Effect of *Moringa oleifera* flower fortification on the nutritional quality and sensory properties of weaning food

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Summary

Moringa oleifera is a nutrient rich plant that has the potential to combat malnutrition problems in Africa. This study aims to investigate the effect of fortification using *Moringa oleifera* flower powder on the sensory and proximate attributes of fermented yellow maize and millet blend (Ogi). The formulation was grouped into seven blends in ratio 100:0:0, 70:30:0, 70:25:5, 70:20:10, 70:15:15, 70:10:20, 70:5:25 for maize, millet and *Moringa oleifera* flower powder (MOFP) respectively. *Moringa oleifera* flower was air-dried for 5days, milled and sieved to obtained fine powder. The fine powder was mixed thoroughly with fermented maize and millet, wet milled and sieved. The proximate composition of fermented yellow maize and millet (Ogi) fortified with *Moringa oleifera* flower powder showed an increase in crude protein, crude fibre, ash and fat with increase in the levels of *Moringa oleifera* flower powder and decrease in carbohydrate and moisture content. Moisture, protein, fibre, fat, ash and carbohydrate contents varied in the range 7.92-9.74%, 10.46–16.06%, 2.31-4.13%, 2.90-4.07%, 1.23-1.93% and 66.45-73.25% respectively. Sensory evaluation shows that blend 6 (20% MOFP) compared favourably with the control. Also, nutritional analysis shows that blend 6 is favourable as weaning food. Therefore, blend 6 formulation can be used as alternative to the weaning foods to improve the nutritional status of children and help to curb protein malnutrition.

Keywords: weaning food, yellow maize, millet, *Moringa oleifera* flower

Introduction

Protein-energy malnutrition has been noted to occur mostly at a crucial transition phase when children are weaned from liquid to semi-liquid foods (Temesgen, 2013). During this transition phase, children need nutritionally balanced supplementary food in addition to breast milk. This is necessary in order to meet the increasing nutritional demands of the growing body. Such supplementary food is usually referred to as weaning food. Weaning food plays significant role in child growth and development. Despite high nutrient requirement for children, their diets in developing countries are mostly cereals (Kebebu et al., 2013). For instance, the first weaning food in Nigeria is referred to as pap, akamu, ogi or koko which is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum spp*.) (Wakil and Kazeem, 2012). Cereal products are limiting in some essential amino acids which make them to have poor nutritional value (Galili and Amir, 2013). Consequently, children fed solely on cereals are prone to diseases such as kwashiorkor and marasmus to mention a few. Considering that cereals are the primary weaning foods in West Africa, there is a need to supplement cereals with a very high protein plant to fortify the weaning food. Such plant should be one that must be readily available, easy to grow and easy to process.

Various sources of protein have been proposed and utilized with the aim of fortifying weaning food. Protein sources from plants such as legumes have been widely used either independently or in combination with animal protein (Wakil and Kazeem, 2012; Amankwah et al., 2009). However, there is a continuous search for a relatively low-cost and readily available plant. Moringa (*Moringa oleifera*), often referred to as miracle tree could be a solution to the making of a complete weaning food. This is because every part of it can be used for food, medication and industrial purposes (Khalafalla et al., 2010). Especially, the foliage of the tree is a potential source to improve nutrition, boost food security and foster rural development. The tree could be a solution to the problem of weaning food in developing countries. Studies have shown that the leaves have immense nutritional value such as minerals, vitamins and amino acids and as a result, the leaves have been used to combat malnutrition especially among infants and nursing mothers (Anjorin et al., 2010; Wakil and Kazeem, 2012). Recent studies have demonstrated the potential bioactives from leaves of *Moringa oleifera* (Saini et al., 2014c) and also showed

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the enrichment of carotenoids, tocopherols (Saini et al., 2014a) along iron bioavailability in animal models (Saini et al., 2014b). The flowers of *Moringa oleifera* have been found to be rich in potassium and calcium (Jideani and Diedericks, 2014). Traditionally, decoction made with fresh *Moringa oleifera* flowers has been used as an excellent herbal tonic for sexual weakness and functional infertility of both males and female (Mehta et al., 2011). In addition, *Moringa oleifera* flowers have been reported for treatment of tumour (Mehta et al., 2011). The flowers are edible when cooked and are considered to share the same taste as mushroom. Flowers are generally regarded as a source of inspiration and positive energy which helps to improve human-welfare (Arya et al., 2014). However, despite the numerous advantages of the *Moringa oleifera* flower, its use in terms of fortification is limited. Often times, the flowers wither without harnessing its potentials, hence this study. The aim of this study is to investigate the effect of *Moringa oleifera* flower fortification on the nutritional quality and sensory properties of weaning food formulated primarily composed of maize and millet. The flower of *Moringa oleifera* is utilized in this study as it provides a good blend in terms of colour with the weaning food, unlike its leaves which may impair the colour of the weaning food.

