

## **Soy/Moringa Pork Balls: A Potential Snack with Desirable Nutritional and Organoleptic Properties**

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### **Abstract**

The authors investigated the potential use of pork balls containing soy flour and *Moringa oleifera* leaf powder as a convenience food product in an effort to combat protein malnutrition in Nigeria and sub-Saharan Africa. Soy/moringa balls were formulated to contain 0/0, 10/0.5, 15/1.0 and 20/1.5% soy and moringa respectively; with 80% minced pork meat and other condiments making up 20%. Proximate composition, varied methods of processing and sensory characteristics were also determined. Treatments were analyzed in triplicates using a two-way factorial arrangement in a Completely Randomized Design (CRD). A total of 228 pork balls were produced as control for frying, baking and steaming processes. Sensory results showed that pork balls were most accepted up to 15/1.0 level. The yields of 10/0.5 and 15/1.0% inclusion levels of baked and fried pork balls were obvious although not statistically different ( $p < 0.05$ ). Excluding the control, steamed pork ball of 10/0.5% soy/moringa inclusion level which had the highest CP content (41.90%) and fried pork balls with the same inclusion level had the lowest moisture content (7.50%). Pork balls at 10/0.5% and 15/1.0% inclusion levels were the most acceptable in this study. These results show that soy/Moringa pork balls can be used in the production of snacks and other related food products for healthy living.

**Keywords:** Malnutrition; Pork Balls; Proximate Composition; Sensory Evaluation; Snacks

### **Introduction**

Millions of people suffer from malnutrition because they lack access to sufficient nutrient intake in their diets which is as a result of poverty, which could be linked to income drop or stagnation [1]. In Nigeria for instance, the daily animal protein intake is below the recommended minimum level of 65 g per caput per day of which only 8.4 g of the 53.8 g of protein consumption level of Nigeria is derived from animal sources [2]. For this reason, over the years poor animal protein intake has resulted in infant mortality, pronounced malnutrition, diseases and reduced human productivity [3]. Due to this acute shortage of animal protein in the diet of average citizens of developing countries, there is need to increase the availability of affordable food/snacks that is rich in protein and other nutrients for all classes of people.

Meat has been regarded as one of the most nutritious animal products because it is a rich source of valuable proteins, vitamins, minerals, micronutrients and fats, which provide multi-faceted nutrient for human health [4]. Demand for meat is ever increasing with increase in the population and awareness about its nutritional value [5]. Lean meat though high in nutrient value but also very expensive and may not be affordable to a large proportion of the population in developing countries. The blending of meat with cheaper plant products such

as soybean and moringa will thus allow more consumers access to animal protein products [6]. Meatball is therefore a type of snacks that can be made from pork, beef, fish and other animal products by mixture of ground/minced lean meat and other condiments such as soy flour, wheat flour, salt, red pepper, thyme, curry [7]. For this reason, it will be justifiable to produce pork balls in which health benefiting plant materials such as soybean flour and moringa oleifera leaf powder are incorporated into. Pork meat on its own is a very good source of various micronutrients. Low-fat pork contains 1.8 mg Iron and 2.6 mg Zinc [8]. Pork in combination with soybean flour and moringa leaf powder is additional value chain incorporation. It had been earlier hypothesized that development of a new meat or related product with the systematic incorporation of other ingredients will be synergistic, highly nutritious and affordable by especially average and low-income earners [2,7,9].

Researchers from recent studies have become convinced that nutrients in fruits and vegetables do more than just prevent deficiency diseases [10]. Moringa leaves contain varieties of antioxidants making it a source of natural antioxidants, a good source of nutraceuticals and functional components as well [11-13]. Use of moringa leaf meal was found to increase crude protein and reduced fat contents in frankfurter type sausages where it was used at a maximum of 6 g/kg meat [14]. It has also been used in beef burger patties to a level of 12% [15]. Many justifiable researches have also shown that its numerous medicinal claims are true [16,17].

Soybean on the other hand, is a legume with the highest amino acid score closest to the standard set by the World Health Organization [18] and Food and Agricultural Organization [19]. Soybean contains two main bioactive components, isoflavones and soy protein [20]. The seeds of the soybean plant are an excellent source of macro nutrients (protein, carbohydrate and lipid). The proximate protein content of soybean is very high (38%). The protein in most soybean products has a protein digestibility corrected amino acid score (PDCAAS) that approaches 1.0 for soy protein and 0.92 for whole soybeans, indicating that both amino acid pattern and digestibility of soy protein are excellent for human nutrition. Recent studies suggested that soy food and soybean protein containing flavonoid genistein, Biochanin A, phytoestrogens (isoflavones) consumption is associated with lowered risks for several cancers including breast [21], prostate [22] endometrial [23], lung [24], colon [25], Liver [26] and bladder [27] cancers [7,28].

