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SOME QUALITY ATTRIBUTES OF SAUSAGE ROLL PRODUCED FROM WHEAT-TIGERNUT COMPOSITE FLOUR

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Abstract: *Among the underutilized crops in Nigeria is tigernut which could find useful application in baking industry because of its high level of dietary fibre and other inherent properties. This study was carried out to investigate the effects of wheat flour substitution with tigernut flour in sausage roll production. Brown variety of tigernut was sorted and dried in a cabinet dryer at 60°C for 72hrs, processed into flour and blended with wheat flour at different ratios of 100:0; 90:10; 80:20; 70:30; 60:40; 50:50, 40:60, 30:70, 20:80, 10:90 respectively. Sausage roll was baked from the flour blends and was analyzed for proximate, mineral composition, physical properties (oven spring, weight, volume, specific volume and colour) and sensory evaluation. Moisture, crude protein, crude fibre, total ash, crude fat and carbohydrate ranged from 25.43 to 28.14%, 7.09 to7.79%, 1.87 to 2.29%, 1.70 to 1.80%, 8.59 to 9.25% and 51.14 to 55.20% respectively. Significant differences ($p<0.05$) also exist in the mineral composition of the sausage roll. Substitution of tigernut flour into wheat flour led to a decrease in oven spring, weight, volume and specific volume of the sausage roll. Addition of tigernut flour up to 40% could be acceptable for sausage roll. However, the use of tiger nut flour in sausage roll production improved the protein, fat and mineral content (sodium, calcium and phosphorus) of sausage roll. The lightness, redness and yellowness of the sausage roll samples varied significantly among different levels of substitution.*

Keywords: *Tigernut flour, Wheat flour, Sausage roll*

1. Introduction

The problem of malnutrition in Africa and how to control it is a major concern of food producers, consumers and processors alike. The situation demands an urgent solution which should be based on the use of locally available crops. Exploring the underutilized crops, some of which has been reported to be rich in nutrient and high density with the purpose of enriching the existing food could be a viable means to tackling malnutriton.

Tigernut (*Cyperus esculentus L.*) is an underused crop which belongs to the divisionMagnoliophyta,classliliopsida,order-cyperales and family-Cyperaceae(family) and was found to be a cosmopolitan perennial crop of the same genus as the papyrus plant. The plant has several names; this include earth almond and yellow nut grass [1, 2]. In Nigeria, three varieties of tigernut are cultivated, this include black, yellow and brown. Among these, only the yellow and brown varieties are readily available in the market. It is also known as 'Aya'in Hausa, 'Ofio' in Yoruba, 'Akiausa'in Igbo.Tigernut has been reported to be a rich sources of good quality oil [3, 4] and contain an average amount of protein [5]. It also serve as a source of some useful minerals such as

potassium, phosphorus and calcium [6] as well as Vitamin E and C [2]. Moreover, tigernut has been reported to have higher essential amino acids than those proposed in the protein standard by the FAO / WHO [7] for satisfying adults needs [8]. It has been reported to contain high in dietary fibre content [9] which could be useful in treatment and prevention of certain diseases such as colon cancer [10], coronary heart disease[11], obesity, diabetes, gastrointestinal disoders [12] and losing weight [13].

Tigernut seeds are cheap and readily available but grossly underutilized and need more attention because of its nutritional qualities such as high fibre content. Recent application of tigernut has been concentrated on tigernut (brown and yellow variety) flour for bread making [14,15], biscuit [16]. However, there is little information on the use of tigernut as composite flour from wheat and brown variety of tigernut for the production of sausage roll. The nutritional content of wheat is low in fibre due to the various processes the whole wheat might have undergone. Therefore, the inclusion of tigernut flour (brown variety) would serve as a source of fibre supplement for the production of sausage roll and this could increase its use in food applications with high level of acceptance. Therefore, this study evaluated the proximate, mineral composition, physical properties and sensory quality of sausage roll produced from wheat and tigernut flour blends.

2. Materials and methods

2.1 Materials

Dry tigernut (brown variety) was locally purchased from Kuto market Abeokuta, Ogun state. Wheat flour and other essential ingredients like baking flour, sugar, nutmeg, salt, butter was purchased at Kuto market in Abeokuta, Ogun state.

