Full Length Research Paper

Investigation of the potential of fortified instant *matooke* flour in rehabilitation of malnourished children (Part 1): Optimal level of fortification of instant *tooke* flour porridge and its nutritional quality attributes

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The aim of this study was to optimize levels of incorporation of soybean and sesame flours into instant *tooke* (cooking banana) flour (ITF) porridge with respect to sensory quality. The flours were prepared using conventional dehydration procedures. A mixture design was developed for incorporating sesame and soybean flours into *matooke* flour. From the design thirteen porridge formulations were developed on which sensory evaluation was determined using 9-point hedonic scale. Sensory parameters determined were taste color, flavor, consistency, mouth feel and overall acceptability. Based on sensory evaluation, one optimal formulation was identified. Nutritional quality attributes of the optimum formulation were determined. Viscosity was determined using the Rapid Visco-Analyser. The optimal formulation was 64.90, 16.34 and 18.76 % *matooke,* soybean and sesame respectively. The results indicated that incorporation of soybean and sesame into ITF porridge significantly (p<0.001) enhanced its sensory quality attributes. Energy density and protein content of the optimum formulation was 502.12 Kcal and 11.1% respectively. Incorporation of sesame and soybean flours into ITF resulted in reduction in viscosity. The study suggested that fortification of ITF with soybean and sesame enhances sensory and nutritional quality.

Key words: *Matooke,* fortification, optimization.

INTRODUCTION

Bananas are an important staple food for more than 70% of Uganda's population. Cooking bananas also known as '*matooke*' (East African highland cooking bananas) are grown by 72% of farmers on an average plot size of one hectare, which is 12.3% of the world total (Karugaba and Kimaru, 1999). The high production levels not with-standing, Nutrition and Health reports in Uganda have indicated high levels of malnutrition and hence high include low energy density of weaning foods and lack of ready to prepare formulations, which lead to infrequent

mortality rates among children less than five years. The underlying factors for malnutrition have been identified to feeding due to the heavy workload of the caregivers especially among the rural poor (Kikafunda, 1996).

However, recent advances in processing of *matooke* have succeeded in reducing the relative bulk of *matooke* starch by pre-gelatinization (Muranga, 1998). Pre-gelatinization can be done either by cooking the *matooke* before drying or by extrusion cooking. Studies on weanling mice showed that both techniques were equally effective in enhancing bioavailability of the *matooke* starch (Muranga et al., 2007). Muranga (1998) reported that *matooke* has high starch content (Dry basis 81.8 - 85.7%) and subsequently has a high potential as a calorie resource base. Energy sufficiency in the diet is critical for a good overall nutritional status at the weaning

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Table 1. Design for the different levels of incorporation of sesame and soybean flours into ITF.

Code	Treatment	ITF %	Soybean %	Sesame %
G	12	80.56	19.44	0.00
E	7	50.33	19.44	30.22
F	10	91.67	2.78	5.56
J	13	60.67	14.58	24.75
I	11	75.22	0.00	24.78
B	2	58.56	25.00	16.44
C	3	61.44	5.56	33.00
G	8	80.56	19.44	0.00
D	4	71.00	12.50	16.50
E	5	50.33	19.44	30.22
A	1	81.33	6.25	12.42
F	6	91.67	2.78	5.56
H	9	66.78	25.00	8.22

stage and the carbohydrate requirement in the diet is adequately covered by the pregelatinised *matooke* starch (Muranga *et al;* 2007).

Additionally, *matooke* flour when mixed with soybean in substantial ratios, results in increase in the protein level and the products have good consumer quality attributes as well as high Protein Efficiency Ratio (PER) because of the latter's good lysine levels (Katebarirwe, 2005). Though deficient in the sulphur containing amino acids, (cysteine and methionine), soybeans' chemical score in comparison to egg protein is high (70%). In compensation for the limiting amino acids, sesame (*Sesamum indicum*) also known locally as *simsim* can be used (FAO, 1989). Sesame contains 988 mg per 100 g of food, of methionine and cystein combined, in contrast to soybean 422 mg per 100 g and eggs at 717 mg per 100 g (FAO, 1989). *Matooke*, sesame and soybean are available locally at an affordable cost and can therefore be used in combination as part of a child's diet to ensure good nutrition. Besides, pilot studies revealed relatively high Protein Efficiency Ratios (PER), when the cooked *matooke* flour fortified with a soybean/sesame composite was fed to weanling rats (Muranga et al., 2003a).

