Determination and sensory evaluation of soy flour-meat combinations in the production of meatballs

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Abstract: The increasing cost of animal protein has necessitated the need to investigate the use of cheaper and nutritive alternatives in various food formulations. The study was carried out to determine the appropriate level of soy flour inclusion in meatball production. The soy meat balls were formulated to contain 0%, 10%, 15%, 20% and 25% of full-fat soy flour which was combined with beef and some condiments. Treatments were analyzed in triplicates in a randomized complete block design. A 7-point hedonic scale was used to evaluate the sensory characteristics (colour, taste, texture and overall acceptance) of the products using a semi-trained taste panel. Nutrient proximate composition values and production cost were also determined. Results showed that on the average, soy flour inclusion in meatballs increased cooking yield by reducing weight loss from 27.33% to 12.96%. Meatballs with soy flour inclusions at 10% and 15% were most acceptable (very much liked). The 20% and 25% level of soy flour inclusion were moderately acceptable, thereby indicating acceptability up to 25% level of soy flour inclusion. Soy inclusion reduced production cost by N37.50 on the average at N45.00 per ball when compared with all meat products as well as, increasing the number of balls per mix from 64 balls (control) to an average number of 89.5 balls (soy meatball). It is recommended that further studies of the soy flour inclusion in meatballs production be carried out to ensure the availability of cheaper, nutritious and acceptable convenience food in the Nigerian market.

Keywords: Meatballs, Sensory evaluation, Soy flour-meat

INTRODUCTION

As the world population continues to grow, various governments are confronted with the serious challenge of meeting the complex food needs of societies faced with short supply of animal protein. Protein is one of the major nutrients in diets needed by the human body. Since soy bean is a rich and cheaper source of plant protein, increasing research into its production and utilization would ensure a steady avenue for providing the much needed cheap but balanced protein. This would meet the teething challenges of declining protein availability in a randomized complete block design. A 7-point hedonic scale was used to evaluate the sensory characteristics (colour, taste, texture and overall acceptance) of the products using a semi-trained taste panel. Nutrient proximate composition values and production cost were also determined. Results showed that on the average, soy flour inclusion in meatballs increased cooking yield by reducing weight loss from 27.33% to 12.96%. Meatballs with soy flour inclusions at 10% and 15% were most acceptable (very much liked). The 20% and 25% level of soy flour inclusion were moderately acceptable, thereby indicating acceptability up to 25% level of soy flour inclusion. Soy inclusion reduced production cost by N37.50 on the average at N45.00 per ball when compared with all meat products as well as, increasing the number of balls per mix from 64 balls (control) to an average number of 89.5 balls (soy meatball). It is recommended that further studies of the soy flour inclusion in meatballs production be carried out to ensure the availability of cheaper, nutritious and acceptable convenience food in the Nigerian market.

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INTRODUCTION

As the world population continues to grow, various governments are confronted with the serious challenge of meeting the complex food needs of societies faced with short supply of animal protein. Protein is one of the major nutrients in diets needed by the human body. Since soy bean is a rich and cheaper source of plant protein, increasing research into its production and utilization would ensure a steady avenue for providing the much needed cheap but balanced protein. This would meet the teething challenges of declining protein availability in the form of soy-based food; such as soy meat combination in the form of soy meatball (Iwe, 2003; Igene et al., 2012; Igene et al., 2006; Igene et al., 2002). One of the reasons animal proteins is costly is perhaps the high cost of animal feed which is more than 65% of the cost of production (Oloma, 2011). In view of the increased interest in soy-based foods such as soy-meat, there is need to strategise in defining the relationship between specific diet component such as soy protein and human health (WHF, 2004). This specifically relates to the mechanisms of beneficial cholesterol lowering and anti-carcinogenic effects of soy proteins and other soy components (Friedman and Brandon, 2001; Raji and Famurewa, 2008).

