

Research Application Summary

Sensory properties and consumer acceptability of nutrient dense porridge from locally available foods for infants in Tanzania

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Abstract

Childhood under nutrition during the first two years of life has been associated with irreversible harm and is linked to higher rates of morbidity, mortality, impaired cognitive ability and poor school performance in children. Low nutrient dense complementary foods are amongst the main causes of childhood malnutrition in developing countries. Thus, the use of locally available nutrient dense foods to improve infants nutrition is of considerable importance. A study to develop and assess sensory properties and consumer acceptability of nutrient dense porridge form locally available foods for infants in Tanzania was carried out in Morogoro region. Five formulations each containing soybeans, amaranth grains, pumpkin seeds and orange fleshed sweet potatoes (SAPO1-SAPO5) at different ratios were developed. The five developed formulations and two control samples were subjected to quantitative descriptive analysis (QDA) and consumer acceptability tests. With exception of oiliness, significant differences ($p \leq 0.05$) were observed between samples tested for all attributes. The formulated samples had significantly higher mean intensity scores of 5.4 ± 1.67 - 5.6 ± 1.67 for aroma, 5.1 ± 1.46 - 7.0 ± 1.44 for hue, 5.3 ± 1.75 - 5.6 ± 1.63 for sweetness and 4.2 ± 1.85 - 4.6 ± 1.98 for oiliness than control samples. Control samples had higher texture values than formulated samples. Consumer groups showed different acceptability for control and formulations. Mothers preferred control samples to formulations contrary to students who preferred formulated samples to control samples. Furthermore, all formulations had higher scores in aroma, sweetness and oiliness compared to control groups, thickness and grittiness were higher in control groups than formulations, while SAPO 3, 4 and 5 had higher scores of color hue than other samples. SAPO5 was the most accepted formulation by both mothers and students. This suggests that its ingredients ratio produced a most accepted product and hence it can be recommended for adoption.

Key words: Amaranth grains, childhood under nutrition, complementary foods, nutrient dense

Résumé

La sous-nutrition infantile durant les deux premières années de vie a été associée à des dommages irréversibles et est liée à des taux plus élevés de morbidité, de mortalité, de déficience cognitive et de mauvaise performance scolaire chez les enfants. Les aliments

complémentaires à faible teneur en nutriments sont parmi les principales causes de malnutrition chez les enfants dans les pays en développement. Ainsi, l'utilisation d'aliments nutritifs denses localement disponibles pour améliorer la nutrition des nourrissons revêt une importance considérable. Une étude visant à développer et évaluer les propriétés sensorielles et l'acceptabilité par les consommateurs, de bouillie riche en nutriments à base des aliments localement disponibles pour les nourrissons en Tanzanie a été réalisée dans la région de Morogoro. Cinq formulations contenant chacune des graines de soja, grains d'amarante, de graines de citrouille et des patates douces à chair orange (SAPO1-SAPO5) à des ratios différents ont été développées. Les cinq formulations développées et deux échantillons témoins ont été soumis à des analyses descriptives quantitatives (QDA) et à des tests d'acceptabilité par les consommateurs. À l'exception de l'aspect huileux, des différences significatives ($p < 0,05$) ont été observées entre les échantillons testés pour tous les paramètres. Les échantillons formulés présentaient des valeurs d'intensité moyenne $5,4 \pm 1,67$ - $5,6 \pm 1,67$ significativement supérieures $5,1 \pm 1,46$ - $7,0 \pm 1,44$ d'arôme, $5,3 \pm 1,75$ - $5,6 \pm 1,63$, de suavité et $4,2 \pm 1,85$ - $4,6 \pm 1,98$ et d'huile que les échantillons témoins. Les échantillons témoins présentaient des valeurs de texture plus élevées que les échantillons formulés. L'acceptabilité des aliments formulés et du contrôle a varié selon les groupes de consommateurs. Les mères préfèrent des échantillons témoins à des formulations, contrairement aux élèves qui préfèrent les échantillons formulés aux échantillons témoins. En outre, toutes les formulations présentaient des scores plus élevées en arômes, en goût et en huile que les témoins. La dureté et l'arôme étaient plus élevés dans les groupes témoins que les formulations, alors que les SAPO 3, 4 et 5 présentaient des scores de teinte plus élevés que les autres échantillons. SAPO5 était la formulation la plus acceptée par les mères et les élèves. Cela suggère que le ratio de ses ingrédients donne un produit plus accepté et, par conséquent, il peut être recommandé.