METHODS

Preparation of ITF, soybean and sesame flours

The ITF was prepared according to patent number UG/P/04/00010. The soybean and sesame flours were prepared according to methodology outlined by Muranga and Mutambuka (2003).

Fortification of ITF and sensory evaluation

Thirteen (13) design points were generated using design expert software version 6.0 computer package Stat-ease, Inc., MN, USA;

2003. Based on previous studies, the levels of incorporation of sesame flour were varied between 0 - 33, while soybean was varied between 0 - 25 and the rest being ITF as shown in Table 1. The flour mixtures were then used to prepare test porridges for sensory evaluation. The test porridges were then prepared by dissolving 100g of composite flour in 300 ml of cold water after which boiling water was added in varying quantities. 700 ml of boiling water was added to mixture A, G and F, 600 ml to mixture H, I and D, and 500 ml to porridge B, C, J and E. The porridges were boiled for five minutes with stirring, after which 10 g of sugar were added. The porridges were then evaluated by a panel of 13 panelists with respect to sensory indicator parameters using the nine - point hedonic scale. The panel consisted of final year students of Masters of Science in Food Science and Technology, Masters of Science in Applied Human Nutrition and Bachelors of Science in Food Science and Technology, all of Makerere University. The above individuals were given basic training before commencing the evaluation. The sensory evaluation data used to determine the optimal levels for incorporating soybean and sesame flours into *matooke* flour using Stat-ease design expert. Optimization was done with respect to mouth feel, taste and overall acceptability by fitting data from the sensory experiment to a quadratic surface response model as shown in Table 2.

ITF physiochemical properties

The viscosity of the porridges was analyzed using the flocken programme of the Rapid Visco Analyser (RVA Flocken Thermocline version 2.0 Newport Scientific Scientific PTY, Ltd, NSW Australia). Proximate analysis was done on the optimum formulation derived, to get the energy, protein, fat, iron and zinc contents, using standard AOAC (1999) and the Vitamin A content using the colorimetric method (Underwood and Stekel, 1984).

DATA ANALYSIS

The data was entered into Excel spread sheet in preparation for analysis. The sensory evaluation data was analyzed by REML and the Viscosity data was analyzed by one way ANOVA using the Gen stat 5 Release 3.2 (PC/Windows NT) statistical package for means

Table 2. Optimization models with respect to taste, mouth feel and overall acceptability.