Soybean processing in Nigeria started with the processing of soybean into daddawa in the Southern Kaduna area of Kaduna State. As popularization of the crop as a source of human food progressed, Home Economics at the Ahmadu Bello University, Zaria documented the preparation of soya milk and soy flour. The timely preparation of soy flour was introduced when the ban on importation of wheat by the Babangida military administration into the processing of soy bean and later on, processors of soy flour or powder came along (Iwe, 2003). Soy protein used in the meat production is increasing because of their unique functional characteristics as meat extenders and functional ingredients. Meat extenders are defined as proteins which are non-meat proteins but are usually plant proteins. A wide variety of meat extenders are available for use in emulsion type sausages to improve consistency, emulsifying and water holding capacity (FAO, 1991). The main value of plant protein in comminuted meat products is to reduce formulation cost. They have the ability to improve viscosity, texture, firmness, moisture, overall yield, fat binding, emulsifying capacity, sensory properties and storage stability (Kinsella, 1979). The
increasing use of soy proteins in meat product is also
due to the availability and low cost of soybean relative
to other extenders such as cotton, sunflower, wheat flour;
sodium caseinate, egg protein and non-fat dry milk
(Lecomte et al., 1993). They are also used in processing
frankfurters, bologna, meat loaves, meatballs, meat
patties, and luncheon meats (Igene et al., 2002).
Health benefits of soy in meat include prevention of heart
diseases, cancer, high blood pressure, diabetes-related
disease and many others. Soy bean oil is rich in fatty
acids and devoid of cholesterol. It is an excellent source
of calcium, iron, and vitamins such as niacin, thiamin and
riboflavin. Soy contains all essential amino acid apart
from methionine and tryptophan. These amino acids
closely match those required for humans. (Russell, 2004;
Sacks et al., 2006). Soy-meat may also help with
menopause symptoms and osteoporosis. Soy contains
an impressive array of phytochemicals (biologically active
components derived from plants (Sacks et al. 2006), which
are beneficial to human nutrition. The proximate
composition, cost analysis and sensory characteristics
of soy meatballs among other important parameters are
yet to be evaluated

The increased level of urbanization in Nigeria has
informed the need to develop more convenience products
using meat and although some studies have investigated
the development of various forms of meatballs, studies
on the inclusion of soy was scarce (Igene et al., 2006;
Igene et al., 2012). The objectives of this study are
therefore to determine the best level of soy flour inclusion
appropriate for meatball using beef, to determine the
sensory characteristics of the products and their levels
of acceptability, to determine the chemical composition
of the different levels of the soy flour inclusion in
meatballs, and to ascertain its cost effectiveness.

MATERIALS AND METHODS

Source of raw materials: The experiment was carried
out in the Faculty of Agriculture laboratory, University
of Benin, Benin City. The following materials were used:
2kg beef was purchased from New Benin market. The
connective tissues were trimmed off after which it was
washed and stored in a deep freezer until when needed.
4kg soybean was purchased from New Benin market, and
processed into soy flour as described in Fig 1.

Experimental treatments: Five different combinations
of soy flour/beef were investigated, each in three
replications. The combinations were as follows; (i)
0/100% soy flour/beef (control) (i) 15/85% soy flour/beef
(ii) 20/80% soy flour/beef, and (iv) 25/75% soy flour/
beef.

Processing: The stored beef was thawed at room
temperature (26 ± 2°C) and was ground using Monlinex
meat mincer, Model (H v 6). The soybean (Glycine max)
was processed into soy flour as shown in Fig. 1

Mix formulation of soy meatball: The mix was produced
as shown in Fig. 2, substituting meat with soy flour at
15%, 20%, 25% and 30% for beef. Whole beef was used
as the control. Blue flame produced by a medium sized
kerosene stove was used. The soy-meat mix formulation
is shown in Table 1. The soy-meat mix was manually rolled
into small balls of 3 cm in diameter each (see Fig 2). In
other to reduce bias, condiments were of equal
proportions in the individual mix formulation resulting
into 250 g per mix. They were then fried in hot vegetable
oil using a deep fat fryer at 170°C (model PH-515) for 3
minutes. Each soy meatball on the average, weighed 3.11
g before frying and 2.622 g after frying. The number of
balls produced per treatment is shown in Table 5.

