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Nutrient and sensory qualities of extruded malted or unmalted millet/soybean mixture

Veronica A. Obatolu

Institute of Agricultural Research and Training (IAR&T), OAU, P.M.B. 5029, Ibadan, Nigeria

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Abstract

Complementary blends were prepared from mixtures of malted or unmalted millet and soybean. The malted or raw millet was fortified with malted or raw soybean grain mixture at two ratios: 50% (an equal amount to the millet) or 30%. The mixture was extruded in a single screw 600 Jr. insta pro-extruder. The extruded mixtures were analysed for nutrient and sensory qualities. The crude protein was least (18.3%) in unmalted mixtures of 70% millet and 30% soybean (RM70RS30). A significantly ($P<0.05$) higher protein value of 28.9% was observed in malted mixtures (MM50MS50). Extruded combinations of 50% raw millet and 50% raw soybean (RM50RS50) had a significantly ($P<0.05$) higher gross energy value (1819 kJ/100 g) than other mixtures. There were significant differences between the calcium, phosphorus, magnesium, sodium and zinc levels of the mixtures. The mixtures were relatively high in minerals. Lysine and methionine content in the mixtures varied respectively, from 4.39 g/100 g protein in RM70RS30 to 5.30 g/100 g protein in MM50MS50 and 1.28 g/100 g protein in RM5ORS5O to 12 17 g/100 g^{-1} protein in MM70MS30. The sensory evaluation showed that taste, flavour and texture increased with a greater proportion of malted ingredients, but the colour became unacceptable. While increase in the level of soybean improved the chemical values, mixtures with less soybean were more acceptable.

Keywords: Malted; Nutrient; Sensory; Soybean; Unmalted

1. Introduction

Protein energy malnutrition is one of the major public health problems in most developing countries. Infancy is considered the most critical stage, during which there is a high mortality rate. The Nutrition Society of Nigeria (1999) noted that malnutrition is still a serious problem in Nigeria and mortality rate of under fives was 146/1000 live births with 45% of stunting (height for age). This is due to the prevailing socioeconomic problems coupled with the fact that infants are traditionally given cereal gruel as complementary food. The most important cereals grown in Nigeria are sorghum, millet, rice and maize (Wudiri, 1991). The poor quality of protein and high viscosity of such gruel makes it difficult for the child to consume enough to meet both energy and protein requirements. To improve the nutrient intake of children in regions of chronic and acute malnutrition, attention is focussed on processing technology and use of inexpensive sources of protein to fortify cereal.

Processing methods, such as malting and extrusion have proved acceptable and improve nutritional value of food blends (Abbey & Mark-Balm, 1988; Mercier, 1993; Obizoba, 1990). Various cereal-based blends, fortified or unfortified with legume, have been developed through extrusion cooking (Akinyele, 1987; Conway & Anderson, 1973; Obatolu & Cole, 2000). Malting, on the other hand, converts cereal starch to fermentable sugars, improves availability of amino acids and other nutrients and modifies the quality of macro-molecules that effect physical qualities of the by-product (Chen, Serafin, Pandaya, & Daun, 1991). In many developing countries, malting is used to partially digest starch (Nout, 1993).

The possibility of fortifying local cereals, such as millet, with legumes, such as soybean, using malting and extrusion cooking, needs to be considered. This can go a long way to reduce the prevalence of protein energy malnutrition among children in developing countries, such as Nigeria.

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Millet is a small-seeded annual grass, of minor importance in developed countries, but a staple in the diet of some Africans (Skouron & Lorenz, 1979). Millet is mostly cultivated in the northern part of Nigeria and forms an important staple in the diet of these people. Millet flour can be partially used to replace wheat flour in breads, cookies and pasta products (Badi, Hoseny, & Finney, 1976; Lorenz & Dilsaver, 1979). Millet is consumed as gruel, especially by infants and/or as porridge by older children and adults. Millets have also been used in the local malt industry.

Protein in millet varies from 5.6 to 14.8% (Burton, Wallace, & Rachie, 1972; Lorenz, Disalver, & Bater, 1979). Badi et al. (1976) observed high values of essential amino acids especially lysine, in pearl millet.

Soybean is often used to improve the protein quality of cereal blends, due to its high levels of protein (40%) and fat (20%). It is particularly high in lysine (Harper, 1980) which is deficient in most cereals. As with all other legumes, the level of sulphur-containing amino acid is low. The high lysine and low sulphur-containing amino acids in soybean, make it a suitable crop for any cereal with high levels of sulphur-containing amino acids, such as methionine. The present study looks into the chemical and sensory qualities of malted and unmalted extruded soybean/millet mixtures.