Response	Second order polynomials	R^2	Significance
Taste	$Y = 0.052539X_1 + 0.11544X_2 + 7.31243E\text{-}003X_3$	0.1442	0.0221
Mouth feel	$Y = 0.070183\ X_1 - 0.035189X_2 + 0.040823X_3$	0.1468	0.0204
Overall acceptability	$Y = 0.11495X_1 - 41.23019\ X_2 + 9.72199\ X_3 + 0.68827\ X_1X_2 - 0.16649\ X_1\ X_3 + 0.52249\ X_2X_3 - 4.00042E\text{-}003\ X_1\ X_2\ X_3 + 2.92411E\text{-}003\ X_1X_2(X_1 - X_2) - 7.07623E\text{-}003\ X_1\ X_3(X_1 - X_3) - 5.50244E\text{-}003\ X_2\ X_3(X_2 - X_3)$	0.2109	0.2938
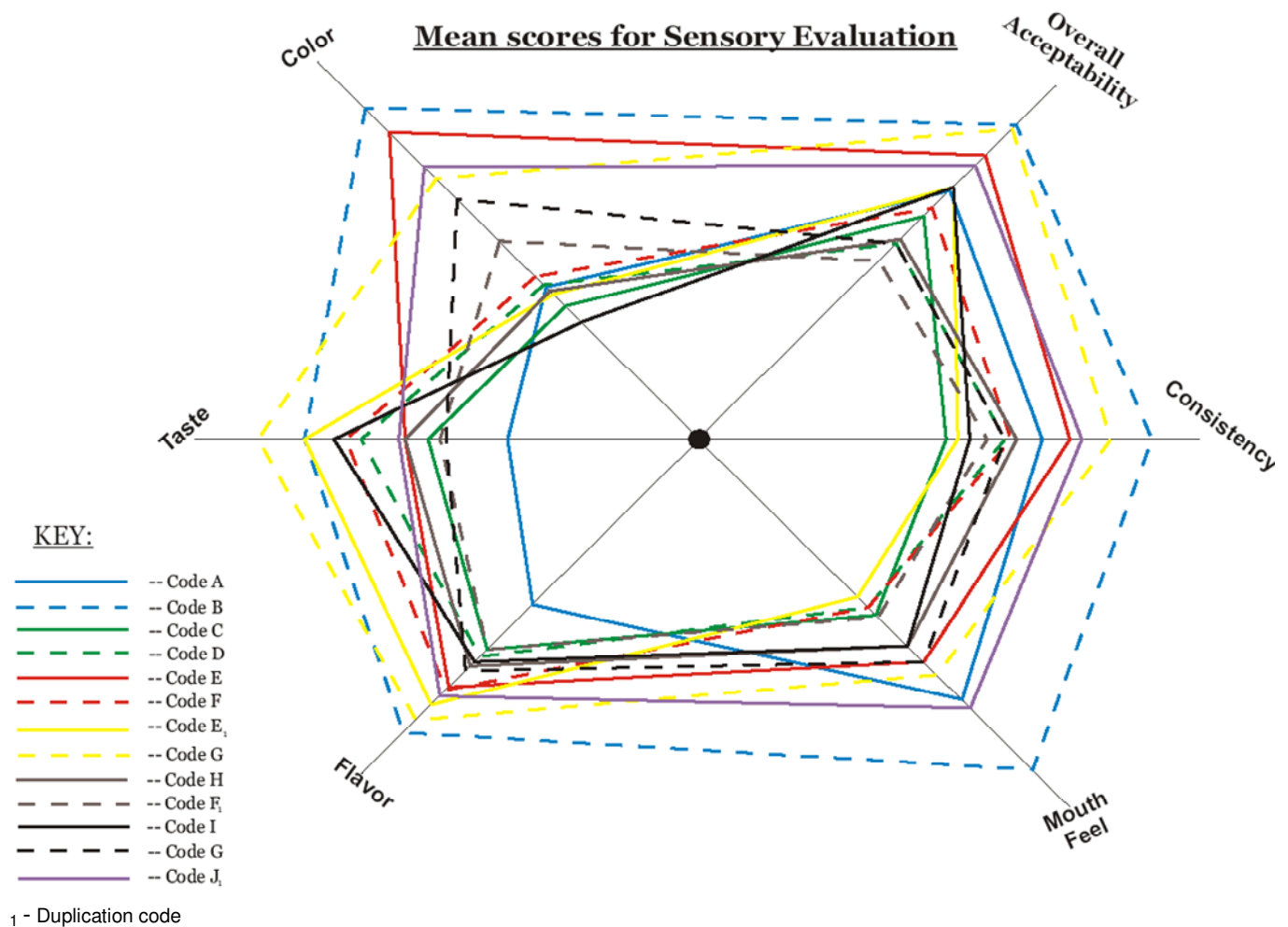
Figure 1. Sensory characteristics of the formulations. Key: Levels of incorporation of *matooke*/soybean/sesame respectively; A – 81.33/6.25/12.42; B – 58.56/25.00/16.44, C - 61.44/5.56/33.00; D – 71.00/12.50/16.50; E – 50.33/19.44/30.33; F – 91.67/2.78/5.56; G – 80.56/19.44/0.00;   H – 66.78/ 25.00/8.22; I - 75.22/0.00/24.78; J – 60.67/14.58/24.75.

means, standard errors of differences and least significant differences.