Weight loss and yield determination: The weight of soy
meat-ball and fried balls were taken and weight loss (%)
was calculated as follows;

Weight loss (g) = soy meat mix-fried soy meatballs
Weight loss (%) = weight loss x 100
Weight of soy meat mix

Proximate analysis: The fried samples were analyzed for
moisture, ash, ether extract, protein and carbohydrate
(NFE) as described by AOAC (1990). These experiments
were carried out in three replicates.

Sensory evaluation: Five samples were coded and
presented to a semi-trained sensory panel made up 20
judges to evaluate samples according to degree of
likeness in respect to colour, taste, texture and overall
acceptance. Water and cracker biscuits were served in
between samples assessment to enable panelists rinse
properly and neutralize carryover flavours in their mouth.
Panelists were served in their separate locations far away
from the sample cooking and preparation room and
samples were coded to reduce bias. A 7-point hedonic
scale having 7 (like extremely) as the highest score and 1
(dislike extremely) as the lowest score was used
according to the procedure described by Watts et al.
(1989).

Statistical analysis: The data obtained from the study
were analyzed using randomized complete block design
(RCBD) and simple LSD test was used to determine which
sample differed significantly from the other.

RESULT AND DISCUSSION

The results of effects of varying soy inclusion on weight
loss and yield parameters are as shown (Table 2). There
was a reduction in weight loss from 27.33% to 12.96%
resulting to an increase in yield as the level of soy flour
inclusion increased. Soy flour inclusion increased the
cooking yield by an average value of 87.04%. There were
### Table 1. Mix formulation of soy meatball.

| Ingredients          | Levels of Soy Flour/Beef (%) | Treatments | 1  | 2  | 3  | 4  | 5  | Total |
|----------------------|-----------------------------|------------|----|----|----|----|----|-------|
|                      |                            |            | 0/100% | 10/90% | 15/85% | 20/80% | 25/75% |        |
| Soy flour            | 80                          | 0          | 20   | 30   | 40   | 50   | 90    |
| Beef                 | 200                         | 180        | 170  | 160  | 150  | 710  |
| Wheat flour          | 6.36                        | 15.9       | 15.9 | 15.9 | 15.9 | 79.5 |
| Salt                 | 0.18                        | 0.45       | 0.45 | 0.45 | 0.45 | 0.45 | 2.25  |
| Water                | 1                           | 2.5        | 2.5  | 2.5  | 2.5  | 2.5  | 12.5  |
| Red pepper           | 0.4                         | 1          | 1    | 1    | 1    | 1    | 5     |
| Thyme                | 0.12                        | 0.3        | 0.3  | 0.3  | 0.3  | 0.3  | 1.5   |
| Curry                | 0.6                         | 1.5        | 1.5  | 1.5  | 1.5  | 1.5  | 7.5   |
| Ginger               | 0.6                         | 1.5        | 1.5  | 1.5  | 1.5  | 1.5  | 7.5   |
| Onion                | 3.0                         | 7.5        | 7.5  | 7.5  | 7.5  | 7.5  | 37.5  |
| Seasoning cube       | 1.6                         | 4          | 4    | 4    | 4    | 4    | 20    |
| Cassava Starch       | 5.14                        | 12.85      | 12.85| 12.85| 12.85| 12.85| 64.25 |
| Sugar                | 1                           | 2.5        | 2.5  | 2.5  | 2.5  | 2.5  | 12.5  |
| Total                | 100%                        | 250g       | 250g | 250g | 250g | 250g | 1000g |