2. Materials and methods

2.1. Materials

The soybean used for the study was collected from the seed store, Institutes of Agricultural Research and Training (IAR&T), Ibadan, Nigeria. The millet grains were purchased from a local market in Zaria, Nigeria. Only whole and viable grains were used in the study.

2.2. Malting

The maltings of the grains were done using a combination of the methods of Marero, Pajuro, Aguinaldo, and Hummas (1988) and Kulkani, Kulkani, and Ingle (1991). The grains to be malted were soaked for 12 h in volumes of water three times their weight and drained using a woven basket. The soaked grain was spread on a wide wooden box for germination at ambient temperature (32±2°C) for 72 h. Water was sprinkled on the grain twice daily. The germinated grains were dried to a moisture content of 10% in an air oven (Hotpack, Phila; USA) set at 50°C for 24 h. The dried-malted grains were cleaned of sprouts and hulls by crushing and winnowing. The grains were separately hammers milled with screen-designed to yield meals of about 500 μm size.

2.3. Preparation of mixture

The millet was either mixed in higher (70:30) or equal (50:50) proportions with soybean meal before extrusion.

2.4. Extrusion cooking

The mixed grains were extruded in a screw 600 Jr. Insta pro-extruder. The extruder specifications were barrel bore diameter (10 mm), screw length (12.5 mm), screw diameter (9.01 mm) and die opening (1.27 mm). Extrusion temperature was maintained between 100 and 120°C and pressure was 300 psi. The feed rate was held constant at 300 kg/h. The expelled hot extrudates were fed directly into the rotating drum cooler (insta-promodel 400 container) for cooling. The extruded mixtures were milled, packed in a polythene bag and stored in a cool room (0°C) until used.

2.5. Chemical analysis

2.5.1. Proximate analysis

Moisture, crude protein, fat, crude fibre and total ash was determined by the method number 960 of AOAC (1990). Carbohydrate was calculated by difference while energy was determined with a ballistic bomb calorimeter (Gallenkamp and Co. Ltd.). Trypsin inhibitor and tannin were determined by the method of Hammerstrand, Black, and Glover (1981) and Holf and Singleton (1977), respectively.

2.5.2. Minerals

From acid-digested samples, calcium, potassium, magnesium, sodium and zinc were analysed using an atomic absorption spectrophotometer (Issac & Johnson, 1975). Phosphorus was calorimetrically analysed (Juo, 1981)

2.5.3. Amino acid analysis

The method of Sotelo, Hernandez, Montalvo, and Sausa (1994) used in determining the amino acid content of the sample. One gram of sample was dissolved in 20 ml of 6N HC1. This was then poured into an hydrolysis tube with screw cap and hydrolysed for 22 h under a nitrogen atmosphere. The acid was evaporated using a rotary evaporator (and residue washed three times with distilled water). The extracted sample was dissolved in 1 ml acetate buffer of pH 3.1. After dilution to a known volume, the hydrolysate was transfered into a Beckman system (model 6300) high performance amino acid analyser.

2.6. Sensory evaluation

The extruded mixtures were made into a gruel using hot water (15 g/100 ml water) and served at 40°C to 15 trained graduate students. The panellists were to taste and swallow each of the gruel samples and rinse their mouths with tap water between samples. The panellists rated the products by four sensory attributes, namely flavour, colour, mouthfeel and overall acceptability. Each of the attributes were scored on a 9 point hedonic scale where 9 = extremely liked and 1 = extremely disliked.

2.7. Statistical analysis

The data obtained were analysed by a statistical analysis system program (SAS, 1985) using analysis of variance (ANOVA). Duncan's multiple range test was then used to separate the means.

3. Results and discussion

3.1. Proximate analysis

The proximate composition of the extruded mixed blends are shown in Table 1. There were no significant differences between the moisture contents of the mixtures. The crude protein, observed in the present study, was higher than combinations of most other cereals and legumes. The crude protein content ranged from 18.3% in unmalted mixtures of 70:30 ratio to 28.9% in malted mixtures of 50:50 ratio. Akobundu (1981) similarly observed an increased in protein level of corn–cowpea mixtures as the proportion of cowpea increased. Malting significantly increased and reduced, respectively, the protein and carbohydrate contents of the mixtures. The protein content of MM70MS30 was significantly higher ($P<0.05$) than MM5ORS5O and RM50RS50. Similar observations of higher protein content have been reported for germinated cowpea (Abbey & Balm, 1988). This might be due to chemical changes, especially in protein chains during malting (Abbey & Balm, 1988; Nout, 1993). Marero, Romos, Trugo, and Souza (1988) attributed the variations to carbohydrate degradation and formation of some amino acids in excess of requirements for protein synthesis. Trugo, Romos, Trugo, and Souza (1990) similarly observed removal of 77% oligosaccharides after 3 days of germination of *P. vulgaris*. This is a desirable effect for complementary formulations. The RM70RS30 that has the least protein content is also an excellent source of protein if compared with the FAO/WHO/UNN (1985) minimum protein level of 15.7%, recommended for supplementary mixtures of protein.

