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Effect of Fermentation and Malting on the Viscosity of Maize-Soyabean Weaning Blends

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Abstract: Weaning foods made from cereals and legumes are used in solving the problem of malnutrition in infants; however, the bulky nature of the porridge discourages many infants from consuming it. In order to improve the dietary bulk of weaning foods, the effects of fermentation and malt addition on the viscosity of maize-soyabean blends were studied. The material balance method was used to target 18% protein and 59% carbohydrate in the weaning formulation. This method was used to achieve the control blend of 70% maize flour and 30% soyabean flour. The rest of the blends were formulated by adding either 5% (M 5) or 10% (M 10) malt to the Unfermented (UF), 2 days fermented (F2) and 3 days fermented maize flour (F3) and mixing each with 30% Soyabean Flour (S). Chemical analysis conducted on the flours showed soyabean flour had the highest protein content of 42.61% and the unfermented maize flour had the highest carbohydrate value of 74.57%. Results of viscoamylography of the various blends showed that M0F2S recorded a higher setback viscosity than the control but blends M5F3S, M10F2S and M10F3S provided porridges that were less viscous. Increase in viscosity as fermentation time increased was due to the increase in the protein, crude fibre and fat during fermentation. Generally, malting alone led to a reduction in product viscosity but fermentation led to an increase. However, the cumulative effect of fermentation and malting with the addition of malt after the fermentation reduced viscosity.

Key words: Weaning food, viscosity, malting, fermentation, maize and soyabean

INTRODUCTION

From birth to the age of 4 months, an infant's nutritional needs are perfectly met by breast milk. According to Cameron and Hofvander (1983), breast milk provides infants with all the essential elements in balanced proportions, and protects them against infections. On the other hand, between 4 and 6 months and beyond, breast milk is no longer sufficient to fully cover energy and protein requirements (World Health Organization, 1988). This is the weaning period during which breast milk supplement must be provided. When these nutrient requirements are not met, the situation is described as malnutrition. The World Health Organization according to Onis *et al.* (1993) defined malnutrition as "the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions." The first solid food and the most popular weaning food is a thin cereal gruel that is called by different names depending on the type of cereal or the West African country. Work by Onilude *et al.* (1999) indicated that, cereals, in order to be suitable for the feeding of young children, are prepared in liquid form by diluting with a large quantity of water, thereby resulting in a large volume with low energy and nutrient density. If the concentration of solids is raised to increase the nutrient and energy density, the gruel will be too thick and viscous for an infant to eat easily. This high viscosity characteristic is referred to as dietary bulk. Various attempts have been tried to modify the starch structure to reduce bulk. These include the use of enzymes, precooking, fermentation, toasting, malting, puffing and extrusion processing of the raw materials. Traditional processes of fermentation or malting of cereals and legumes have also been tried with some success in reducing bulk in porridges (Chavan *et al.*, 1988; Nout *et al.*, 1989; Westby and Gallat, 1991; Mensah *et al.*, 1991). Applying malting to reduce dietary bulk seems to be successful; however, the potential of fermentation to reduce bulk is still debatable (Ashworth and Draper, 1992). On reviewing other peoples work, they based their argument on the fact that depending on the method of fermentation and particularly the microorganism responsible, the viscosity of the gruel could be reduced or not. Akpapunam and Sefa-Dedeh in 1995 studied the effects of traditional lactic acid fermentation and the addition of malt on the physicochemical properties of maize-cowpea blends. They realized that malt addition caused a reduction in viscosity, whereas fermentation led to an increase. Combining fermentation with malting also led to an increase in viscosity. This conclusion was drawn because malt was added to the maize-cowpea blends and were all fermented together. They proposed that adding malt to the blend after fermentation should be studied. This work aimed at improving the dietary bulk of maize-soyabean weaning blends by evaluating the effect of fermentation on the viscosity of the maize-soyabean weaning blends, the effect of malting on the viscosity of the blends and the cumulative effect of both fermentation and malting on the weaning blends when malt is added after fermentation. Maize (*Zea mays sp.*) and soyabean (*Glycine max. sp.*) were used in this formulation.

MATERIALS AND METHODS

Source of raw materials: Maize (*Obatampa variety*) and soyabeans (*Anidaso variety*) were obtained from Crop Research Institute in Kumasi. This study was carried out in the fermentation laboratory at the department of Biochemistry and Biotechnology, KNUST.

