{Moisture to be added} = 1166 - 824.23 = 341.8$$

Sodium nitrate = 0.11g

Vitamin C to be added = 0.52g

Sausage Preparation

Minced meat, salt, sugar, minced fat, spices, vitamin C, sodium nitrate and half of calculated ice water were introduced to a Hobart Chopper; the Chopper was then started for about 4 min. The added materials were dispersed uniformly. Then the ground wheat germ, starch was added together with the remainder of the calculated water. The entire mass was chopped for about 5 min. then transferred to manual stuffer to be stuffed into cellulose casing of 23 mm in diameter and linked at lengths of 15cm. The framed sausage was heated in water at 98°C for about 40 min, followed by immediate cooling in ice water, for 15 min. The cooled processed sausage was peeled and packed in foam trays over-wrapped with Polyvinyl Chloride (PVC) and stored refrigerated for up to 7 days. The WGF replacement levels in beef sausage formulation and processing were performed following the same procedures explained above.

Method of Analysis

Sausage were assessed at 0 day (i-e immediately after processing) after three and seven days' post processing.

Peroxide Value (PV)

Peroxide value PV of oil indicates not only the extent of overall oxidation but also resistance of oil rancidity. To PV of the oil sample was determined according to [5]. One gram of extracted oil was accurately weight into 250ml conical flask. Thirty ml of a mixture of glacial acetic acid and chloroform (3-2) were added and the solution was gently dissolving the oil. one ml of saturated solution of potassium iodide was added. The flask was quickly shaken for 1min and kept away from the light for exactly 5 min. Then 75ml of distilled water was added and the liberated iodine was

titrated with accurately standardized solution of sodium thiosulphate 0.01N using 1% starch solution as an indicator. Peroxide value was estimated as ml equivalent of active oxygen per kilogram. [6]. Duplicate determination was carried out together with blank test. Peroxide value was determined by the following equation;

$$PV = \frac{(A - B) \times N \times 1000}{S}$$

Where:

B = reading of blank mill

A = reading of sample mil

S = weight of sample in gram

N = normality of sodium thiosulphate.

pH Measurement:

pH was measured similar to that of [7]. Ten gram of the sample was placed in a blender jar and 100 ml of distilled water were added the mixture was blended at high speed for 1 min, the pH of the mixture was measured by using pH meter. This has been calibrated with two standard buffers (6.8 and 4.0).

Water Holding Capacity(WHC)

Water holding capacity was measured similar to that of [8] one gram of cooked sausage was placed between two pieces of the nylon cloth (to allow separation of the meat from the filter paper) which in turn was placed between two filter (whatman No11) the whole system was placed between glassy plates firmly for two minutes the pressure was maintained sufficiently high and constant. The pressed meat was removed and weighed. WHC was expressed as the following equation;

Water holding capacity = 100 - water index

$$\text{Water index} = \frac{\text{loss in weight} \times 100}{\text{Original weight}}$$

Storage Loss

Sample was taken from processed sausage and weighed at 0 day then stored frozen at freezer and weighed again at third and seventh day.

$$\text{Storage loss \%} = \frac{\text{Weight loss} \times 100}{\text{Weight of sample before storage.}}$$

Cooking Loss

Beef sausage samples was deep fried in cotton seed oil the cooking loss was calculated as follows:

$$\text{Cooking loss \%} = \frac{\text{Weight loss} \times 100}{\text{Original weight}}$$

Statistical Analysis:

The data collected from the different treatments was subjected to analysis of variance and whenever appropriate the mean separation procedure of Duncan was employed [9]. The SAS program [10]. was used to perform the General Linear Model (GLM) analysis.

Results and Discussions

Peroxide Value (PV)

The Peroxide Value (PV) of Skinless beef sausage was slightly decreased ($p < 0.05$) with addition of WGF Table 4. 15% replacement level of meat by (WGF) samples had relatively the lowest P.V (Table 4). The decreased P.V. with increased addition of WGF may be due to vitamin E. (tocopherols) which are abundant in wheat germ [11].