2.2 Tigernut flour preparation

The method described by Ade-omowaye [14]was used in the preparation of brown variety of tigernut flour. Dry tiger nuts (*Cyperusesculentus*) were sorted manually to remove unwanted materials like stones, pebbles and other foreign seeds. The cleaned nuts were dried in a cabinet dryer at 60°C for 72hrs. Dried nuts was milled using laboratory mill and the milled sample was sieved (using 250µm screen) to obtain the flour. The tigernut flour was packed and sealed in polyethylene bags at ambient temperature (26±20C) and 760mmHg until further analysis.

2.3 Preparation of sausage roll

The method described by Kohajdova and Karovicova[17] with little modification of recipe was used for the preparation of sausage roll. A straight dough process was used for the preparation of sausage roll, recipe such as butter (100g), sugar (1g), salt(1g), water (15ml), baking powder (2g) and tigernut flour was added in appropriate proportion to each of the flour blends and control flour. The substitution of tigernut flour into wheat flour was (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% and 90%) for making sausage roll dough. The blends were mixed with ingredients in a spiral mixer (for 5 minutes). Water was added to the flour inside the spiral mixer and kneaded for 3 minutes. The dough was scaled and shaped. Baking was done at a temperature of 220ºC for 13 minutes.

2.4 Proximate composition of sausage roll produced from wheat and tigernut flour

Proximate composition of the sausage roll (moisture content, crude protein, crude fat, total ash and crude fibre) prepared from wheat and tigernut flour blends was analyzed using the method described by [18]. Carbohydrate contents of sausage roll samples were calculated by difference

2.5 Mineral composition of sausage roll produced from wheat and tigernut flour

The mineral content of the sausage roll was analyzed for Potassium (K), Calcium (Ca), and Sodium (Na) using the atomic absorption spectrophotometry (AAS), after being subjected to dry ashing method. Dry ashing was carried out by weighing 1gram of sample into a porcelain crucible, pre-ashed at a temperature of 300°C and later brought to 600°C. Ashing was done for 2hours in a furnace and then left to cool. 25ml of 3M HCL will be added. The mixture was filtered into a 100ml volumetric flask and diluted to a volume with deionized water. The sample was vortexed for proper mixing, after which the sample was transferred to centrifuge tubes and centrifuged at 3000rpm for 10minutes. The supernatant was decanted into a clean vial for micro and macro determination using Atomic Absorption Spectrophotometry

2.6 Physical properties of sausage roll produced from wheat and tigernut flour

2.6.1 Determination of oven spring

Oven spring was determined from the differenced in the height of dough just before and after baking using the method described by Idowu et al. [19].

2.6.2 Determination of weight of sausage roll

The sausage roll weight was determined using the modified method of Shittu et al. [20] The weights of the sausage roll was determined with the aid of weighing balance after cooling and the weight values was recorded for each sample.

2.6.3 Determination of volume and specific volume of sausage roll

Sausage roll volume was measured using the modified method described Feili et al. [21], Sausage roll volume was determined using sorghum seed displacement method. The sorghum seeds were put into a container to measure the volume and it was measured in a graduate cylinder and mark as V_1. Thereafter, the sample was placed in the same container and seeds were poured till the test sausage roll is covered. Again the sorghum seeds was been measured in another graduated cylinder and mark as V_2**.** The volume of sample was then calculated based on the following equation.

$$\text{Sausage volume (ml)} = V1 - V2 \quad (1)$$

Where V_1 represents the volume of the sorghum seeds in the empty container (ml), V_2 represent volume of the sorghum seeds in the container containing sample (ml).