Product formulation: The material balance method was used to achieve the control blend formulation of 70% maize flour to 30% soyabean flour (18% protein and 59% carbohydrate) as indicated in Table 1. This method required the use of proximate values of the raw materials and employed three basic categories; materials in, materials out and materials stored. The rest of the blends were formulated by adding either 5% or 10% malt to the unfermented, 2 days fermented and 3 days fermented maize flour and mixing with 30% soyabean flour. Mixing was done to achieve the desired texture, appearance, flavour and consistency. Figure 1 is a flow diagram for the preparation of the weaning blend.

Table 1: Composition of Maize-Soyabean-Malt Blends

	Ingredients (%)				
Blends	Malt	UF	F2	F3	Soy
Control	0	70	0	0	30
M5UFS	5	65	0	0	30
M10UFS	10	60	0	0	30
M0F2S	0	0	70	0	30
M5F2S	5	0	65	0	30
M10F2S	10	0	60	0	30
M0F3S	0	0	0	70	30
M5F3S	5	0	0	65	30
M10F3S	10	0	0	60	30

M0 = 0% malt, M5 = 5% malt, M10 = 10% malt, UF = Unfermented maize Flour, F2 = Fermented maize flour for 2 days, F3 = Fermented maize flour for 3 days, S = Soyabean flour

Malting and fermentation of maize: Maize was sorted to remove stones, dust and light materials, insect infested, broken grains, undersized and immature grains. It was cleaned thoroughly with water (3 times). Part of whole maize was soaked in water (1:3 w/v) at 29°C for six hours and germinated in a woven cane basket lined with a sterilized moist jute sack. The grains were watered two times a day at regular intervals. After germinating for 72 h, the grains were dried in a solar drier (designed by the Food Science and Technology Department, KNUST). The vegetative parts were removed by rubbing the grains between the palms and winnowed. The dried malted grains were milled in an attrition mill and sieved to remove the hulls.

The other part of the maize was soaked in water (1: 3 w/v) at 29°C for 48 h, milled in an attrition mill and divided into three equal parts. One part was spread on a plastic tray and solar dried. Water was added to the two remaining portion, formed into dough, placed in plastic bowls, covered and allowed to ferment at room temperature for two and three days respectively. These were solar dried and milled into flour.

Soyabean processing: The soyabeans were sorted and cleaned thoroughly. They were then blanched for about 15 min and solar dried. The beans were roasted until they turned golden brown, allowed to cool, milled into flour and sieved.

Physicochemical properties

Chemical analysis: Chemical analysis on the flours was conducted to aid the use of the material balance in order to obtain the target formulations. Moisture, ash, crude fat, crude protein and crude fibre contents of the samples were determined by AOAC methods (AOAC, 1990). The carbohydrate content was estimated by the difference in value obtained when all the chemical composition values were subtracted from 100%.

pH and TTA: The pH was determined by mixing 10 g of the sample with 100 ml of distilled water. The mixture was left at room temperature for 30 min. The pH of the supernatant was then measured with a pH meter.

Titratable acidity was determined by dissolving 10 g of the sample in 100 ml of distilled water and titrating 10 ml aliquots with 0.1 N NaOH to phenolphthalein end point.

Viscosity measurement: The cooked paste viscosities of the samples were determined with Brabender Viscograph E (IDENT 802525, Duisburg-Germany) at the Food Research Institute, Accra. The samples were heated at 1.5°C per minute to 95°C, held for 15 min, cooled uniformly at the same rate to 50°C and held for 15 min. The Brabender Viscoamylograph indices (gelatinization temperature, maximum viscosity, viscosity at 95°C and 95°C-Hold and viscosity at 50°C and 50°C-Hold) were measured.

Statistical analysis: The Completely Randomized Design (CRD) was used in evaluation. Treatments were in duplicates. The effect of fermentation and malting on the weaning blend were evaluated by comparing them to a control and measuring the Least Significant Difference (LSD) at 5%. The control was formulated from 70% unfermented maize flour and 30% soyabean flour. Data obtained was subjected to analysis of variance (ANOVA) to determine the least significant differences between the formulated products at $p<0.05$ using STATGRAPHICS Centurion XV.