Based on these facts, developing pork ball with highly nutritious plant materials such as *Moringa oleifera* leaf powder and soybean flour becomes a reasonable and viable remedy of supplementing high quality protein intake, promoting the consumption of this healthy and medicinal plants and in the long run contribute towards fighting malnutrition. The use of moringa and soybean as extenders add volume to the meatball thereby replacing meat. Therefore, the final products will be high quality and cheap snacks that become affordable to the poor people of the world [7]. Although available literature exists on the production of pork balls and in depth economic analyses, materials involving the inclusion of health promoting additives such as soy flour and *Moringa oleifera* appear to be scarce. This research therefore aims to evaluate the proximate composition and sensory properties of formulated pork balls incorporated with *Moringa oleifera* leaves and soybean at different levels of inclusion. It is expected that the product so developed will not only add to the value chain production system of pork, but it will also promote the addition of soy flour/moringa leaf powder incorporation in our local snacks production, as well as intensify future research works aimed at lowering protein malnutrition in Nigeria and sub-Saharan Africa. To our knowledge, this is the first organized study of the development of pork balls as well as the study of its sensory characteristics and proximate composition.

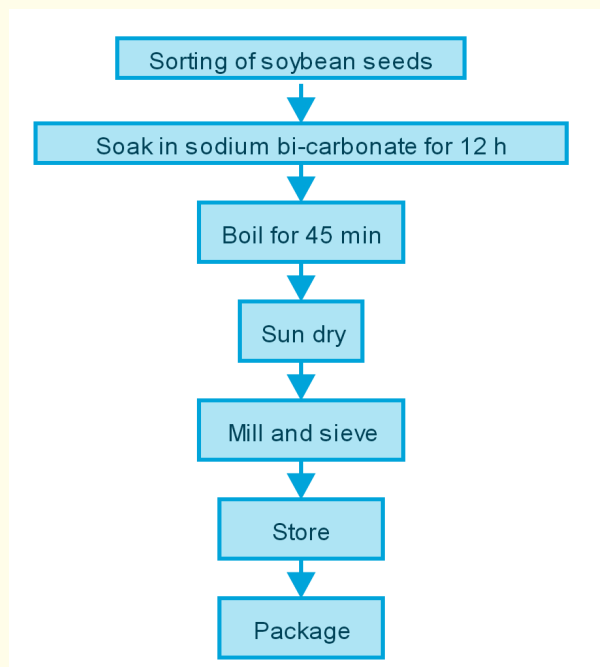
## Methodology

### Site of study

The experiment was conducted at the Kilishi Productions Factory situated at the Ekehuan Campus of the University of Benin, Benin City, Edo State, Nigeria.

### Source of Raw Materials

A total of 20 kg pork was purchased from a local market in Benin City, Nigeria and used for the study. Grains of soybean (6 kg) were processed into flour as described in Figure 1. Moringa oleifera leaf powder was purchased from an accredited processor.



**Figure 1:** Unit Operation for the Production of soy flour (Odiase, et al. 2013)

### Experimental treatments

Four different combinations of soy flour were investigated for pork ball formulation, each in three replications. The combinations were; (i) 0/100% soy flour/meat control (ii) 10/90% soy flour/minced pork (iii) 15/85% soy flour/minced pork and, (iv) 20/80% soy flour/ minced pork respectively. Four different combinations of moringa leaf powder were also investigated for all the soy flour/minced pork each in three replications. The combinations were as follows (i) 0/100% moringa leaf powder/ pork (ii) 0.5/99.5% moringa leaf powder/ pork (iii) 1/99% moringa leaf powder/ pork (iv) 1.5/98.5% moringa leaf powder/ pork. A 4x4x3 factorial design was used to accommodate all the experimental treatments in this study.

### Mix formulation of Soy/moringa Pork ball

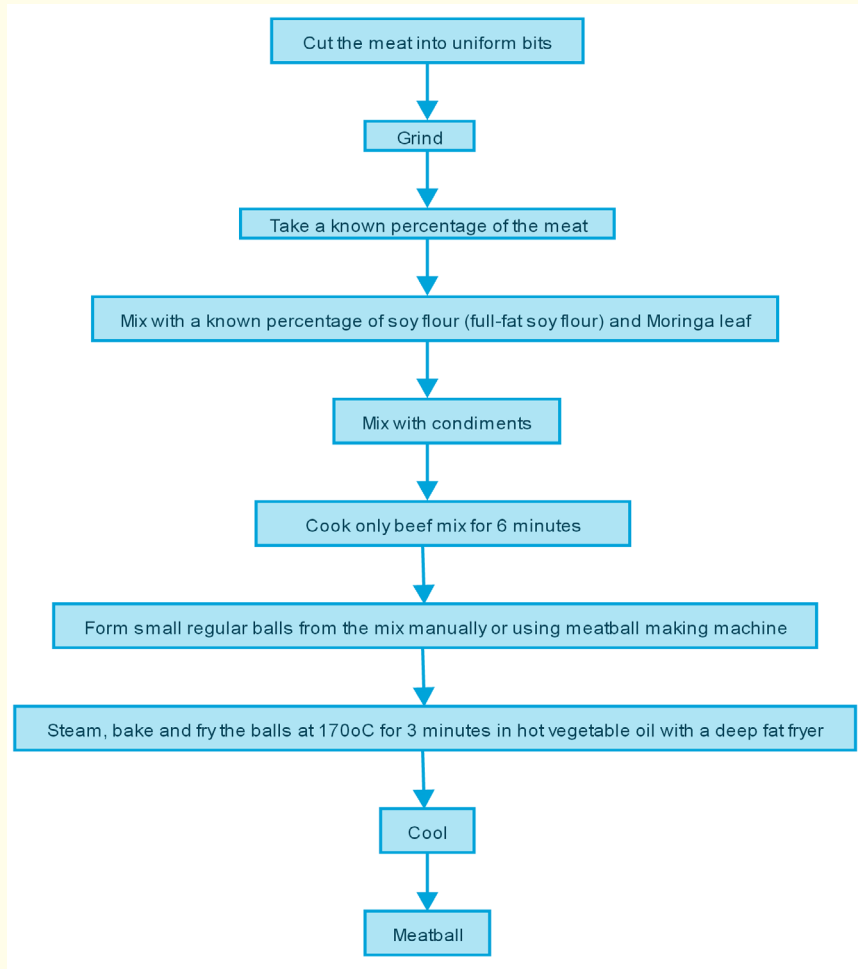
The mix was produced by substituting soy flour at 10, 15 and 20%, moringa leaf powder at 0.5, 1 and 1.5% pork respectively (Table 1). Whole pork was used as control. In order to reduce bias, condiments of equal proportions were used for individual mix formulation which resulted into 1500 g per mix.