Materials and methods

Sample collection

Yellow maize (*Zea mays*) and millet (*Pennisetum glaucum*) grains were purchased at Oja Oba in Ilorin, Nigeria. *Moringa oleifera* flowers were obtained from Unilorin Moringa Plantation, Ilorin, Kwara State, Nigeria. They were harvested in the early hours at about 0800 hours and transported to the laboratory which is about 2 km from the plantation in cleaned polyethylene bags for further processing.

Processing of the cereal and the M.oleifera flower

The cereal grains were sorted, washed and steeped in tap water for two days in a large basin. The contents were allowed to ferment at room temperature for 0 to 48 h. The steeped water was changed with fresh water after each day. The steeped water was decanted and the fermented cereal ground to slurry in a hydraulic mill. The slurries were sieved through a fine sieve (muslin cloth) with water. The seed coat and other coarse particles were discarded and the sediment allowed to settle, ferment for 48 hours and squeezed to remove excess water. The *Moringa oleifera* flower was air-dried under shade and milled into powder using blender through 355 μm sieve to obtain fine powder.

Formulation of composite blends

The formulation was grouped into seven blends on the percentage. In accordance with Malleshi et al. (1989) and Wakil and Kazeem (2012), the blends 1-7 represent maize, millet and *Moringa oleifera* flower powder (MOFP) in ratios: 100:0:0, 70:30:0, 70:25:5, 70:20:10, 70:15:15, 70:10:20, 70:5:25 w/w respectively.

Preparation of gruel

The weaning food formulations were individually prepared into gruel with boiling water 100% of each sample mixed with 50 ml of clean water to make it liquid and 200 ml of boiling water to form instant gruel for sensory evaluation.

Proximate analysis

Moisture, fat and ash content were determined using AOAC methods (AOAC, 2000). The protein content was determined by kjeldahl method (N×6.25). Total carbohydrate was calculated by difference as expressed below.
Carbohydrate = 100 – (Moisture + Ash + Fat + Protein).

Sensory evaluation of samples

Sensory characteristics of the prepared gruel were assessed by twenty trained panellists of nursing mothers (Age 30-40) from University of Ilorin, Ilorin, Kwara State, Nigeria. The panelists were in good health and are familiar with the taste, flavour and other attributes of weaning food. The evaluation started at around 1 p.m. The cooked gruel were prepared and served in sensory evaluation cups. White bulbs were fitted in the sensory room to detect the genuine colour of the sample. The samples were assessed for colour, taste, flavour, aroma, texture and overall acceptability. The panellists were instructed to sip water before and after assessing each product. The samples were assessed using 9 point hedonic scale ranging between 9 (like extremely) to 1 (dislike extremely). Like Extremely 9; like very much 8; like moderately 7; like slightly 6; neither like nor dislike 5; dislike slightly 4; dislike moderately 3; dislike very much 2; dislike extremely 1.

Statistical analysis

All data readings were done in triplicates and subjected to analysis of variance using statistical package for social science (SPSS).

Results and discussion

The dried flower of *Moringa oleifera* had a crude protein of 25.16%, carbohydrate content of 53.67% and Ash 6.01% (Table 1). The proximate values obtained in this study for the flower is comparable with the value obtained for leaves by Moyo et al. (2013). The results obtained show that *Moringa oleifera* flower contain nutritious compounds. Noteworthy is the crude protein content, though lower than sunflower and soy bean, but comparable with other legumes such as cowpea, bambara groundnut and pigeon pea (Mapiye et al., 2010; Hillocks et al., 2012; Adegbola and Bamishaiye, 2011). This level of crude protein content is of particular nutritional significance as it may meet infant protein and boost immune system against diseases (Moyo et al., 2013).