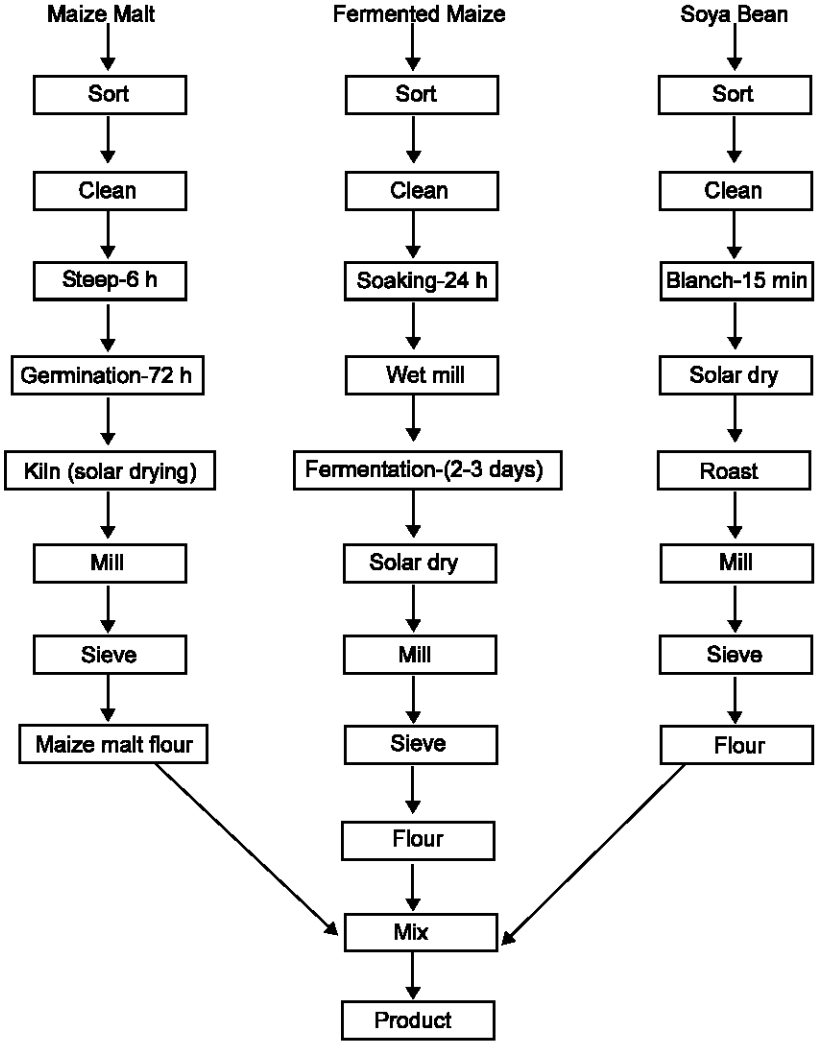

Fig. 1: Formulation of weaning Food from Fermented Maize, Malted Maize and Soybean

RESULTS AND DISCUSSION

Chemical analysis, pH and TTA on Flours: Protein-energy Malnutrition (PEM) is associated with early weaning, delayed introduction of complementary foods and a low protein diet, thus the rich protein and high carbohydrate contents of the soyabean and maize flour respectively can be used to combat PEM and its associated risks (Akinele and Omotola,1986; Rice *et al.*, 2000).

The protein content increased in maize as fermentation days increased (Table 2). This improvement in protein content was due to the proteolytic activities of enzymes produced by microorganisms during fermentation, which increase bioavailability of amino acids. Nanson and Field in 1984 reported on the improvements in the concentrations of available lysine, methionine and tryptophan during fermentation of corn meal. Fermentation also increased the ash, crude fat and crude fibre contents and reduced significantly the pH of maize from 5.5-4.3, whilst titratable acidity increased from 0.4-0.9 with increased fermentation time. According to Akinrele (1970), the metabolic activities of microorganisms during fermentation reduce the pH and increase titratable acidity. Mensah *et al.* (1991) reported that fermented foods with low pH have some antimicrobial activities and as a result, exhibit longer shelf life.

Although, fermentation time influenced the trend in chemical composition of the raw materials (Table 2), the moisture contents could also be a contributing factor. Morris *et al.* (2004) reported that the removal of moisture generally increases concentrations of nutrients and can make some nutrients more available. Therefore, it is recommended that the raw materials should be dried to a moisture content of 3-8% (Oduro *et al.*, 2007a) in subsequent reproduction of this work.