Ingredients	Levels of Soy Flour/Moringa leaf powder /Meat (%)	Treatments				Total
		1	2	3	4	
		0/100%	10/0.5/89.5%	15/1/84%	20/1.5/78.5%	
Soy flour		0	120	180	240	540
Moringa leaf powder	80	0	6	12	18	36
Minced catfish		1200	1074	1008	942	4224
Corn Starch	5.25	78.75	78.75	78.75	78.75	315
Wheat flour	6.5	97.5	97.5	97.5	97.5	390
Sugar	1	15	15	15	15	60
MSG	0.15	2.25	2.25	2.25	2.25	9
Seasonal	1	15	15	15	15	60
Paprika	0.3	4.5	4.5	4.5	4.5	18
Pepper	0.3	4.5	4.5	4.5	4.5	18
Curry	0.6	9	9	9	9	36
Thyme	0.1	1.5	1.5	1.5	1.5	6
Ginger	0.6	9	9	9	9	36
Ice water	1	15	15	15	15	60
Shalliot	0.1	1.5	1.5	1.5	1.5	6
Onion	3.0	45	45	45	45	180
Garlic	0.1	1.5	1.5	1.5	1.5	6
Total	100%	1500g	1500g	1500g	1500g	6000g

**Table 1:** Mix formulation of soy/moringa Pork ball.

### Processing

The frozen minced pork was thawed at room temperature ( $26 \pm 2^{\circ}\text{C}$ ). The soybean was processed into soy flour (Figure 1). Mix formulation was prepared according to the mix formulation (Table 1) by mixing thoroughly. The mixes were placed in meatball making machine (Model YQ-280, China) where balls of 2.28 cm in diameter were formed. After which the balls were steamed, fried in hot vegetable oil using a deep fat fryer at  $170^{\circ}\text{C}$  (Model PH-515) for 3 min and baked in oven (Figure 2).



**Figure 2:** Unit production of Soy Moringa meatball (Odiase, et al. 2013).

## Data Collection and Analysis

### Proximate Analysis

The processed samples were analyzed for moisture, ash, ether extract, protein and carbohydrate (NFE) as described by [29]. These experiments were carried out in two replications.

### Sensory Evaluation

Six samples were coded and presented to a semi-trained sensory panel made up of 20 judges to assess samples according to degree of likeness in respect to colour, aroma, taste, texture and overall acceptance. Water and cracker biscuits were served in between samples assessment to enable panelists rinse their mouth properly and neutralize carryover flavours. This was carried out for the three processing methods. Panelists were served the coded samples in a testing room far away from the sample cooking and preparation area. A 5-point hedonic scale having 5 like very much as the highest score and 1 dislike very much as the lowest score was used [30].

### Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) in a two way factorial arrangement in a Completely Randomized Design (CRD) using [31] package. Significant means were separated using Duncan Multiple Range Test at 5% level of significance.

## Results

### Proximate Composition

The proximate composition of pork ball is shown in Table 2. Across the processing method and within the various level of soy/moringa inclusion, there were significant ( $P < 0.05$ ) differences in the moisture and dry matter content. The highest value for ash were observed in 20/1.5% level of inclusion in baked (4.05%), steamed (3.05%) and fried (4.50%) pork balls. Fried beef balls had the highest value of crude fat (37.50%) at 10/0.5% level of inclusion, while the least (22.50%) was from baked balls of control treatment. Treatments with the highest level of soy flour and moringa leaf powder inclusion had the highest level of crude fibre, the highest value (2.05%) being steamed balls of 20/1.5% treatment. In respect to the crude protein (CP) value of pork balls, baking reduced the CP by an average of 32.28% while steaming by an average of 36.73% and frying by an average of 34.54%. It was observed that despite the reduction in crude protein due to processing, the values were still high. In pork balls, steamed balls of 0/0% had the highest protein content (43.63%) followed by steamed balls of 10/0.5 (41.90) and the lowest (29.75%) being steamed balls of 15/1.0.