Table 1. Proximate composition of *Moringa oleifera* flower powder

Proximate composition	Values (%)
Protein	25.16
Fibre	7.55
Ash	6.01
Fat	1.57
Moisture	5.8
Carbohydrate	53.67

The proximate composition of the *Moringa oleifera* flower powder (MOFP)-fortified fermented Ogi shows an increase in protein with increase in level of *Moringa oleifera* flower (Fig. 1). The result obtained reveals that the constituent protein in sample 1 (control) was the lowest and as such, sample 1 is considered to be significantly poor in nutrient in protein when compared with other samples. The protein content of the fortified samples were significantly higher than the protein content reported for ogi made from corn, millet, and sorghum respectively (Oyarekua and Eleyinmi, 2004). This implies that *Moringa oleifera* flower powder could help in improving the crude protein. According to FAO/WHO (1982), a minimum protein content of 15% is required for maximum complementation of amino acids in foods and growth. Therefore, the formulation blends 6 and 7 with protein content 15.54% and 16.06% respectively satisfy the protein demand of infants (Sanni et al., 1999). Ogi has a poor biological value. Thus, children weaned entirely on 'Ogi' made solely from maize are known to suffer from malnutrition. Generally, "Ogi" supplies insufficient amount of some key nutrients required to meet the recommended nutrient intake of children during the age of 6-24 months. Hence the need for its enrichment (Dewey and Brown, 2003).
Upon the addition of *Moringa oleifera* flower, the fat content was observed to be comparable (Fig. 1). Demaeyer (1976) recommended a low fat content of 2-4% for weaning food. This is because the fat content of a food sample can affect its shelf life. Fat can undergo oxidative deterioration which leads to rancidification and spoilage, thereby reducing the shelf life of the food sample. Hence, a food with high fat content is prone to spoilage than one with low fat content.

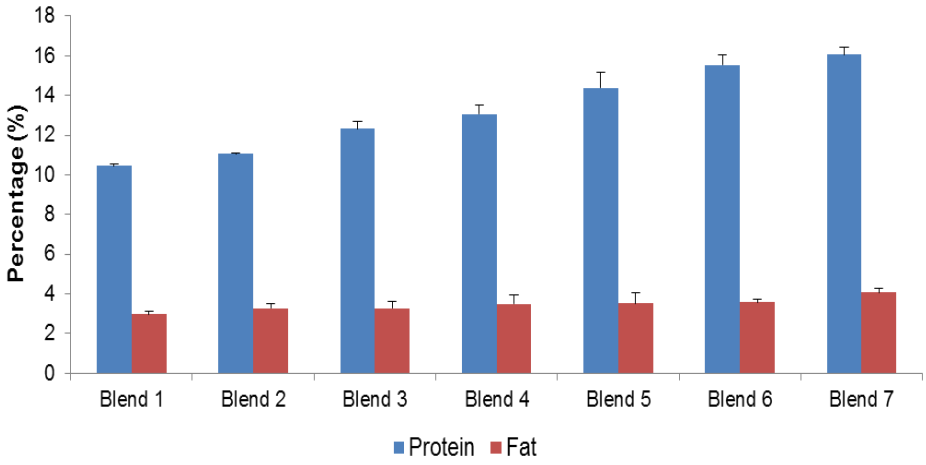

Fig. 1. Protein and fat content of the various blends

The increase in crude fibre with increase in *Moringa oleifera* flower level (Fig. 2) makes the ogi more favourable, as high fibre content of food helps in easy digestion. The increase in ash content with increase in level of *Moringa oleifera* flower also indicates that *Moringa oleifera* flower could be a good source of mineral. The increase in mineral as a result of increase in the level of *Moringa oleifera*

flower may be attributed to the *Moringa oleifera* flowers which have been found to be rich in potassium and calcium (Jideani and Diedericks, 2014).