Mots clés: Graines d'amarante, sous-nutrition infantile, aliments complémentaires, nutriments denses, pomme de terre à chair orange, graines de citrouille, soja.

Background

Tanzania has tried different approaches like vaccination, food fortification, child feeding (nutrition rehabilitation) and micronutrient supplementation in promoting a conceptual framework for nutrition and health through its national institution, the Tanzania Food and Nutrition Centre (TFNC) (Mwanri *et al.*, 2013). However, despite those efforts, Tanzania is still faced with childhood under nutrition and is the third most affected country in Africa after Ethiopia and the Democratic Republic of Congo (DRC) (Muhimbula and Zacharia, 2010). Tanzanian children suffer from one form of malnutrition or another resulting into underweight, stunting, wasting and anemia (Mamiro *et al.*, 2005). The Tanzania Demographic and Health Survey (TDHS) (2010) indicated high prevalence of malnutrition among children below five years. For example, stunting was estimated at 42%, wasting at 5%, anemia at 69%, vitamin A deficiency at 35% and iron deficiency at 33%. The high prevalence levels of malnutrition are attributed to the consumption of less nutrient complementary foods. Various studies (Moshia *et al.*, 1998; Mamiro *et al.*, 2005;

Muhimbula and Zacharia, 2010) have shown that majority of the children in Tanzania are born with the recommended weight of 2.5 kg and start their life in sound health. However, their growth start to abate during and/or after introduction of complementary foods due to nutrients deficiencies in the foods.

Malnutrition is often attributed to dependence on cereals, starchy roots with high fiber content and pulses in rural as well as in urban areas (Mkenda, 2004). These foods are inadequate in protein, energy, vitamin A, iron and zinc and associated with higher rates of childhood under nutrition (Mosha *et al.*, 2000). This suggest that action is required to address this potent challenge among communities in Tanzania at all levels to overcome this challenge. The use of food based approach to combat the problem by developing formulation using locally available foods seems to be appropriate. However, despite adequate literature review, information on formulation based on combination of soybeans, amaranth grains, pumpkin seeds and orange fleshed sweetpotatoes is limited. Therefore this study focused at utilizing those locally available nutrient- dense foods to produce acceptable and nutrient dense porridge that can be used as a complementary food in Tanzania. These ingredients were mainly selected due to their availability and nutrient content. The main objective of the study was to develop nutrient dense complementary food products based on locally available foods in Tanzania, and assess their sensory properties and consumer acceptability.

Materials and method

This study was conducted at Sokoine University of Agriculture in Morogoro, Tanzania. Solar drying of crops and product development were carried out at the Solar Tunda Project premises while sensory analyses activities were carried out at Department of Food Technology, Nutrition and Consumer sciences laboratory. Fresh orange fleshed sweet potatoes were purchased from farmers in Arusha. Pumpkin seeds, Soy beans, amaranth grains and other ingredients / materials were purchased from Morogoro market, in Tanzania.

A complete Randomized Design (CRD) was used with different formulations considered as the principal factor. The effect of principal factor on sensory properties and consumer's acceptability was determined. Fourteen formulations were developed using Nutrisurvey (2007) software. However, only five formulations with at least half of the targeted amount of the nutrients of interest in the study were used (Table 1) subsequently.

Table 1: Various food formulations used in the study

	Soy bean (%)	Amaranth Grain	Pumpkin seeds (%)	OFSP (%)	Energy (Kcal)	Protein (g)	Vitamin A (µg)	Iron (mg)	Zinc (mg)
SAPO1	50	20	25	5	370.2	26.7	476.7	8.6	2.8
SAPO2	40	20	30	10	393.8	27.2	478.6	8.9	3.0
SAPO3	30	35	20	15	408.1	26.1	472.4	9.4	3.6
SAPO4	25	25	20	30	426.0	29.4	488.6	8.9	2.8
SAPO5	20	40	15	25	292.8	25.3	2120.5	6.6	3.0

The five formulations were used to prepare porridges which were tested against two control groups following preparation by mixing 300g of maize flour in 1500 ml of boiling water. The mixtures were constantly stirred for about 15 minutes, and then 30g of sugar was added to the ready porridges. The formulations and controls were then subjected to sensory evaluation

Quantitative descriptive analysis (QDA). The test was conducted at the Food Technology laboratory involving a trained panel of 14 judges. Judges were selected and trained according to ISO (1988). Six attributes of hue, aroma, sweetness, thickness, grittiness and oiliness were developed during training and assessed in duplicate between the samples using a 10 point line scale (1=no or low intensity while 10 for high intensity). All principals of good sensory practices such as coding, randomization and rinsing of mouth were observed.