### Table 2. Weight loss and yield per ball.

| Samples | Number of balls per mix | Weight before frying (g) | Weight after frying (g) | Weight loss (g) | Weight loss (%) | Yield (%) |
|---------|-------------------------|--------------------------|-------------------------|-----------------|-----------------|-----------|
| 0%      | 64                      | 3                        | 2.18                    | 0.82            | 27.33           | 72.67     |
| 10%     | 80                      | 3.07                     | 2.58                    | 0.49            | 15.96           | 84.04     |
| 15%     | 85                      | 3.13                     | 2.66                    | 0.47            | 15.02           | 84.98     |
| 20%     | 91                      | 3.15                     | 2.69                    | 0.46            | 14.60           | 85.40     |
| 25%     | 102                     | 3.2                      | 3.00                    | 0.2             | 6.25            | 93.75     |

Note: the diameter of each meatball was 3 cm

### Table 3. Proximate analysis of the soy meatball.

| Soy meatball | Moisture (%) | Ash (%) | Fat (%) | Protein (%) | Carbohydrate (%) |
|--------------|--------------|---------|---------|-------------|------------------|
| 0%           | 35.81        | 1.833   | 12.33   | 38.33       | 11.70            |
| 10%          | 34.92        | 1.933   | 14.67   | 34.88       | 13.56            |
| 15%          | 27.23        | 1.967   | 19.00   | 33.28       | 18.40            |
| 20%          | 25.05        | 2.133   | 21.33   | 33.09       | 18.55            |
| 25%          | 15.76        | 2.333   | 29.33   | 27.56       | 25.01            |

### Table 4. Treatment means of sensory evaluation for fried soy meatballs.

| Fried soy meatball | Colour | Taste | Texture | Overall acceptance |
|--------------------|--------|-------|---------|--------------------|
| 0%                 | 3.833a | 6.383a| 6.150a  | 6.3a               |
| 10%                | 6.017b | 6.100b| 5.560b  | 6.233a             |
| 15%                | 6.567a | 5.883b| 5.350bc | 6.017a             |
| 20%                | 5.550c | 5.217d| 5.083bc | 5.367b             |
| 25%                | 5.433c | 5.100d| 4.950d  | 5.200b             |

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

Significant differences (P<0.05) between the weights of the soy meatball due to frying. This result suggests an inverse relationship between soy inclusion levels and weight loss. Cooking yield represents the retention of water and solutes during processing of food product (Lecomte et al. 1993). Ray et al. (1981) observed significant increase (P<0.05) in cooking yield up to 26% soy concentration in his study using ground beef. According
to Scheiwger (1974), soy protein is commonly used in processed meat as a binder to reduce processing cost and increase yield. The trend in weight changes showed an increase in weight due to the increasing ability of the soy flour to bind moisture. This is consistent with the finding of Vaisey et al. (1975) that replacement of meat with legumes resulted in reduction drip losses. Soy protein contributes to the nutritional and general overall eating quality of meat products (Waggle et al., 1981). It has also been reported that preference of acceptance testing is often used to evaluate products reformed with soy ingredients and it is not common to find reports of reformulated products that are significantly preferred over the all meat control. The highest yield in this study is however lower than that of uncured and unspiced meat ball samples prepared in an earlier study (Igene et al., 2012), thus suggesting that there may be other factors which determine the yield of a sample. These range from length of thawing, frying, steaming and quantity of oil used.