RESULTS

Sensory Evaluation: Six sensory characteristics namely color, taste, flavor, mouth feel, consistency and overall acceptability were analyzed. The results are presented in Figure 1.

Porridge (I) containing 0.00, 24.78 and 75.22% soybean, sesame and *matooke* respectively had the lowest scores for color because no soybean was added to it to give the yellow color, while porridge (B) with 25.00, 16.44 and 58.56% soybean, sesame and *matooke* respectively had the highest score due to the high soybean content. Porridge (A) containing 6.25, 12.42 and 81.33% soybean, sesame and *matooke* respectively had
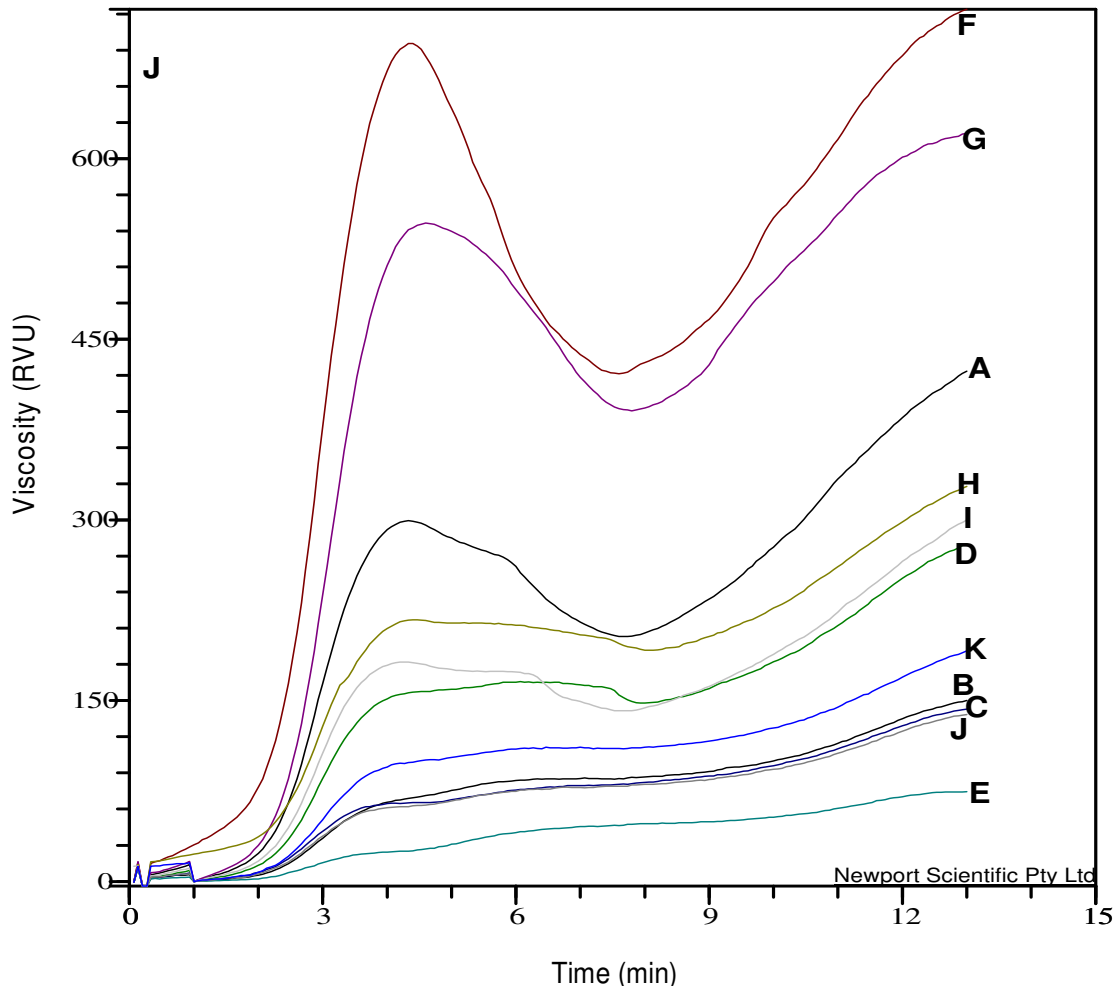
Figure 2. Viscoamylograph for *matooke*/soybean/sesame formulations. Key: levels of incorporation of *matooke*/soybean/sesame respectively. A – 81.33/6.25/12.42; B – 58.56/25.00/16.44, C - 61.44/5.56/33.00; D – 71.00/12.50/16.50; E – 50.33/19.44/30.33; F – 91.67/2.78/5.56; G – 80.56/19.44/0.00; H – 66.78/ 25.00/8.22; I - 75.22/0.00/24.78; J – 60.67/14.58/24.75; K - 65.00/16.00/19.00.