Consumer acceptability of the porridge. The test was conducted at the Food technology laboratory by a total of 76 untrained and semi-trained consumers. Two groups of consumers, one involving mothers from Sabasaba Health Centre and another one involving university students participated in the tests using seven point and nine point hedonic scales respectively.

Statistical data analysis. Data were analyzed by using R software (R Core Team) for two way analysis of variance to determine the significant differences between samples at $p \leq 0.05$. Means were separated by Tukeys Honest significant difference at $p \leq 0.05$. Principal component analysis (PCA) was done by Panel Check to assess systematic variations between variables.

Results

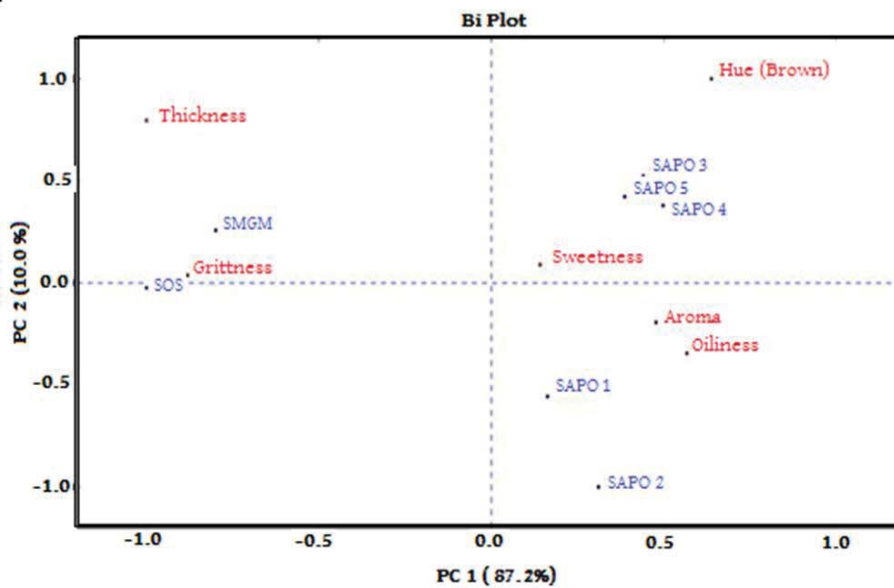
Quantitative descriptive analysis. The mean intensity scores of samples differed significantly ($p \leq 0.05$) with the developed formulations having higher scores for aroma, Hue, sweetness and oiliness than control samples (Table 2). On the other hand, the control samples had significantly higher thickness (8.2 ± 0.83 - 8.4 ± 0.83) and grittiness (5.6 ± 1.23 - 6.9 ± 1.33) than formulated samples (SAPOs); being (4.5 ± 1.35 - 5.3 ± 1.46) and (3.1 ± 1.33 - 4.4 ± 1.31), respectively (Table 2).

The bi-plot of principal component analysis shows that PC1 accounts for 87.2% of the variation and it was a contrast between SAPOs and control samples (SOS and SMGM) while PC2 accounts for 10% of the variations and it was a contrast between SAPO 1 and 2 on one side and the rest of the samples. SAPO 1 and 2 were closely associated in aroma and oiliness attributes while SAPO 3, 4 and 5 were closely associated in hue and sweetness. Control samples were associated with thickness and grittiness (Figure 1).