A general low level of fat was observed in mixtures with higher levels of millet. Millet has been reported to be low in fat content (Mtebe et al., 1993). An implication is the need for fat fortification in millet/legume mixtures, to meet the minimum fat requirement of 6% for complementary formulations (Mitzner et al., 1984). RM50RS50 had a significantly ($P<0.05$) high gross energy content of 18.9 kJ per 100 g. A lower level of fat was observed for malted mixtures and consequently lower gross energy. Fat content has been reported to decrease during germination (Mtebe et al., 1993). This loss in total energy can be compensated for by the reduced viscosity due to malting, therefore allowing a high level of solid matter in the gruel. Generally, the fat content is increased when soybean is present at high levels and hence the level of energy is higher, whereas the carbohydrate level increased when the proportion of millet was greater.

Table 1
Proximate (g/100 g) and mineral (mg/100 g) composition of mixed millet/soybean extrudate[a]

	MM50 MS50	MM70 MS30	MM50 RS50	MM70 RS30	RM50 RS50	RM70 RS30
Moisture	5.8	6.11	6.3	5.9	6.0	6.4
Protein	28.9a	25.0b	21.2c	18.3e	20.ld	18.27e
Fat	8.6a	3.6c	9.7a	5.lb	9.5a	3.3c
Ash	3.6	3.6	4.5a	3.3	3.7	3.3
Carbohydrate	53.0d	55.7c	66.9a	67.4a	58.3b	68.7a
Crude Fibre	3.6ab	4.la	3.0b	3.5ab	3.lab	3.3ab
Energy(kJ)	b729b	1585d	1690c	1663c	l819a	1575d
Calcium	72c	l22abc	l20abc	179a	l40ab	8lbc
Phosphorus	98d	91e	110c	125a	120b	101d
Potassium	644	939	633	571	793	641
Magnesium	143b	165a	173a	120c	140bc	l40bc
Sodium	343d	345d	504a	386cd	406bc	439b
Zinc	3.0c	3.3ab	3.2bc	3.lbc	3.5a	2.7d

[a] Mean values in the same row with different letters are significantly different ($P<0.05$). MM50MS50: malted millet + malted soybean (50:50); MM70MS30: malted millet + malted soybean (70:30); MM50RS50: malted millet + raw soybean (50:50); MM70RS30: malted millet + raw soybean (70:30); RM50RS50: raw millet + raw soybean (50:50); RM70RS30: raw millet + raw soybean (70:30).

Except for MM50RS50, there seemed to be no significant difference in ash or fibre content. Mtebe, Ndabi, Kunze, Bangu, and Nwemezi (1993) similarly observed a non-significant effect of germination on ash content of cereals. The low level observed for trypsin inhibitor and tannin is because of extrusion cooking. Dry heats, such as extrusion cooking, are very effective in destroying trypsin inhibitor activity.

The mineral compositions of the mixtures are also shown in Table 1. Calcium and phosphorus are significantly higher in MM70RS30 when compared with other mixtures of millet and soybean. There were no significant ($P<0.05$) differences between the levels of potassium in the blends. The value of magnesium ranged from 120/100 g in MM70RS30 to 173 mg/100 g in MM50RS50. A significantly high level of 504 mg was observed for sodium in MM50RS50, while the zinc value of 3.48 mg, observed for RMS0RS50, was significantly ($P<0.05$) higher than those in other mixtures, except MM70MS30. Soybean is not a major source of minerals but only contributes to overall requirements in the diet (Shurpalekar, Chandrasekhara, Swaminathan, &

Table 2
Amino acid composition of extruded millet soybean mixture (100 g protein)[a]

	MM50 MS50	MM70 MS370	MM50 RS50	MM70 MS30	RM5 RS30	RM70 RS30	FAO/WHO (1973)
Threonine	4.9a	4.6ab	4.5b	4.4b	3.9c	4.0c	4.0
Valine	6.2a	6.0a	5.9ab	5.4b	5.5b	5.5b	5.0
Methionine + Cystine	2.7bc	3.2a	2.4cd	3.1a	2.9ab	2.3d	3.5
Isoleucine	4.8	4.4ab	4.0bc	3.7cd	3.5cd	3.5d	4.0
Leucine	12.0a	12.1a	11.1c	12.3a	11.6b	12.3a	7.0
Tyrosine +	4.5a	4.2abc	3.5c	3.5bc	4.6a	4.1abc	6.00
Phenylalanine	4.6	4.6	4.5	4.8	4.2	4.5	
Lysine	6.3	6.3	5.4	5.5	5.2	6.0	5.5
Histidine	3.21	3.23	3.18	3.18	2.87	3.08	2.6[b]