Viscosity of blends: The values presented in Table 3 showed information on the hot and cold paste viscosity

Table 2: Chemical Characteristics of Unfermented and Fermented Maize Flours and Soyabean Flour

Sample	Moisture	Ash	Crude Fat	Crude Fibre	Protein	Carbohydrate	pH	TTA
UF	10.13 (±0.20)	0.89 (±0.22)	5.9 (±0.23)	0.83 (±0.37)	7.68 (±0.72)	74.57 (±0.55)	5.5	0.4 (±0.01)
F2	11.62 (±0.04)	1.09 (±0.06)	6.43 (±0.44)	1.83 (±0.44)	7.81 (±1.17)	71.22 (±2.03)	5.4	0.55 (±0.01)
F3	7.89 (±0.23)	1.13 (±0.08)	7 (±0.55)	2.08 (±0.33)	8.56 (±2.02)	73.34 (±1.94)	4.3	0.9 (±0.03)
S	3.18 (±0.14)	4.69 (±0.10)	21.89 (±1.22)	4.64 (±0.21)	42.64 (±1.77)	22.99 (±0.10)	-	-

UF= Unfermented maize flour F2=Fermented maize flour for 2 days F3=Fermented maize flour for 3 days S= Soyabean flour

Table 3: Brabender Amylography of Maize-Soyabean Weaning Blend

	Viscosity (BU)							
Blend	Beginning of Gelatinization (°C)	Maximum Viscosity	Start of Holding Period	Start of Cooling Period	End of Cooling Period	End of Final Holding Period	Break down	Setback
Control	81.2	47	45	44	89	86	3	45
Effect of Fermentation on The Weaning Blend								
M0F2S	82.5	57	54	54	117	113	3	63
M0F3S	81.2	50	46	46	88	88	4	41
Effect of Malting on The Weaning Blend								
M5UFS	50.2	9	3	4	12	11	5	8
M10UFS	50.8	3	1	2	5	5	1	3
Cumulative Effect of Fermentation and Malting on The Weaning Blend								
M5F2S	60	9	2	3	9	8	6	6
M5F3S	57.4	5	0	1	3	4	4	3
M10F2S	50.1	3	1	2	7	6	0	4
M10F3S	50.4	3	0	2	5	4	1	3

M0 = 0% malt M5= 5% malt M10 = 10% malt UF = Unfermented maize flour
F2 = Fermented maize flour for 2 days F3=Fermented maize flour for 3 days S = Soyabean flour

of the maize-soyabean weaning blends. All the viscoamylograph indices were affected by malting and fermentation. The temperature at which the first detectable viscosity is measured is generally accepted as the temperature of beginning of gelatinization or pasting temperature.

Limpisut and Jindal (2002) defined the pasting temperature as the temperature that indicates an initial increase in viscosity. In this study, the pasting temperature decreased in the blends containing malt as compared to the control. However, blends containing fermented maize without malt increased in pasting temperature, with the blend M0F2S having the highest pasting temperature. Blends, which contained both fermented and malted maize, showed decreased pasting temperatures depending on the level of malt or days of fermentation. This signifies that blends which have their pasting temperature lower than the control will gel and cook faster than blends with high pasting temperature.

In addition, results of amylography of the various blends as indicated in Table 3 generally show that M0F2S recorded a higher setback viscosity (63BU) than the control. This means that fermentation increased the viscosity of the blends and this falls in line with a report by Akpapunam and Sefa-Dedeh (1995). In addition to the nutritional significance of protein, crude fibre, fat and carbohydrate to the consumer, these have been reported to increase the viscosity of food (Martinez *et al*., 1992; Jimoh and Kolapo, 2007; Oduro *et al*., 2007b). As a result of this, the increase in viscosity as fermentation time increased (Table 2) was due to the increase in these nutrients during fermentation.

The product viscosity in the unfermented blends, as denoted by the setback viscosity, reduced as the malt increased. This trend was also observed in the fermented blends. Limpisut and Jindal (2002) defined setback as the rise and fall in the viscosity when the cooling cycle was ending. Although, the trend in the indices observed in M10UFS was similar to that observed in M5F3S, M10F2S and M10F3S, a synergy of malting and fermentation better than malting alone because, not only does the synergy reduce viscosity, the fermentation component imparts colour, flavour and increases shelf life of a product (Enwere, 1998). Upon cooling of the hot pastes of the fermented and malted blends, the gels that were formed were low making the porridges less viscous. Although Akpapunam and Sefa-Dedeh (1995) concluded that fermentation for three days further neutralized the known effects of reducing viscosity by the addition of malt, this study showed that the addition of malt after fermentation does not neutralize the effect of reducing viscosity but rather reduces the bulky nature of the weaning food.

Conclusion: Increase in viscosity as fermentation time increased was due to the increase in the protein, crude fibre and fat during fermentation. Malting alone led to a reduction in product viscosity but fermentation led to an increase. However, the cumulative effect of fermentation and malting with the addition of malt after the fermentation reduced product viscosity.

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