Results of proximate analysis showed that 10% soy inclusion level yielded the highest protein level (34.88%) with 25% inclusion level yielding the lowest (27.56%). This suggests an inverse relationship between these parameters and thus requires further research. Increasing inclusion levels resulted in correspondingly higher fat content of the samples. The need to analyse the fatty acid profile of these samples is necessary to further elucidate the value of each sample as regarding the age groups of persons for which it is appropriate. There was no significant difference between the moisture content of the various combinations except the control (0% soy flour inclusion), which displayed the highest water holding capacity, while 25% soy flour inclusion was the poorest (Table 5). The estimate of ash in samples containing soy flour may be due to stored waste products in plants animals. It is known that plants do not have the ability to dispose of waste materials, instead they are stored as harmless materials in some parts of the plant which could be the seed, consequently the ash content of the full fat soy, flour is high. The fat emulsion at 0% soy flour inclusion being the lowest may have been due to fat drip during frying. This finding compares favourably with that of Igene et al. (2002). The increase in fat content may be attributed to the binding of free fat (fat absorption) by soy proteins (Wolf and Cowan, 1975; McWaters and Cherry, 1971; Roa et al., 1984). The
Cut the meat into uniform bits

Grind

Take a known percentage of the meat

Mix with a known percentage of soy flour (full-fat soy flour)

Mix with condiments

Cook mix for 6 minutes

Form small regular balls from mix manually

Fry the balls at 170°C for 3 minutes in hot vegetable oil with a deep fat fryer

Cool

Meatball

Fig. 2. Unit production of Soy meatball.

decrease in protein content is consistent with the work of Ray et al. (1981) that as the soy level increased in ground meat, the protein decreased. In the sensory evaluation, the colour scores were significantly different (P<0.05) at 0% to 15% except 20% and 25% which were not significantly different (P<0.05) from each other (Table 4). However, the value for colour at 0% soy flour inclusion was lowest while 15% was highest. In processing, colour has been identified as the single most important factor of meat products that influences consumer buying decision and affects their perception of the freshness of the product (Boles and Pegg, 2005). Generally, the taste decreased in the likeness for texture though there were no significant difference between 20% and 25% soy flour inclusion. 25% had the lowest texture score. The products were generally accepted. However, up to 15% soy flour inclusion was liked very much. This may indicate that soy flour inclusion up to 25% is acceptable. There were no significant differences between 0%, 10% and 15% soy flour inclusion in terms of overall acceptance. Up to 15% inclusion of soy flour in meatball formulation would therefore be most appropriate in the interim (Table 5). Cost analysis of the various soy meatballs produced in this study showed that as soy flour inclusion increased the cost of production decreased (Table 5). At 10% soy flour inclusion, there was a cost reduction of N15.00, while at 25% there was a cost reduction of N60.00. On the average, there was a cost reduction of N37.50 at N5.00 per ball. This shows that the use of binders/extenders
which are relatively cheap can culminate in economic production of these nutritious products for the ever-soaring Nigerian population (Igene et al., 2012). These soy meatballs can therefore be recommended for inclusion into the diets of different categories of individuals based on health needs. They can also serve as convenience foods/snacks for the Nigerian consumers who have been earlier projected to buy more of pastries and other convenience foods to complement their busy lifestyles (DFM, 2007).

Conclusion

The study concluded that up to 25% soy flour inclusion was generally accepted by consumers. Amidst the soy flour inclusion, 10% and 15% were liked very much while 20% and 25% were moderately liked with respect to acceptability. It was obvious that the addition of soy flour helped in increasing the cooking yield by 87.04% on the average and reduction of production cost by N37.50 on the average when compared with the all meat product (control). Soy flour as an extender, increased the number of balls per mix from 64 balls (the control) to an average number of 89.5 balls (the soy meatballs). The analysis has therefore proven that the product can be accepted up to 25% soy flour inclusion as well as reducing production cost and increasing cooking yield. Since Nigeria has been blessed with abundant soybeans, incorporating soy protein products (its derivative) into meat and meat products will not only serve to reduce the cost of meat products, but will also act as a meat extender as well as lengthening its shelf-life. In view of the health benefits of soy, it is therefore important that advances in research and development of soy meat combination that has significant value in the fast food industry be made, especially in Nigeria and other developing countries where animal products supply is a major challenge.

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