Pork Ball	Soy/moringa inclusion level (%)	Baked	Steamed	Fried	Overall SEM $\pm$
Moisture Content (%)	0/0	10.40 <sup>a</sup>	7.50 <sup>b</sup>	7.50 <sup>c</sup>	0.06
	10/0.5	8.75 <sup>b</sup>	10.25 <sup>a</sup>	7.50 <sup>c</sup>	0.20
	15/1.0	4.50 <sup>c</sup>	8.25 <sup>b</sup>	10.25 <sup>a</sup>	0.20
	20/1.5	4.75 <sup>c</sup>	4.75 <sup>c</sup>	8.25 <sup>b</sup>	0.25
	Overall SEM $\pm$	0.18	0.22	0.18	
Dry Matter (%)	0/0	89.60 <sup>c</sup>	92.50 <sup>b</sup>	92.50 <sup>a</sup>	0.06
	10/0.5	91.25 <sup>b</sup>	89.75 <sup>c</sup>	92.50 <sup>a</sup>	0.20
	15/1.0	95.50 <sup>a</sup>	91.75 <sup>b</sup>	89.75 <sup>c</sup>	0.20
	20/1.5	95.25 <sup>a</sup>	95.25 <sup>a</sup>	91.75 <sup>b</sup>	0.25
	Overall SEM $\pm$	0.18	0.22	0.18	
Ash (%)	0/0	1.00 <sup>c</sup>	1.03 <sup>c</sup>	1.00 <sup>b</sup>	0.014
	10/0.5	1.03 <sup>c</sup>	1.25 <sup>c</sup>	1.00 <sup>b</sup>	0.15
	15/1.0	2.01 <sup>b</sup>	2.00 <sup>b</sup>	1.00 <sup>b</sup>	0.0058
	20/1.5	4.05 <sup>a</sup>	3.05 <sup>a</sup>	4.50 <sup>a</sup>	0.29
	Overall SEM $\pm$	0.03	0.13	0.25	
Crude fat (%)	0/0	22.50 <sup>c</sup>	26.50 <sup>b</sup>	34.00 <sup>b</sup>	0.41
	10/0.5	23.50 <sup>c</sup>	26.50 <sup>b</sup>	37.50 <sup>a</sup>	0.50
	15/1.0	29.00 <sup>a</sup>	25.50 <sup>b</sup>	33.50 <sup>b</sup>	0.41
	20/1.5	25.50 <sup>b</sup>	31.00 <sup>a</sup>	31.50 <sup>c</sup>	0.41
	Overall SEM $\pm$	0.43	0.43	0.43	
Crude fibre (%)	0/0	1.00 <sup>d</sup>	1.00 <sup>d</sup>	1.00 <sup>d</sup>	0.14
	10/0.5	1.25 <sup>c</sup>	1.20 <sup>c</sup>	1.20 <sup>c</sup>	0.03
	15/1.0	1.50 <sup>b</sup>	1.50 <sup>b</sup>	1.45 <sup>b</sup>	0.03
	20/1.5	1.90 <sup>a</sup>	2.05 <sup>a</sup>	2.00 <sup>a</sup>	0.06
	Overall SEM $\pm$	0.06	0.025	0.025	

Crude protein (%)	0/0	36.25 <sup>a</sup>	43.63 <sup>a</sup>	38.25 <sup>a</sup>	0.33
	10/0.5	32.75 <sup>b</sup>	41.90 <sup>b</sup>	35.15 <sup>b</sup>	0.10
	15/1.0	30.25 <sup>c</sup>	29.75 <sup>d</sup>	33.25 <sup>c</sup>	0.32
	20/1.5	29.88 <sup>c</sup>	31.65 <sup>c</sup>	31.50 <sup>d</sup>	0.11
	Overall SEM ±	0.36	0.17	0.15	
Nitrogen free Extract (%)	0/0	27.75 <sup>b</sup>	20.35 <sup>c</sup>	18.25 <sup>c</sup>	0.38
	10/0.5	32.73 <sup>a</sup>	18.90 <sup>c</sup>	17.65 <sup>c</sup>	0.43
	15/1.0	32.74 <sup>a</sup>	33.00 <sup>a</sup>	20.55 <sup>b</sup>	0.42
	20/1.5	34.17 <sup>a</sup>	27.50 <sup>b</sup>	22.25 <sup>a</sup>	0.31
	Overall SEM ±	0.37	0.49	0.27	

**Table 2:** Proximate composition of pork ball.

Mean superscripted by the same alphabet within rows and columns are not significantly different ( $P > 0.05$ ). Each parameter is expressed as mean ± SEM (Standard Errors of Means).