the lowest score for taste and flavor because of the high sesame content vis-à-vis the soybean.   Porridge (E) containing 19.44 and 30.22% soybean and sesame respectively had the lowest score for mouthfeel due to the high sesame content which was not finely ground, while porridge (C) containing 5.56, 33.00 and 61.44% soybean, sesame and *matooke* respectively had the lowest score for consistency also due to the large particle size of the sesame which was also in a high quantity.

Porridge (F) containing 2.78, 5.56 and 91.67% soybean, sesame and *matooke* respectively had the lowest value for overall acceptability while porridge (B) with 25.00, 16.44 and 58.56% soybean, sesame and *matooke* respectively had the highest score for overall acceptability. Porridge (B) containing 25.00, 16.44 and 58.56% soybean, sesame and *matooke* respectively were the best liked porridge. There was a significant (p < 0.001) enhancement in the sensory characteristics in all the porridges except for color in porridge (I).

Sensory evaluation of the formulations

Optimization of the sesame and soybean into the *Matooke* Flour: A numerical optimization was done using the design expert of the Stat-ease statistical package to come up with the optimal product, using the sensory evaluation data. The most optimum combination had a ratio of 64.9: 16.34: 18.76 for the ITF/ soybean/ sesame mixture.

Physiochemical properties of *Matooke* flour

Viscosity of the formulations: The *matooke*/soybean/sesame formulations were analyzed for viscosity and the results are as shown in Figure 2. Porridge F and G had the highest peak trough, setback and final viscosities due to the low levels of incorporation of the soybean and sesame, while porridge E had the

lowest due to the high levels of incorporation of the soybean and sesame. Porridge B, C and J had similar trends for the peak, trough, setback and final viscosity, as they both had almost no peak and were level throughout. Porridge H, I and D had intermediate peak trough, setback and final viscosities. The decline in peak viscosity was rapid for porridge F, G and A, but was gradual for porridge H, I and D. Porridge K, the optimum formulation had a lower peak viscosity, a level trough and setback and a gradual increase to the final viscosity, indicating its stability.

Proximate analysis: The average composition of moisture, protein, iron, zinc vitamin A and energy of the optimized sample were analyzed. The crude protein content was 11.1%, Energy content 502.12 Kcal/100g, Iron content 0.003%, Zinc content 0.009% and Vitamin A content was 185 µg/100g.

DISCUSSION

Sensory evaluation

Porridge (B) was liked best; this could be attributed to the addition of soybean and sesame up to 25 and 16% respectively. This gave the porridge a good color, flavor, mouth-feel, consistency and taste. The same percentage of incorporation of soybean was also reported in a previous study (Katebarirwe, 2005). There was a significant (p < 0.001) enhancement in the sensory characteristics in all the porridges except for color in porridge (I). This could be attributed to the lack of soybean in this mixture. Soybean has a yellow color which is attributed to carotenoids, also present in the commonly available foods (Lee, 1983). Fennema (1986) reported an apparent increase in yellowness in blanched products, which he attributed to inactivation of lipoxygenase, an enzyme that catalyses oxidative decomposition of carotenoids. Soybean has a characteristic beany flavor, which has been attributed to formation of volatile compounds by lipoxygenase activity (Kwang et al., 2000). Addition of soybean beyond 25% makes the beany flavor more pronounced, hence reducing its acceptability (Katebarirwe, 2005). However, addition of sesame helped to mask the beany flavor and subsequently the general enhancement in acceptability as previously recorded.