The specific volume was also calculated using the method described by Feili et al. [21] as shown in the following equation below:

$$\text{Specific volume (cm}^3\text{/g)} = \frac{Volume\ of\ Sausage\ roll}{Weight\ of\ Sausage\ roll}$$

2.6.4 Determination of density of sausage roll

The sausage roll density was determined using method described by Feili et al. [21]. The sausage roll density was calculated by dividing the weight of sausage roll obtained by the volume of sausage roll

$$\text{Density (g/cm}^3\text{)} = \frac{Weight\ of\ Sausage\ roll}{Volume\ of\ Sausage\ roll}$$

2.6.5 Crumb and crust colour of sausage roll

Crust and crumb color measurement was measured by the method described by Feili et al. [21], Minolta chroma meter (CR-410 Japan) was used based on (CIE) L*a*b* scale. After calibrating the instrument by covering a zero calibration mask followed by white calibration plate, crust and crumb was analyzed by placing them on the petri dish and the image was captured on the samples. The color attributed such as lightness (L*) and (0 = black and 100 =

white) and chromatically coordinated (a* corresponds to the color range from red-green coordinates (- is given, while + is red)), (b* corresponds to the colour range from blue – yellow coordinates (- is blue with + indicating yellowness) was recorded.

2.7.Sensory evaluation of sausage roll produced from wheat and tigernut flour

The method described by Iwe [22] was used. The sensory panel consisted of 50 members who were familiar with the product and were asked to score the bread using a 9-point hedonic scale based on their degree of likeness where 9 = like extremely; 5 = neither like nor dislike; 1 = dislike extremely. Sensory quality attributes evaluated were: colour, aroma, taste, texture, appearance and overall acceptability.

2.8 Statistical analyses

Data obtained were subjected to statistical analysis. Means, Analysis of variance (ANOVA) were determined using SPSS version 21.0 and the differences between the mean values were evaluated at $p<0.05$ using Duncan's multiple range test.

3 Results and Discussion

3.1 Proximate composition of sausage roll produced from wheat and tigernut flour

The proximate composition of sausage roll produced from wheat and tigernut flour blend is presented in Table 1. Significant differences ($p<0.05$) exist in the moisture content of the sausage roll. The moisture content of sausage roll produced wheat and tigernut flour blend from was high and ranged from 25.43 to 28.14%. Sausage roll produced from 100% wheat flour had the highest moisture content while sausage roll produced from wheat flour substituted with tigernut at 70% had the lowest moisture content. Sanni et al. [23] reported that the lower the moisture content of a product to be stored, the better the shelf stability of such product. High moisture content has been associated with short life as they encourage microbial proliferation that leads to spoilage [24]. The moisture content of wheat-tigernut composite sausage roll was in agreement with the findings of Oke et al. [15]. The crude protein content of the sausage roll ranged from 7.09 to 7.79%. Sausage roll produced from 100% wheat flour had the highest moisture content while sausage roll produced from wheat flour substituted with tigernut at 70% had the lowest moisture content. The protein content of the wheat-tigernut composite sausage roll observed in this study was moderate; this could be attributed to the level of protein present in wheat and tigernut flour. Significant differences ($p<0.05$) exist in the crude fibre content of wheat-tigernut composite sausage. The crude fibre ranged between 1.87 and 2.29% with sausage roll produced from 100% wheat flour having the lowest crude fibre content while sausage roll produced from wheat flour substituted with tigernut at 90% had the highest crude fibre content. According to Ekwe et al. [25] and Chugh et al. [26] reported that consumption of food rich in dietary fiber reduces the risk of diabetes mellitus, cardiovascular diseases, constipation, appendicitis, hemorrhoids and colon cancer. The ash content is also a rough estimate of the mineral contents of the samples [27]. The ash content of the sausage ranged from 1.70 to 1.80%. The result shows that sausage produced 100% wheat flour and sausage produced from wheat flour substituted with tigernut at 40% and 80% had the highest ash content when compared with other samples as showed statistically. This suggests that sausage produced from 100% wheat flour and wheat-tigernut flour at 40 and 80%

will be rich in mineral. The crude fat ranged from 8.59 to 9.26%. The high crude fat content obtained in this study could be attributed to the high crude fat content of the tigernut as reported by Bamishaiye and Bamishaiye [28]and other baking ingredient that was added such as margarine. Peter-Ikechukwu et al. [29] reported that high level of fat are undesirable in food products because they could lead to rancidity in foods. Significant differences ($p<0.05$) exist in the carbohydrate content of the sausage produced from wheat and tigernut flour. Sausage produced from 100% wheat flour and wheat-tigernut flour at 40 and 80% had the lowest carbohydrate content while sausage produced from wheat flour substituted with tigernut at 70% had the highest carbohydrate. The carbohydrate content of the sausage samples substituted with wheat and tigernut flour blends were higher than the sausage produced from 100% wheat flour sample. This may be as a result of the substitution which led to the reduction or changes in the carbohydrate content of the blended sample.