### Sensory Characteristics

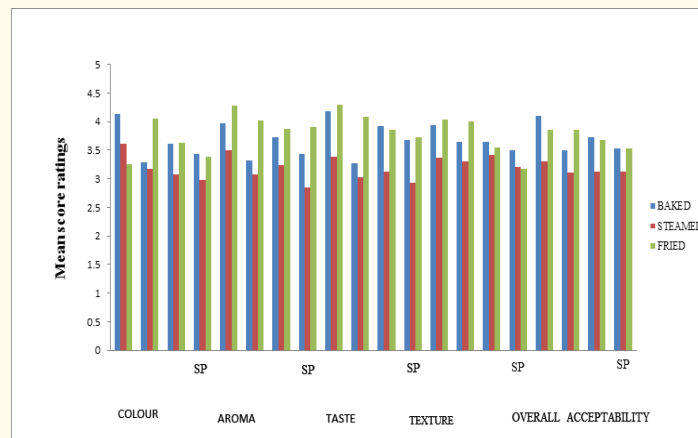
In regard to colour assessment in pork ball (Table 3), there were significant differences ( $P < 0.05$ ) in baked and steamed balls within the level of inclusion, while fried balls showed no significant difference ( $P > 0.05$ ). Also, the levels of 10/0.5, 15/1.0 and 20/1.5 % soy/moringa inclusion due to processing method showed significant differences ( $P < 0.05$ ). At 10/0.5 and 20/1.0 %, fried balls were significantly different ( $P < 0.05$ ) from baked and steamed balls which showed no difference from each other. At 15/1.0 % level of inclusion, colour was significantly different ( $P < 0.05$ ) with regard to processing method. Fried balls were not different from steamed balls, but the baked and fried balls were significantly different ( $P < 0.05$ ) from each other. Although there was no significant difference ( $P < 0.05$ ) between all fried pork balls, the control had the lowest average score in this study and the first inclusion (10.0/1.5) had the highest average score. From this study, frying process did not have any significant difference ( $P < 0.05$ ) on the color, taste, aroma and overall acceptability at various inclusion levels of all pork balls produced. All pork balls due to processing method showed no significance difference in respect to overall acceptability, however, the most accepted ball was the control ball of baked ball (4.10) while the least accepted was 10/0.5% treatment of steamed ball (3.10). The graphical representation is shown in (Figure 3).

Parameters	Soy/moringa inclusion level (%)	Baked	Steamed	Fried	Overall SEM ±
Colour	0/0	4.13 <sup>a</sup>	3.62 <sup>a</sup>	3.25 <sup>a</sup>	0.16
	10/0.5	3.28 <sup>b</sup>	3.17 <sup>b</sup>	4.05 <sup>a</sup>	0.10
	15/1.0	3.62 <sup>ab</sup>	3.08 <sup>b</sup>	3.63 <sup>a</sup>	0.16
	20/1.5	3.43 <sup>b</sup>	2.98 <sup>b</sup>	3.38 <sup>a</sup>	0.18
	Overall SEM ±	0.17	0.14	0.14	
Aroma	0/0	3.97 <sup>a</sup>	3.50 <sup>a</sup>	4.28 <sup>a</sup>	0.14
	10/0.5	3.32 <sup>b</sup>	3.07 <sup>b</sup>	4.02 <sup>a</sup>	0.09
	15/1.0	3.73 <sup>ab</sup>	3.23 <sup>ab</sup>	3.87 <sup>a</sup>	0.20
	20/1.5	3.43 <sup>ab</sup>	2.85 <sup>b</sup>	3.90 <sup>a</sup>	0.11
	Overall SEM ±	0.23	0.11	0.14	
Taste	0/0	4.18 <sup>a</sup>	3.38 <sup>a</sup>	4.30 <sup>a</sup>	0.11
	10/0.5	3.27 <sup>b</sup>	3.03 <sup>ab</sup>	4.08 <sup>a</sup>	0.12
	15/1.0	3.92 <sup>ac</sup>	3.13 <sup>ab</sup>	3.85 <sup>a</sup>	0.17
	20/1.5	3.68 <sup>bc</sup>	2.93 <sup>b</sup>	3.72 <sup>a</sup>	0.12
	Overall SEM ±	0.13	0.12	0.14	

Texture	0/0	3.93 <sup>a</sup>	3.37 <sup>a</sup>	4.03 <sup>a</sup>	0.11
	10/0.5	3.65 <sup>ab</sup>	3.30 <sup>a</sup>	4.00 <sup>a</sup>	0.07
	15/1.0	3.65 <sup>ab</sup>	3.42 <sup>a</sup>	3.55 <sup>ab</sup>	0.15
	20/1.5	3.50 <sup>b</sup>	3.20 <sup>a</sup>	3.17 <sup>b</sup>	0.20
	Overall SEM ±	0.11	0.18	0.13	
Overall Acceptability	0/0	4.10 <sup>a</sup>	3.30 <sup>a</sup>	3.85 <sup>a</sup>	0.15
	10/0.5	3.50 <sup>a</sup>	3.10 <sup>a</sup>	3.85 <sup>a</sup>	0.14
	15/1.0	3.73 <sup>a</sup>	3.13 <sup>a</sup>	3.68 <sup>a</sup>	0.24
	20/1.5	3.53 <sup>a</sup>	3.12 <sup>a</sup>	3.53 <sup>a</sup>	0.16
	Overall SEM ±	0.18	0.13	0.22	

**Table 3:** Table of sensory Evaluation of Pork Ball.

Mean superscripted by the same alphabet within rows and columns are not significantly different ( $P > 0.05$ ). Each parameter is expressed as mean ± SEM (Standard Errors of Means).