Treatment	Storage period	Storage loss %	Peroxide value PV
(control) 0%	3	0.29 ^{ab} ± (0.03)	2.41 ^{aA} ± (0.02)
	7	0.39 ^{ab} ±(0.03)	2.55 ^{aA} ±(0.12)
WGF 10 %	3	0.35 ^{bA} ±(0.03)	2.19 ^{bB} ±(0.01)
	7	0.43 ^{bA} ±(0.03)	2.024 ^{bB} ±(0.07)
WGF 15%	3	0.27 ^{cC} ±(0.05)	2.06 ^{cC} ±(0.08)
	7	0.33 ^{cC} ±(0.30)	2.21 ^{cC} ±(0.60)

n = 3

a-c = means in the same column for the storage period bearing different small letters are Significantly different ($p < 0.05$) A – C = means in the same column within each treatment group bearing different capital letters ($p < 0.05$).

Table 4: Storage loss and peroxide value of Beef sausage with or without WGF store frozen for up to 7 days.

Reported that germ constitutes about 2.5% of grain weight and comprises minimal amount of protein; but greatest share of fat, vitamins especially tocopherols. Gerrard [12] reported that vitamin E is abundant in oil obtained from wheat germ. Vitamin E act as natural antioxidant. Rumsey [13] reported that in lipid peroxidation, the unsaturated fatty acids undergo a loss of hydrogen, resulting in the formation of a free radical at the site of unsaturation. If the feed material in which this reaction is taking place does

not contain vitamin E or some other effective antioxidant, the free radical is quickly converted to a fatty acid peroxide free radical and finally to a fatty acid hydroperoxide. [14] when studied the effect of vitamin E and C in improving pigment and lipid stability, found that vitamin E treatment reduced pigment and lipid oxidation compared to control samples. The result of Table 5 indicates that the storage periods (3 and 7 days) had no effect ($p > 0.05$) on PV for the control (0%), 10% and 15% WGF replacement samples. The slight increase in PV of samples may be due to lipid oxidation, (Table 4). Jude et al. (1990) Reported that reaction of oxidative rancidity could continue slowly even in the frozen state.

Treatment	Storage period (days)	WHC	pH
Control	0	62.03 ^{BC} ± (0.42)	6.22 ^{AA} ± (0.010)
	3	59.55 ^{BC} ± (0.45)	6.18 ^{EA} ± (0.02)
	7	59.40 ^{BC} ± (0.30)	6.16 ^{BA} ± (0.02)
WGF 10%	0	76.55 ^{AB} ± (1.73)	6.21 ^{AA} ± (0.02)
	3	76.02 ^{BB} ± (0.22)	6.20 ^{BA} ± (0.01)
	7	75.94 ^{BB} ± (0.18)	6.19 ^{CA} ± (0.07)
WGF 15%	0	79.78 ^{AA} ± (0.90)	6.21 ^{AB} ± (0.02)
	3	78.92 ^{AA} ± (0.42)	6.19 ^{BB} ± (0.02)
	7	76.89 ^{BA} ± (0.16)	6.06 ^{CB} ± (0.05)

n = 3

a-c = means in the same column for the storage period bearing different small letters are: Significantly different ($p < 0.05$)

A – C = means in the same column within each treatment group bearing different capital letters.

Table 5: pH and WHC of Beef Sausage.

pH Measurement

As shown in (Table 5) there was no significant difference ($p > 0.05$) between 0% and 10% treatment in pH, for the 15% WGF replacement level there were significant decrease ($p < 0.05$) and that may be due to relatively low pH of raw WGF (6.17), Generally, the rang of pH in all samples from the different treatments so acceptable (6.06 – 6.22). Gerrard [12] reported that the meat from freshly killed cattle will usually have pH 6.5 to 6.8 (slightly acid); but its fall to lowest level, around 5.5 with a pH of 6 its considered to be of good durability, 6.4 is classified as of, insufficient durability; whilst meat with pH reading of over 6.5 are regarded as evidence of poor keeping quality. pH had significantly ($p < 0.05$) decreased with increase of storage period for replacement levels 10% and 15% samples. in control sample (0%) there were no significant different ($p > 0.05$) between 0 and 3 days' storage period; but the pH significantly ($p < 0.05$) decreased after 7 days' storage period.