Table 1

Proximate composition of sausage roll produced from wheat and tigernut flour blend (%)

WF:TF	Moisture Content	Crude Protein	Crude Fibre	Total Ash	Crude Fat	Carbohydrate
100:0	28.14 ± 0.39^{f}	7.79 ± 0.11^{f}	1.87 ± 0.01^{e}	1.80 ± 0.00^{a}	9.26 ± 0.12^{f}	51.14 ± 0.62^{a}
90:10	26.79 ± 0.47^{cd}	7.44 ± 0.12^{cd}	2.01 ± 0.01^{bc}	1.70 ± 0.00^{b}	8.84 ± 0.15^{cd}	53.22 ± 0.75^{cd}
80:20	27.09 ± 0.37^{cde}	7.51 ± 0.10^{cde}	2.06 ± 0.01^{cd}	1.75 ± 0.07^{bc}	8.93 ± 0.11^{cde}	52.66 ± 0.66^{bcd}
70:30	25.98 ± 0.18^{ab}	7.23 ± 0.05^{ab}	2.12 ± 0.00^{ab}	1.70 ± 0.00^{ab}	8.59 ± 0.06^{ab}	54.38 ± 0.29^{ef}
60:40	27.49 ± 0.18^{ab}	7.62 ± 0.01^{def}	2.15 ± 0.00^{cde}	1.80 ± 0.00^{c}	9.06 ± 0.02^{def}	51.88 ± 0.09^{abc}
50:50	26.51 ± 0.33^{bc}	7.36 ± 0.08^{bc}	2.24 ± 0.01^{bc}	1.70 ± 0.00^{ab}	8.75±0.10bc	53.44 ± 0.52^{ef}
40:60	26.00 ± 0.15^{ab}	7.24 ± 0.04^{ab}	2.14 ± 0.00^{ab}	1.70 ± 0.00^{ab}	8.60 ± 0.05^{ab}	54.32 ± 0.23^{ef}
30:70	25.43 ± 0.42^{a}	7.09 ± 0.11^{a}	2.21 ± 0.01^{a}	1.65 ± 0.07^{a}	8.42 ± 0.13^{a}	55.20 ± 0.76^{f}
20:80	27.69 ± 0.29^{ef}	7.67 ± 0.07^{ef}	2.25 ± 0.01^{de}	1.80 ± 0.00^{c}	9.12 ± 0.09^{ef}	51.47 ± 0.46^{ab}
10:90	26.90 ± 0.23^{cd}	7.47 ± 0.06^{cd}	2.29 ± 0.01^{bc}	1.70 ± 0.00^{ab}	8.87 ± 0.07^{cd}	52.77 ± 0.37^{cd}

Mean values with different superscripts within the same column are significantly different ($p<0.05$)
WF: Wheat flour, TF: Tigernut flour

3.2 Mineral composition of sausage roll produced from wheat and tigernut flour

The mineral composition of sausage produced from wheat and tigernut flour blend is presented in Table 2. Significant differences ($p<0.05$) exist in the mineral composition of the sausage. The sodium and calcium content of the sausage ranges from 102.9 to 552.8mg/100g and 17.06 to 24.26mg/100g respectively. Sausage produced from wheat flour substituted with tigernut at

10% had the highest sodium and calcium content while sausage produced from wheat flour substituted with tigernut at 40% had the lowest sodium and calcium content. Sodium maintains proper acid-base balance, assists with transmission of nerve signals and absorption of glucose/other nutrients and aids muscle contraction [30]. Calcium is necessary for supporting bone formation and growth, muscle contraction and maintenance of healthy blood pressure [30]. The potassium content of the sausage ranges from 76.15 to 375.3mg/100g. Sausage produced from 100% wheat flour had the lowest potassium content while sausage produced from wheat flour substituted with tigernut at 80% had the highest potassium content. Potassium is important in the regulation of heartbeat, neurotransmission and water balance of the body.