**Figure 3:** Mean organoleptic scores for soy/moringa pork ball.

## Discussion

Apart from the inherent quality of the various proteins, a reduction in quality takes place if there is damage to amino acids when the food is cooked. Nutrients may be lost during cooking in two ways. First, by degradation, this can occur by destruction or by other chemical changes such as oxidation, and secondly by leaching into the cooking medium [32]. The highest protein content was associated with steamed balls. This result was also in consonance with the findings of a recent study showing that steamed catfish balls had a CP value of 40.25% with a soy/moringa inclusion level of 15.0/1.0 [33]. Protein is a vital part of the human diet and its absence has been shown in several previous studies to cause poor development, malnutrition, wasting among others [34-36]. Findings of this study thus suggest that the steaming process retained more nutrients and this may explain the high protein content observed after processing.

The result of the proximate composition showed that baking pork balls reduced fat by an average of 25.13%, steaming by an average of 27.34% and frying by an average of 34.13%. Baking reduced fat content significantly ( $P < 0.05$ ) while steaming did so slightly. The result agreed with a study by Freitas., *et al.* [37] on the effect of cooking method in the formation of 7-ketocholesterol in Atlantic hake and Smooth weak fish. It was found that baking greatly reduced the cholesterol content which was associated with a large increase in 7-Ketocholesterol levels, while steaming produced small decrease and fried samples were changed. Varela, [38] indicated that the gain



or loss of lipid from meat is related to the lipid content in raw food and to the quantity of the coating flour or bread crumbs on the food surface. The kind of fat used had no essential influence on fat uptake. A slight change in fat contents of pork balls incorporated with soy/moringa inclusion has an explanation in the ability of moringa to act as hypo-cholesterolemic agent. This is in agreement with the findings of Ghasi, *et al.* (2000) where *Moringa oleifera* along with high-fat-diet decreased the high fat in the diet. Decreasing protein content down incorporation levels in pork balls agreed with the work of Ray, *et al.* [39] and Odiase, *et al.* [7] that as the soy level increased in ground meat, the protein decreased.

The mean score value from sensory assessment showed that the mean of 20/1.5% inclusion level was lowest compared to the other levels in pork balls (Table 2). This was as a result of higher percent level of moringa which added characteristic colouration to products introduced and thus making it unappealing to potential consumers. Colour measurement is an important parameter in meat products because consumers associate this product with a bright and characteristics pink colour. In food processing, colour stands out as the single most important factor of meat products that influences consumer buying decision and affect their perception of the freshness of the product [40]. Significant differences ( $P < 0.05$ ) among the inclusion levels due to baking and steaming was observed. Colour is the main factor affecting meat product acceptability at the time of consumer purchase [41]. The colour of cooked meat products arise mainly from pigmentation of the meat from which they are made and the ingredients used in the processing [42].

Aroma and taste of fried balls showed no significant differences ( $P > 0.05$ ) irrespective of soy/moringa inclusion, while there were significant differences ( $P < 0.05$ ) in produced balls due to baking and steaming. Frying imparts a characteristic odour to meat product types. Frying improves the sensory quality of food by formation of aroma compounds, attractive colour, crust and texture. This is in consonance with results of sensory analysis carried out by Bogнар, [43] that good to very good sensory quality can be achieved when breaded meat are deep fried.

It was also observed that 20/1.5% levels were least accepted mostly due to hardness of the meatball from soy/moringa inclusion level. In relation to texture, frying had little or no effect on texture. This must be as a result of frying sensory qualities on food. In pork ball produced, there was significant differences ( $P < 0.05$ ) in texture due to baking. This finding agreed with Otunola, *et al.* [44], where the cookies without moringa leave waste were superior.

Irrespective of colour, aroma, taste, texture and processing methods, the products of pork balls were generally accepted, baked and fried balls were generally accepted with 20/1.5 level having the least mean score value. In the pork ball produced, the order of overall acceptance was fried > baked > steamed balls. It should be noted that deep fat frying is an important food processing operation that involves heat and mass transfer inducing structural changes such as shrinkage [45]. Food frying is a common process in the food industry which is used to enhance the overall quality, texture and flavor of snack foods, doughnuts, French fries and poultry products [46]. Textural properties play a significant role in the perception and acceptability of any processed food product. Processing conditions and ingredient formulation have a direct impact on the textural behavior of food products. Factors responsible for textural properties in meat products are the degree of extraction, degree of comminuting and level of non meat ingredients [47]. Among all textural properties, hardness is the most important parameters as it decides the commercial value of meat product [48]. Deep fat fried balls were rated better than baked and steamed ones because of their crispy texture and bright colour [49,50]. Hsu and Chung, 1998 and Hsu and Yu, 1999 also found that processing conditions and the meatball formulation have significant effect on product quality. Despite the high fatty content of most pork produced in developing countries and the religious prejudice facing pork consumption, the nutritional efficacy of soy/moringa pork ball cannot but be adopted into our regular snacks as it is a useful means of fighting hunger and malnutrition. Swine are prolific animals and as such soy/moringa pork ball into the economy of developing countries will not only be an anti-nutritional measure also the food chain incorporation will be a means of income generation for the poor people of the world [51].