Water Holding Capacity (WHC)

Water holding capacity is the ability of meat to retain its water or added water during application of external forces such as

cutting, heating, grinding or pressing [15]. The WHC of skinless sausage from the different treatments was given in (Table 5) for all treatment samples there were significant differences ($p < 0.05$). The control sample (0%) had relatively the lowest WHC and 15% had highest WHC. WHC of skinless sausage slightly decreased ($p < 0.05$) with the increased of storage period for 3 and 7 days; but there were no significant different ($p > 0.05$) among 0 and 3 days of storage period. That may be due to slightly decreased of the pH value of these samples [16]. Reported that the highest water index of samples could be due to fact that these samples have lower pH values. Lower pH values may decrease water holding capacity due to protein denaturation or due to muscle protein reaching their iso-electric point. Serdaroglu and Degirmencioglu [17] indicated that corn flour at 2 and 4% level increase moisture retention in treated meat ball samples.

Storage Loss

At any one of the storage period tested (i.e. 3 and 7 days), the 15% WGF replacement level in the processed beef sausage tended to have lower storage losses than the control (0%) or 10% WGF replacement level samples (Table 4). Numerically the difference in the storage losses between the control and 10% WGF replacement level, was so small, yet later had highest ($p < 0.05$) storage loss value at any one of the storage period tested. Within each WGF replacement level tested the storage loss of beef sausage tended to increase with the increase of the storage period i.e. value on the 7th day of storage period were always higher than their corresponding values on the 3rd day of storage. Elgasim and Alwesali [18] reported that addition of non-meat protein such as whey or soy protein to formulate meat product has been widely practiced by meat processors. However, other plant proteins such as oat, corn germ, wheat germ protein and samh flour were found able to provide functional properties and were recommended in the processing of meat product. The slight increase in storage loss with increase of storage period that may be due to evaporation of moisture and this agrees with the finding of [16], who reported that generally the result indicated that moisture content of all samples decreased after storage due to evaporation loss commonly observed during storage at two different temperatures, like the loss occurs as result of evaporation of the water from meat surface, when brought from a cold store into ordinary room temperature. An increase of the storage loss, lead to decrease of moisture content.

Cooking Loss

Figure 1 depict changes in the cooking loss of beef sausage extended with different levels of WGF. Generally cooking loss of beef sausage was increase related with WGF replacement level. i.e. decreases with the increase in WGF level. Obviously the 15% WGF replacement level had the lowest cooking loss (12.9% v. s 17.04% and 13.85%). Among their treatment (0%, 10% and 15% WGF replacement levels), meat batters containing wheat germ protein flour had lower cooking losses and lower percent water. Also the increase of WHC. Due to increase protein tended to de-

crease the cooking loss [19] reported that this increase was in consistence's with the fact that an increase in Water Holding Capacity (WHC) due to protein addition reduced the insignificant drop in cooking losses. The increase of WHC during cooking may be due to the degradation of protein. [20] reported that the heat degradation of protein increases the concentration of peptides and amino acid and result in increases intracellular osmotic pressure and this tend to increase water holding capacity.

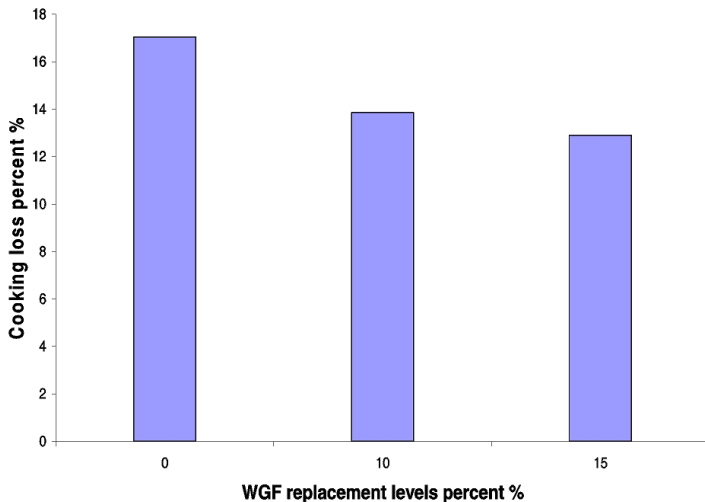


Figure 1: Cooking loss of beef sausage extended with WGF.

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