Table 2

Mineral composition of sausage roll produced from wheat and tigernut flour blend

WF:TF	Na (mg/100g)	Ca (mg/100g)	K(mg/100g)
100:0	273.5±0.01^{e}	22.59±0.01^{i}	76.15±0.07^{a}
90:10	552.8±0.01^{i}	24.26±0.01^{j}	138.1±0.01^{b}
80:20	412.8±0.01^{h}	17.45±0.00^{b}	140.2±0.01^{c}
70:30	102.9±0.01^{a}	21.38±0.03^{g}	173.1±0.01^{d}
60:40	102.9±0.01^{a}	17.06±0.01^{a}	242.7±0.14^{e}
50:50	350.7±0.01^{g}	18.86±0.01^{d}	244.0±0.01^{f}
40:60	288.0±0.01^{f}	21.59±0.01^{h}	263.6±0.00^{g}
30:70	103.7±0.01^{b}	19.26±0.01^{e}	261.2±0.00^{h}
20:80	198.2±0.01^{d}	21.26±0.01^{f}	375.3±0.01^{i}
10:90	194.4±0.00^{c}	17.72±0.01^{c}	363.2±0.00^{j}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); WF: Wheat flour, TF: Tigernut flour, Na: Sodium, Ca: Calcium, K: Potassium

3.3 Physical properties of sausage roll produced from wheat and tigernut flour

The physical properties of sausage produced from wheat and tigernut flour blend is presented in Table 3. Oven spring is an important baking characteristic which measure the height of the dough before baking and height of the dough after baking. The oven spring of sausage produced from wheat and tigernut flour blend ranges from 0.03 to 0.16cm. Sausage produced from 100% wheat flour had the highest ovenspring while sausage produced from wheat flour substituted with tigernut at 90% had the lowest ovenspring. The oven spring showed no definite trend but varied significantly ($p<0.05$) from one another. Weight is basically determined by the quantity of

dough baked and the amount of moisture and carbon dioxide diffused out of during baking [20]. The weight of the sausage ranged between 17.00 and 27.50g. Sausage produced from 100% wheat flour had the highest weight while sausage produced from wheat flour wheat flour substituted with tigernut at 90% had the lowest weight. It was observed that weight of the sausage decreased as wheat and tigernut flour was added; this can be attributed to lower level of gluten network in the dough and consequently decreased ability for the dough to rise [31, 15].

Volume is an important quality characteristic of a baked product. Significant differences ($p<0.05$) exist in the volume of sausage produced from wheat-tigernut composite flour. The volume of the sausage ranges from 45.00 to 175.5cm^3. The volume of the control sausage sample and wheat flour substituted with tigernut at 10% was higherthan that of samples that is incorporated with tigernut flour. This effect is probably related to the decreased visco-elasticity of dough resulting from tigernut flour addition. As the level of tigernut flour substitution increases, the volume of the sausage gradually decreased. The decrease in volume could be attributed to poor gas retention which was an indication of the low gluten content of that has weakened the flour due to the addition of tigernut flour. Other researchers such as Chen *et al.* [32]; Doxastakis et al. [33]; Gomez et al. [34] and Borchani et al. [35] also observed decreasing volume of different bakery products such as bread, cookies and muffins.