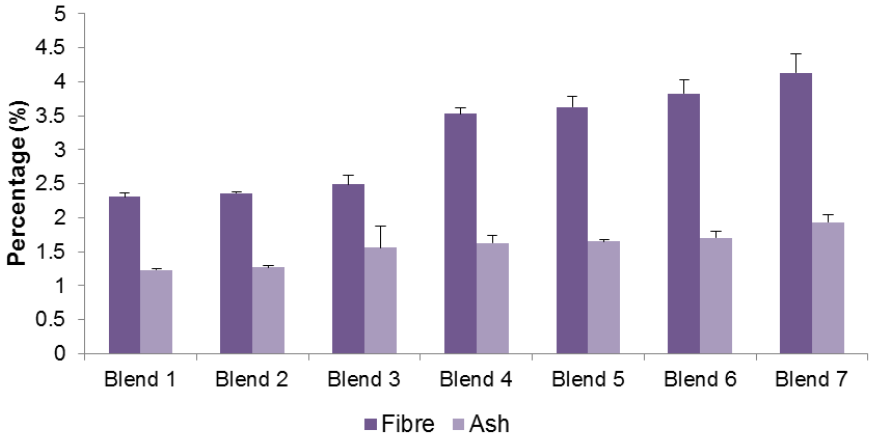

Fig. 2. Fibre and ash content of the blends

The carbohydrate content decreases with increase in level of addition of *Moringa oleifera* flower (Fig. 3). This is in agreement with the observation made by Mbata et al. (2009) where the addition of plant to cereal-based traditional foods resulted in carbohydrate content reduction. The moisture content of the gruel decreases with an increase in the level of *Moringa oleifera* flower. This indicates that addition of *Moringa oleifera* flower gives the gruel a good keeping quality, considering that spoilage microbes thrive better in the presence of adequate moisture (Damodaran and Parkin, 2008). Though the carbohydrate content of the formulations decreased from 72% to 66%, the percentage carbohydrate is within the amount recommended by Amankwah et al. (2009) for weaning food.

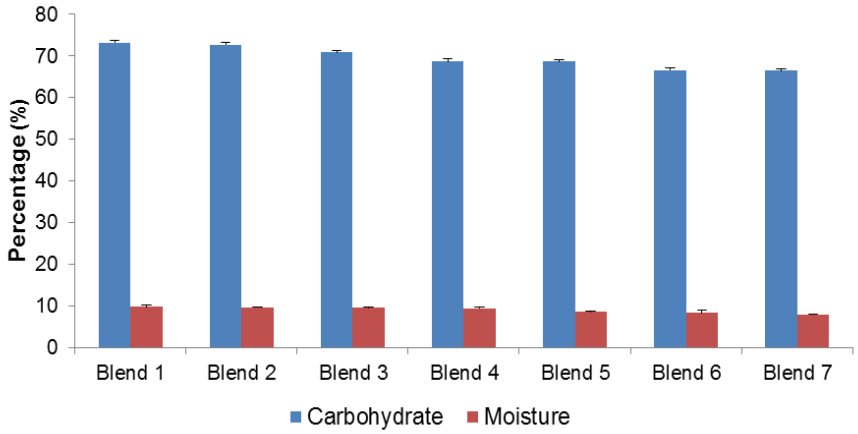

Fig. 3. Carbohydrate and Moisture content of the blends

Sensory analysis indicates a significant difference in aroma, texture and general acceptability. The result shows that blend 6 (20% *Moringa oleifera* flower inclusion) has better acceptance among the fortified samples (Fig. 4). Blend 6 was the richest in colour (7.33±0.52), taste (7.00±0.89), flavour (7.50±0.84) and general acceptability (7.67±1.05) (Fig. 4). Generally, these results suggest that blend 6 has better acceptability among the fortified mixture fermented cereal formulation (Fig. 4).

There was no much significant difference in the colour of blend 2, 3 and 4 (Fig. 4). The three blends are the least accepted for colour. This may be due to the dark color of the millet. However, the blends had better colour as the level of *Moringa oleifera* flower increases. This may be attributed to the light yellow colour of the *Moringa oleifera* flower. This result further elucidates the potential of the *Moringa oleifera* flower over its leaves in producing a desirable colour for ogi.