Viscosity

Porridge F and G had the highest peak, setback and final viscosity due to the low levels of soybean and sesame incorporated into the formulations. Peak viscosity denotes maximum peak of pasting of native starch and the beginning of the cooking stage, and is said to be indicative of the ease of swelling by the starch granules with a low peak value reflecting restricted swelling (Muranga, 1998). Solubilised or totally gelatinized starch has virtually no peak viscosity at normal starch/water ratio in the pasting cycle. Setback viscosity is a measure of the setback that occurs on cooling the hot paste while the final viscosity gives a measure of the stability of the cooked paste under simulated use conditions (Muranga, 1998). According to Mazurs et al. (1957), exhibition of restricted swelling is true for modified or cross-linked starches, which often have minimal setback on cooling. Addition of sesame and soybean into the *matooke* flour significantly (p < 0.001) decreased the final and set back viscosity values for all the porridges except porridge E, which did not peak at all. Reduction of the peak viscosity can be attributed to solubilization of starch (50%) by the protein supplement in soybean and sesame on the one hand and to the interaction between the starch and the lipids (Freidman, 1995 and Collar, 2002). A low viscosity is important for weaning foods because it allows incorporation of more solids in a given porridge volume leading to an increase in energy and protein density.

Proximate analysis

Addition of soybean and sesame increased the protein content of the optimum formulation. Soybean and sesame have been reported to be rich in protein (Osho, 1991 and Salunkhe et al., 1992), whereas cooking banana is a poor source of protein (Simmonds, 1959; Morton, 1987 and INIBAP, 2000). However, the protein content of the optimum formulation was lower (11.1%) than that shown by Muranga and Bukuusuba (2003) who quoted it to be 13.17%. This was due to the differences in the conversion factors used. The conversion factors used were 5.7, 5.71 and 5.3 for *matooke,* soybean and sesame respectively, giving an average factor of 5.57 (Watt and Merrill, 1975), whereas Muranga and Bukuusuba (2003) used the traditional (6.2) conversion factor. This gives a more accurate picture of the actual protein content of the product. Addition of soybean and sesame also increased the energy content of the formulation. This is due to their high protein, carbohydrate and fat contents (Harrison and Tukamuhabwa, 1992 and Salunkhe et al., 1992). The gross energy was also higher (502.12 Kcal/100 g) compared to 459 Kcal/100 g reported by Muranga and Bukuusuba (2003). This was due to the higher sesame content of 19% compared to Muranga and Bukuusuba (2003) who had a sesame content of 16.5%. The optimum product therefore, had a higher nutrition content compared to the product developed by Muranga and Bukuusuba (2003). The Iron and Zinc were in trace amounts while the beta-carotene content was 185 µg/100 g. Fungo et al., 2006 reported similar results for iron, zinc and beta-carotene in fresh *matooke.* Morton (1987) and INIBAP (2000) reported that matooke contains 225 µg of betacarotene and 0.9 mg iron. Salunkhe et al. (1992) reported that Sesame contains 10.5 mg/100 g iron and 30

IU of Vitamin A, while Osho (1991) reported Soybean to contain 110 ppm Iron and 50 ppm Zinc.

The major limitation to the study was time and monetary resources, hence it was not possible to train an expert panel, therefore we had to use the students in the Department of Food Science and Technology as panelists. It would also have been useful to determine protein- energy ratio (PER) using animal studies if it was not for financial constraints.

SUMMARY

Incorporation of soybean and sesame into *matooke* flour porridge significantly (p< 0.05) enhanced its sensory quality attributes and improved on its nutritional quality by lowering its viscosity, thereby improving its protein content and energy density. The most optimum combination was 64.9: 16.34: 18.76 for the *matooke/* soybean/ sesame respectively. This formulation could be useful in preventing and treating malnutrition in children.

From the results, an optimized fortified ITF formulation has a high potential as a weaning food due to its high energy and protein content. Additionally, it reduces the cost of preparation as it takes a short time to prepare and cook, giving the mother enough time to engage in other economic activities. This formulation therefore has the potential of reducing the high malnutrition rates currently plaguing the country.

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