Table 3

Physical properties of sausage roll produced from wheat and tigernut flour blend

WF:TF	Oven Spring (cm)	Weight (g)	Volume (cm^3)	Specific Volume (cm^3/g)	Density (g/cm^3)
100:0	0.16±0.01^{d}	27.50±0.71^{d}	175.0±7.07^{g}	6.36±0.10^{e}	0.16±0.00^{a}
90:10	0.11±0.01^{c}	27.00±1.41^{d}	175.0±7.07^{g}	6.49±0.08^{e}	0.16±0.01^{a}
80:20	0.06±0.01^{d}	27.00±1.41^{d}	155.0±7.07^{f}	5.74±0.04^{d}	0.18±0.01^{ab}
70:30	0.06±0.01^{d}	26.00±1.41^{d}	145.0±7.07^{ef}	5.58±0.03^{d}	0.18±0.00^{ab}
60:40	0.11±0.01^{c}	25.50±0.71^{d}	130.0±14.1d^{e}	5.09±0.41^{c}	0.20±0.01^{bc}
50:50	0.05±0.01^{ab}	22.50±0.71^{c}	115.0±7.07^{d}	5.11±0.16^{c}	0.20±0.01^{bc}
40:60	0.11±0.01^{c}	20.50±0.71^{bc}	95.00±7.07^{c}	4.63±0.18^{c}	0.22±0.01^{c}
30:70	0.05±0.01^{cb}	19.50±0.71^{b}	75.00±7.07^{b}	3.80±0.28^{b}	0.26±0.01^{d}
20:80	0.05±0.01^{ab}	18.50±0.71^{ab}	65.00±7.07^{b}	3.50±0.25^{b}	0.29±0.02^{d}
10:90	0.03±0.01^{a}	17.00±1.41^{a}	45.00±7.07^{a}	2.84±0.20^{a}	0.38±0.03^{e}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); WF: Wheat flour, TF: Tigernut flour

3.4 Colour attribute of sausage roll produced from wheat and tigernut flour

The colour attribute of sausage roll produced from wheat and tigernut flour blend is shown in Table 4. Colour is an important attribute because it can arouse individual's appetite. It is one of the parameters used for process control during baking and roasting, because brown pigments appear as browning and

caramelization reactions progress [36]. The colour results in terms of lightness (L*), redness (a*), yellowness (b*). Significant ($p<0.05$) differences existed in lightness (L*), redness (a*) and yellowness (b*) of sausage produced from wheat and tigernut flour blend. Lightness, redness and yellowness ranges from 49.14 to 60.39, 3.47 to 6.84 and 12.68 to 22.08 respectively. The colour of the sausage changed to brown as wheat flour is diluted with tigernut flour. This might have been attributed to an increased maillard reaction taking place during baking due to higher lysine content [37]. In the maillard reaction reducing carbohydrates react with free amino acid side chain of protein mainly lysine and lead to amino acid–sugar reaction products (polymerized protein and brown pigments).

Table 4

Colour attribute of sausage roll produced from wheat and tigernut flour blend

WF:TF	L*	a*	b*
100:0	60.39 ± 0.13^{g}	3.47 ± 0.00^{a}	18.92 ± 0.29^{d}
90:10	55.26 ± 0.41^{e}	4.76 ± 0.01^{d}	18.71 ± 0.08^{d}
80:20	56.88 ± 0.44^{f}	6.84 ± 0.00^{f}	22.08 ± 0.02^{e}
70:30	52.80 ± 0.82^{cd}	4.36 ± 0.13^{c}	15.21 ± 0.37^{c}
60:40	50.66 ± 0.66^{b}	4.46 ± 0.13^{c}	12.68 ± 0.07^{a}
50:50	51.81 ± 0.50^{c}	6.18 ± 0.18^{f}	15.24 ± 0.22^{c}
40:60	53.21 ± 0.32^{d}	5.33 ± 0.10^{e}	12.84 ± 0.07^{a}
30:70	49.14 ± 0.47^{a}	3.80 ± 0.10^{b}	12.43 ± 0.28^{a}
20:80	53.17 ± 0.29^{d}	3.92 ± 0.00^{b}	15.10 ± 0.07^{bc}
10:90	53.33 ± 0.21^{d}	4.27 ± 0.13^{c}	14.59 ± 0.44^{b}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); WF: Wheat flour, TF: Tigernut flour, L*: Lightness, a*: Redness, b*: Yellowness