## Conclusion

In this study the possible production and incorporation of soy/moringa pork balls as a means of fighting malnutrition and incorporation into regular food system was investigated. Steamed pork ball of 10/0.5% soy/moringa inclusion level had the highest CP content (41.90%). Based on the organoleptic study of pork ball produced, it was recommended that soy/moringa pork balls should be baked or fried at 10/0.5 and 15/1.0% level of inclusion.

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## Bibliography

1. Odotola AF. "Poverty in Nigeria: An Electric Appraiser". Proceedings of the Nigerian Economic Society's Annual Conference (1997).
2. Ajala MK., *et al.* "Characteristics of smallholder pig production in southern Kaduna Area of Kaduna State, Nigeria". *American-Eurasian Journal of Agriculture and Environmental Science* 2.2 (2007): 182-188.
3. "A Statistical Analysis of Food Supply and Demand in Nigeria from 1985-1995". Federal Office of Statistics (FOS) (2008).
4. Mba, A. U. "Meat production in Nigeria: Prospects and problems. In T. Atinmo & L. Akinyele (Eds.), Nutrition and food policy. Kuru: National Institute for Policy and Strategic Studies (1983).
5. Raghavendra H N. "An analysis of meat consumption pattern and its retailing: A case of Dharwad district". Unpublished Thesis, University of Agricultural Sciences, Dharwad (2007).
6. "Food and Agriculture Organization of the United Nations, Asia. Meat processing technology for small to medium scale producers" FAO (2007).
7. Odiase MO., *et al.* "Determination and sensory evaluation of soy flour-meat combinations in the production of meatballs". *Journal of Applied and Natural Science* 5.2 (2013): 482-487.
8. Biesalski HK and Nohr D. "The nutritional quality of meat. In: J.P. Kerry and D. Ledward (eds). Improving the sensory and nutritional quality of fresh meat, 1<sup>st</sup> edn. Cambridge: Woodhead Publishing Ltd, England (2009).
9. Igene JO., *et al.* "Preliminary studies on the development of meatballs". *Journal of Applied Science and Environmental Management* 16.2 (2012): 167-170.
10. Sodamade A., *et al.* "Proximate Analysis, Mineral Contents and Functional Properties of Moringa Oleifera Leaf Protein Concentrate". *IOSR Journal of Applied Chemistry* 4.6 (2013): 47-51.
11. Anwar F., *et al.* "Moringa oleifera: a food plant with multiple medicinal uses". *Phytotherapy Research* 21.1 (2007): 17-25.
12. Makkar HPS and Becker K. "Nutritional value and nutritional components of whole and extracted Moringa oleifera leaves". *Animal Feed Science and Technology* 63.1-4 (1996): 211-228.
13. McCarty MF. "Should we restrict chloride rather than sodium?". *Medical Hypothesis* 63.1 (2004): 138-148.
14. Teye G.A., *et al.* "Effects of Moringa (Moringa oleifera) leaf powder and dawadawa (Parkia biglobosa), on sensory characteristics and nutritional quality of frankfurter-type sausages". *Global Advanced Research Journal of Agricultural Science* 2 .1 (2013): 029-033.

15. Sharaf AM., *et al.* "Influence of Using Moringa Meal Flour as Meat Extender on Quality Characteristics of Beef Burger Patties During Frozen Storage". *World Journal of Dairy & Food Sciences* 4.1 (2009): 32-40.
16. Sharma V and Paliwal R. "Isolation and characterization of saponins from *Moringa oleifera* (Moringaceae) pods". *International Journal of Pharmacy and Pharmaceutical Sciences* 5.1 (2013): 179-183.
17. Kwaghe AV and Ambali AG. "Acute Toxicity Studies of the Ethyl Acetate Fraction of the Aqueous Extract of *Moringa oleifera* Leaf in Cockerels". *Sahel Journal of Veterinary Science* 10.1 (2011):19-22.
18. World Health Organisation and UNICEF. "Meeting the MDG drinking water and sanitation target; the urban and rural challenge of the decade". *WHO Library Cataloguing in Publication Data* (2006).
19. "International Technical Conference (2010) Report, Agricultural biotechnologies in developing countries: Options and opportunities in crops, forestry, livestock, fisheries, and agro-industry to face the challenges of food insecurity and climate change (ABDC-10)". *FAO* (2010).
20. Xiao C W. "Health effects of soy protein and isoflavones in humans". *Journal of Nutrition* 138.6 (2008): 1244S-1249S.
21. Messina M., *et al.* "Addressing the soy and breast cancer relationship: review, commentary, and workshop proceedings". *Journal of the National Cancer Institute* 98.18 (2006): 1275-1284.
22. Jacobsen BK., *et al.* "Does high soy milk intake reduce prostate cancer incidence? The Adventist health study (United States)". *Cancer Causes Control* 9.6 (1998): 553-557.
23. Lof M and Weiderpass E. "Epidemiological evidence suggests that dietary phytoestrogens intake is associated with reduced risk of breast, endometrial and prostate cancers". *Nutrition Research* 26.12 (2006): 609-619.
24. Swanson CA., *et al.* "Dietary determinants of lung-cancer risk - results from a case-control study in Yunnan province, China". *International Journal of Cancer* 50.6: 876-880.
25. Azuma N., *et al.* "Preventive effect of soybean resistant proteins against experimental tumorigenesis in rat colon". *Journal of Nutritional Science and Vitaminology* 46.1 (2000): 23-29.
26. Kanamoto R., *et al.* "Soybean resistant proteins interrupt an enterohepatic circulation of bile acids and suppress liver tumorigenesis induced by azoxymethane and dietary deoxycholate in rats". *Bioscience, Biotechnology, and Biochemistry* 65.4 (2001): 999-1002.
27. Sun CL., *et al.* "Dietary soy and increased risk of bladder cancer: The Singapore Chinese health study". *Cancer Epidemiological Biomarkers Preview* 11.12 (2002): 1674-1677.
28. Igene JO., *et al.* "Development of Hamburger using Full Fat Soybean Flour". *Global Journal of Agricultural Science* 1.2 (2002): 71-76.
29. AOAC. Official Methods of Analysis. 17th edition. Association Official Analytic Chemist, Arlington, VA (2000).
30. British Nutrition Foundation. Sensory Evaluation Hedonic scale hand out (2004).
31. GENSTAT. GENSTAT PC/windows Vista package, version 8.1. Lawes Agricultural Trust, Rothamsted Experimental station (2005).
32. Food and Agriculture Organization of the United Nations, Rome. "Root, tubers, plantains and bananas in human nutrition" *FAO* (1990).