Table 2: Mean intensity scores of porridge samples by sensory panel

Sample	Aroma	Hue (brownish)	Thickness	Grittiness	Sweetness	Oiliness
SAPO1	5.4± 1.67 ^a	5.6 ±1.45 ^b	4.8±1.41 ^{bc}	4.4±1.31 ^c	5.3±1.75 ^{ab}	4.2±1.98 ^a
SAPO2	5.6 ± 1.47 ^a	5.1 ±1.46 ^{bc}	4.5±1.35 ^b	3.3±0.90 ^d	5.5±1.75 ^{ab}	4.6±1.98 ^a
SAPO3	5.6±1.67 ^a	7.0 ±1.44 ^a	5.3±1.44 ^b	3.5±1.23 ^d	5.6±1.63 ^a	4.3±1.92 ^a
SAPO4	5.5 ±1.20 ^a	6.9±1.76 ^a	5.0±1.55 ^{bc}	3.1±1.33 ^d	5.6±1.52 ^a	4.2±1.89 ^a
SAPO5	5.6±1.23 ^a	6.9±1.086 ^a	5.3±1.46 ^b	3.7±1.46 ^{cd}	5.5±1.29 ^{ab}	4.2±1.85 ^a
SOS	4.4 ± 1.49 ^b	4.4 ±0.95 ^c	8.4±0.83 ^a	6.9±1.33 ^a	5.3±1.68 ^{ab}	2.6±1.25 ^b
SMGM	3.9±1.53 ^b	4.6±1.6 ^c	8.2±0.83 ^a	5.6±1.23 ^b	4.8±1.92 ^b	2.3±1.25 ^b

Means bearing different superscript on the same column are significant different ($P<0.05$). Samples SAPOP1-SAPOP5 are complementary porridges made from formulated flour while SOSP and SMGMP are porridges from control groups' flour ($N=14$).

**Figure 1:** Bi-plot of PCA showing association between samples and attributes

Consumer acceptability. There was a significant difference in acceptability of the porridge by each group ($p<0.05$). Mothers showed significantly ($P<0.05$) lower acceptability for SAPO 1, 2 and 3 on one hand compared to the rest of the samples (Table 3). Contrary, the students showed a higher preference for the formulations with all SAPOs having higher hedonic values (7.1 ± 1.56 , 6.9 ± 1.37 , 7.2 ± 1.59 , 7.0 ± 1.62 , and 7.4 ± 1.11) than control samples with (6.3 ± 1.25 and 5.3 ± 2.25) (Table 3).

Table 3: Mean hedonic score for porridge samples by mothers and students

Samples	Acceptability	
	Mothers	Students
SAPO1	4.5±1.60 ^b	7.1±1.56 ^{ab}
SAPO2	4.5±1.57 ^b	6.9±1.37 ^{ab}
SAPO3	4.5±1.52 ^b	7.2±1.59 ^a
SAPO4	5.1±1.84 ^{ab}	7.0±1.62 ^{ab}
SAPO5	6.0±1.26 ^a	7.4±1.11 ^a
SOS	5.9±1.01 ^a	6.3±1.25 ^b
SMGM	5.7±1.17 ^a	5.3±2.25 ^c

Means bearing different superscript on the same column are significant different ($P < 0.05$). Samples SAPOP1-SAPOP5 are complementary porridges made from formulated flour while SOS and SMGM are porridges from control groups' flour. SOS=Sorghum, Orange fleshed sweet potato and soybean. SMGM= Soybean, maize, groundnuts and millet.

Discussion

The observed increase in acceptability when soybean ratio was decreasing could be associated to the effect of beany flavor which has been reported as cause of low acceptance of soybean based food products (Laswai *et al.*, 2010). Acceptability was not only affected by soybean ratio but also amaranth grains ratio. Formulation SAPO5 which had the highest amaranth grains ratio was the most accepted by both groups. This observation is similar to the findings by Muyonga *et al.* (2014).

The variation observed in aroma could be due to the effect of extrusion cooking and roasting of soybean and pumpkin seeds which is associated with increasing aroma of the product. The variation observed in hue between formulations and control groups could be associated with the ingredients used as well as the effect of roasting and extrusion cooking. Roasting and extrusion cooking have an impact on color changes on the roasted and extruded product (Navale *et al.*, 2015). A significant ($p < 0.05$) difference observed in thickness between formulations and control groups could be attributed to the ingredients used. This is because the use of sorghum, maize, millet and other cereals is associated with bulkiness as previously reported by Muhimbula and Zacharia (2010).

The higher mean scores of sweetness in formulations than control groups is attributed by the inclusion of orange fleshed sweet potato due to its sweetness characteristic. Moreover, significant ($P < 0.05$) difference in oiliness between formulations and control groups is related to the inclusion of soybean, amaranth grains and pumpkin seeds. This observation is similar to the findings by Hassan *et al.* (2008), Ngozi *et al.* (2014) and Muyonga *et al.* (2014) that show the contribution of fats from soybean, amaranth grains and pumpkin seeds.