3.5 Sensory evaluation of sausage roll produced from wheat and tigernut flour

The sensory score of sausage roll produced from wheat and tigernut flour blend is presented in Table 5. There were significant differences ($p<0.05$) in all the attributes measured. The colour, aroma, taste, texture, appearance and overall acceptability ranged from 4.07 to 7.83, 4.17 to 7.70, 4.37 to 7.47, 4.03 to 7.57, 3.90 to 7.63 and 4.10 to 7.70 respectively. Sausage roll produced from 100% wheat flour had the highest value of likeness for colour, aroma, taste, texture, appearance and overall acceptability while sausage roll produced from wheat flour substituted with tigernut at 90% had the lowest value of likeness for colour, aroma, taste, texture, appearance and overall acceptability. It is observed that up to 40% wheat replacement was accepted (6.47). So addition of tigernut flour up to 40% could be acceptable for sausage roll.

It was observed from the sensory score, preference for wheat-tigernut composite sausage decreased with the amount of tigernut flour substitution in the sausage roll and this is due to the familiarity of the consumers to the 100% wheat flour sausage roll.

Table 5

Sensory score for roll produced from wheat and tigernut flour blend

WF:TF	Colour	Aroma	Taste	Texture	Appearance	Overall Acceptability
100:0	7.83 ± 1.02^{f}	7.70 ± 0.84^{a}	7.47 ± 1.00^{fg}	7.57 ± 1.25^{f}	7.63 ± 0.81^{e}	7.70 ± 0.84^{g}
90:10	7.33 ± 1.06^{ef}	7.40 ± 0.89^{fg}	7.43 ± 0.70^{fg}	7.10 ± 1.21^{ef}	7.63 ± 0.81^{e}	7.33 ± 0.84^{fg}
80:20	7.60 ± 1.00^{f}	7.67 ± 0.76^{f}	7.67 ± 0.96^{g}	7.27 ± 1.41^{ef}	7.47 ± 0.97^{e}	7.80 ± 1.03^{g}
70:30	7.00 ± 0.83^{de}	6.87 ± 0.82^{ef}	6.87 ± 0.73^{ef}	6.63 ± 0.85^{e}	6.80 ± 0.72^{d}	6.90 ± 0.80^{ef}
60:40	6.63 ± 0.93^{cd}	6.60 ± 0.77^{de}	6.67 ± 0.84^{e}	5.90 ± 1.16^{d}	6.37 ± 0.96^{d}	6.47 ± 0.82^{de}
50:50	6.13 ± 0.90^{c}	6.00 ± 1.23^{cd}	5.90 ± 1.16^{d}	5.77 ± 1.13^{d}	5.77 ± 1.00^{c}	5.97 ± 1.10^{cd}
40:60	5.47 ± 0.82^{b}	5.83 ± 1.31^{c}	5.60 ± 1.42^{cd}	5.37 ± 1.30^{cd}	5.40 ± 1.07^{bc}	5.57 ± 1.10^{bc}
30:70	5.17 ± 1.23^{b}	5.10 ± 1.42^{b}	5.03 ± 1.25^{bc}	4.73 ± 1.23^{bc}	4.93 ± 1.17^{b}	5.03 ± 1.24^{b}
20:80	4.40 ± 1.40^{a}	4.46 ± 1.67^{a}	4.60 ± 1.57^{ab}	4.23 ± 1.59^{ab}	4.33 ± 1.45^{a}	4.33 ± 1.40^{a}
10:90	4.07 ± 1.55^{a}	4.17 ± 1.64^{a}	4.37 ± 1.67^{a}	4.03 ± 1.50^{a}	3.90 ± 1.42^{a}	4.10 ± 1.58^{a}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); WF: Wheat flour, TF: Tigernut flour

4 Conclusion

This study shows that sausage roll can be produced from wheat and tigernut flour blends.The use of tigernut flour in sausage roll production has the advantage of improving the protein, fat and mineral content (sodium, calcium and phosphorus) of sausage roll. Incorporation of tigernut flour led to reduction of sausage roll weight, volume and specific volume. The lightness, redness and yellowness of the sausage roll samples varied significantly among different levels of substitution. Tigernut flour could be incorporated up to 40% for the production of sausage roll without affecting the overall acceptability

5 References

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