33. Igene JO., *et al.* "Proximate composition and sensory evaluation of three forms of soy flour/moringa catfish (*Clarias gariepinus*) balls". *Journal of Raw Materials Research* 10.2 (2016): 1-17.
34. Tettey ECT., *et al.* "Studies on the quality of traditionally smoked-dry snail meat (*Achatina achatina*) in Ghana". *Ghanian Journal of Agricultural Science* 30 (1997):145-150.
35. Aletor O., *et al.* "Comparative Study of the Nutritive Characteristics, Functional Properties and In Vitro Protein Digestibility of Fish-meal and some Unconventional Protein Concentrates". *Journal of Sustainable Technology* 1.1 (2010): 67-75.
36. Ebabhamiegbeho PA., *et al.* "Improvement in smoked beef production using the hazard analysis and critical control points (HACCP) system". *Nigerian Journal of Agriculture, Food and Environment* 9.1 (2013): 80-86.
37. Freitas MT., *et al.* "Effect of cooking method on the formation of 7-ketocholesterol in Atlantic hake (*Merluccius hubbsi*) and smooth weakfish (*Cynoscion leiarchus*) fillets". *LWT-Food Science and Technology* 62.2 (2015): 1141-1147.
38. Várela, G. "Frying Food in Olive Oil". *International olive oil council, Madrid* (1994): 16-17.
39. Ray FK., *et al.* "Effect of Soy Level and Storage Time on the Quality Characteristics of Ground Beef Patties". *Journal of Food Science* 46.6 (1981):1662-1664.
40. Boles JA and Pegg R. "Meat colour". Montana State University and Saskatchewan food product innovation programme", University of Saskatchewan (2005).
41. Faustman C and Cassens R G. "Proceedings. 35th International Congress of Meat Science and Technology. Copenhagen, Denmark (1989): 446.
42. Serdaroglu M. "Improving low fat meat balls characteristics by adding whey powder". *Meat Science* 72.1 (2006): 155-163.
43. Bognar A. "Comparative study of frying to other cooking techniques influence on the nutritive value". *Grasas y Aceites* 49.3-4 (1998): 250-260.
44. Otunola GA., *et al.* "The effects of addition of Moringa leaf waste fibre on proximate and sensory characteristics of cookies". *Agrosearch* 13.1 (2013): 69 -75.
45. Wang Y., *et al.* "Shrinkage of chicken nuggets during Deep-fat frying". *International Journal of Food Properties* 13.2 (2010): 404-410.
46. Chukwu O. "Influences of drying methods on nutritional properties of tilapia fish (*Oreochromis niloticus*)". *World Journal of Agricultural Sciences* 5.2 (2009): 256-258.
47. Serdaroglu M., *et al.* "Quality of low fat meatballs containing legume flour as extenders". *Meat Science* 70.1 (2005): 99-105.
48. Chambers IV E and Bowers J R. "Consumer perception of sensory qualities in muscle foods". *Food Technology* 47 (1993): 116-126.
49. Hsu S Y and Yu S H. "Effect of phosphate, water, fat and salt on qualities of low fat emulsified meat ball". *Journal of Food Engineering* 39.2 (1999): 123-130.
50. Hsu S Y and Chung H Y. "Effect of processing factors on qualities of emulsified meat balls". *Journal of Food Engineering* 36.3 (1998): 337-347.

51. Makkar HPS and Becker K. "Nutrients and antiquality factors in different morphological parts of the Moringa oleifera tree". *Journal of Agricultural Science* 128.3 (1997): 311-322.

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