[a] Mean values in the same row with different letters are significantly different ($P<0.05$). MM50MS50: malted millet + malted soybean (50:50); MM70MS30: malted millet + malted soybean (70:30); MM50RS50: malted millet + raw soybean (50:50); MM70RS30: malted millet + raw soybean (70:30); RM50RS50: raw millet + raw soybean (50:50); RM70RS30: raw millet + raw soybean (70:30).
[b] NRS/NAS (1980).

Table 3
Sensory qualities of extruded millet/soybean mixtures[a]

Sample	Colour	Flavour	Mouthfeel	Taste	Texture	Overall acceptability
MM50MS50	3.5d	7.5a	6.5	6.0b	7.2ab	5.ld
MM70MS30	3.8d	7.8a	6.8	6.8a	7.3a	7.0a
MM50RS50	5.2c	7.2a	6.2	5.3cd	6.8bc	5.8bc
MM70RS30	6.lb	7.5a	6.6	7.2a	6.6cd	7.3a
RM50RS50	6.4b	4.4c	6.6	5.1d	6.2d	5.4cd
RM70RS30	7.6a	5.4	6.4	5.8bc	6.2d	6.lb

[a] Mean values in the same column with different letters are significantly different ($P<0.05$). MM50MS50: malted millet + malted soybean (50:50); MM70MS30: malted millet + malted soybean (70:30); MM50RS50: malted millet + raw soybean (50:50); MM70RS30: malted millet + raw soybean (70:30); RM50RS50: raw millet + raw soybean (50:50); RM70RS30: raw millet + raw soybean (70:30).

Subramenyan, 1961). The good level observed for the mixtures shows the complementary effect of cereals (millet) and legumes (soybean), as observed by Sankara and Deosthale (1981).

3.2. Amino acid composition

The amino acid composition values are shown in Table 2. As already known, lysine and methionine are generally limiting in cereals and legumes, respectively. Lysine content in the mixtures varies from 4.39 g/100 g protein in RM70RS30 to 5.30 g/l00 g protein in MM50MS50. The variations in the lysine contents of mixtures were not significantly ($P<0.05$) different. Methionine ranged from 1.28 g/l00 g protein in RM50RS50 to 12.17 g/100 g protein in MM70MS30. Higher significant values for methionine was in malted-based mixtures. Mixtures with lower levels of soybean showed higher methionine values. Higher levels of other amino acids were observed in the malted mixtures. Similar observations have been observed by other authors when grains were malted or malted grains incorporated into complementary food (Issac & Johnson, 1975; Obatolu, 1998). The data observed from the study revealed that valine, methionine, leucine, tyrosine, phenylalanine, lysine and histidine were present in adequate levels if compared with the recommended values of FAO/WHO (1973) and NRC/NAS (1980), respectively. Threonine and isoleucine were only adequate in malted mixtures.

3.3. Sensory evaluation

Sensory quality is shown in Table 3. The flavour, taste and texture were improved with greater proportions of malted ingredient over raw ingredient. Subsequently, the malted-mixtures had higher scores for overall acceptability. This implies that the beany flavour, that has always been a hindrance in soybean acceptability, was suppressed by the malted flavour. Mtebe et al. (1993) have previously observed an improvement in flavour and level of consumer preference when malted fmger millet was mixed with ungerminated flours from other cereals. The scores for mouthfeel of the mixtures were not significantly different from one another. The colours of mixtures with malted ingredient were rated low. This might be due to the characteristic dark brownish colour of the product after extrusion. Colour changes in extruded products have been reported to be due to decomposition of pigments, product expansion causing colour fading and chemical reactions, such as caramelization of carbohydrates (Chen et al., 1991). The level of soybean fortification affected the overall acceptability. The lower the level of soybean incorporation, the higher the acceptance. This may be attributed to the beany flavour imposed by the raw soybean grains.

4. Conclusion

The mixture of malted millet and soybean significantly improved protein quantity and quality in terms of amino acids. Malting of millet, grains in gruel preparations, can improve both nutrient quality and acceptability. Based on the present level of fortification, soybean inclusion should not exceed 30% for good acceptability.

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