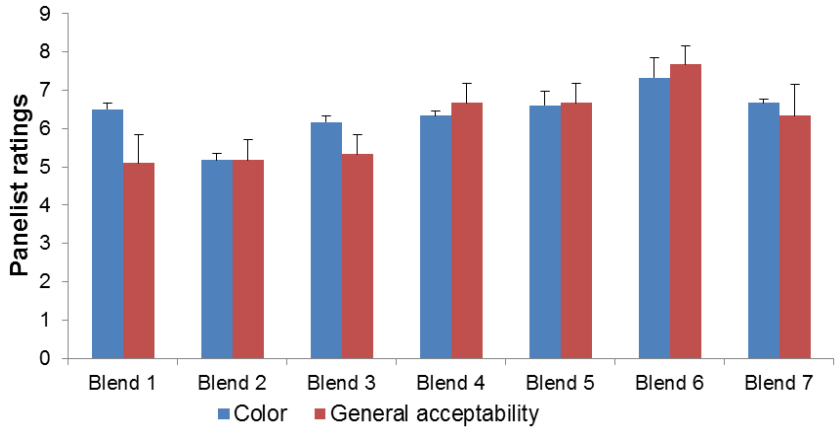

Fig. 4. Colour and general acceptability of the blends

The rating for the taste and flavour increases with increase in the level of inclusion of *Moringa oleifera* flower (Fig. 5). The high rating for the taste may be ascribed to the *Moringa oleifera* flower which has been reported to taste like mushroom when cooked. The palatable taste exhibited by the flower has consequently given rise for its use in soup preparation in some communities (Jideani and Diedericks, 2014).

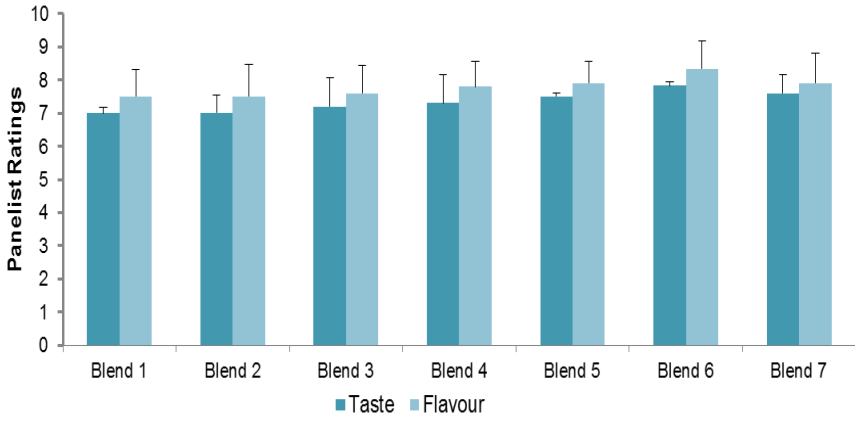

Fig. 5. Taste and flavour of the blends

There is no significant difference among the blends in terms of texture (Fig. 6), with the exception of blend 7 (70:5:25) which has slight lower rating. The slight lower rating may be as the result of high level of inclusion of the *Moringa oleifera* flower. Nevertheless, the inclusion of the *Moringa oleifera* flower still returned a good rating for texture as judged by the panellist. None of the panellists developed any side effects such as diarrhoea and emesis after consuming the preparations.

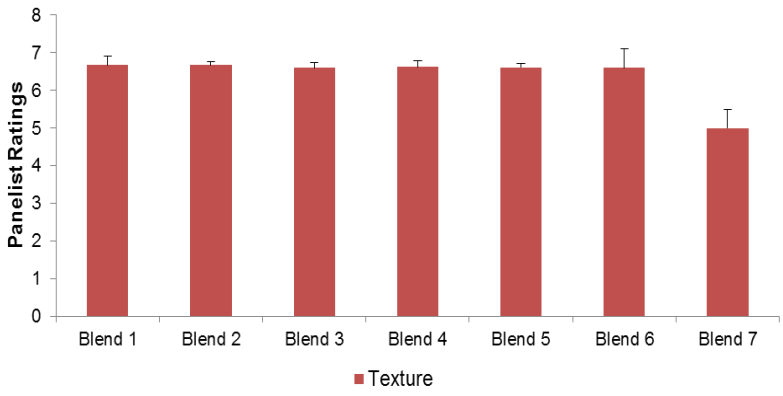

Fig. 6. Texture of the blends

Conclusions

The study showed that the proximate composition and organoleptic properties of cereal such as maize, millet and others could be enhanced through the addition of *Moringa oleifera* flower powder. The crude protein content of the maize and millet infant formula fortified with *Moringa oleifera* flower (blend 7, 25% inclusion of *Moringa oleifera*) increased significantly ($p<0.05$) by 60%. This shows that in developing economies where maize or other cereals of low nutritional value are being used as infant meal, fortification with *Moringa oleifera* flower powder could help in increasing the nutritional value of such cereal blend. Based on the sensory evaluation conducted, blend 6 (70:10:20) was found to be the most generally acceptable. Additionally, blend 6 met the standard required protein, carbohydrate and fat contents required for weaning food. Therefore, preparation in accordance with blend 6 could be recommended as a viable and fortified formulation for infant food.

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