The observed positions of samples in Bi-plot of principle component analysis were determined by a relationship between samples and attributes. From Figure 1, it is observed that all formulations had a similarity in hue, sweetness, aroma and oiliness compared to control groups. This similarity is attributed to ingredients used as well as extrusion cooking effect. The observed association in aroma and oiliness between SAPO1 and 2 is due to higher ratio of soybean compared to other formulations. Furthermore, the observed association in hue and sweetness for SAPO 3, 4 and 5 could be attributed to the increased ratio of orange fleshed sweet potato and amaranth grains (Table 1). The control groups were associated with thickness due to the ingredients used as it has been reported as one of the characteristics of cereal based porridge.

Conclusion

This study showed that there was a variation in sensory attributes between formulations and control groups and within formulations. Formulations SAPO 1, 2, and 3 had higher scores in aroma and hue than other samples. Thickness and grittiness were higher in control groups than formulations, and sweetness was higher in SAPO 3 while oiliness was higher in all formulations compared to control groups. Both mothers and students accepted SAPO 5. This suggests that the ingredients ratio in SAPO 5 produced the most accepted product and hence adoption of this product is recommended.

Acknowledgement

This study was funded by IAGRI and RUFORUM. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

References

- El Hassan, N. M., Hamed, S. Y., Hassan, A. B., Eltayeb, M. M. and Babiker, E. E. 2008. Nutritional evaluation and physiochemical properties of boiled and fried tree locust. *Pakistan Journal of Nutrition* 7 (2): 325–329.
- Laswai, H., Martin, H. and Kulwa, K. 2010. Nutrient content and acceptability of soybean based complementary food. *African Journal of Food Agriculture, Nutrition and Development* 10 (1): 2040–2049.
- Mamiro, P. S., Kolsteren, P., Roberfroid, D., Tatala, S., Opsomer, A.S. and Van Camp, J. H. 2005. Feeding practices and factors contributing to wasting, stunting, and Iron-deficiency anemia among 3-23-months old Children in Kilosa District, Rural Tanzania. *Journal of Health, Population and Nutrition* 23 (3): 222-230.
- Mkenda, H.J. 2004. Prevalence and factors associated with child malnutrition in Nzega District, rural Tanzania. *Journal of Social Sciences* 7 (3): 94-100.
- Mosha, T. C.E., Dakiyo, S.O.S. and Laswai H. 1998. Breastfeeding, weaning practices and anthropometric status of children in Morogoro district, Tanzania. *Ecol. Food Nutr.* 37 (4): 309–338.
- Mosha, T.C.E., Laswai, H.S. and Tetens, I. 2000. Nutritional composition and

- micronutrient status of homemade and commercial weaning foods consumed in Tanzania. *Plant Foods Hum Nutr.* 55 (3): 185-205.
- Muhimbula, H.S. and Zachariah, A. 2010. Persistent child malnutrition in Tanzania: Risks associated with traditional complementary foods (A review). *African Journal of Food Science* 4 (11): 679 – 692.
- Muyonga, J. H., Tibagonzeka, J., Muyinda, A. M. and Nakimbugwe, D. 2014. Acceptability and nutritional contribution of grain amaranth recipes in Uganda. *African journal of Food, Agriculture, Nutrition and Development* (4): 3.
- Mwanri, L., Masika, J. and Bundara, N. 2013. Addressing childhood under nutrition in Tanzania: challenges and opportunities. *African Journal of Food, Agriculture, Nutrition and Development* 13 (1): 7288-7306.
- Navale, S. A., Swami, S. B. and Thakor, N. J. 2015. Extrusion cooking technology for foods : A Review. *Journal of Ready to Eat Food* 2 (3): 66–80.
- Nwosu, I., Ngozi, N., Ngozi, I. and Maduforo, N. 2014. Development and nutritional evaluation of infant complementary food from maize (*Zea mays*), soybean (*Glycine max*) and *Moringa oleifera* leaves. *International Journal of Nutrition and Food Sciences* 3 (4): 290–299.
- Ramachandra, H. G. and Thejaswini, M. L. 2015. Extrusion technology: A novel method of food processing. *International Journal of Innovative Sciences, Engineering and Technology* 2 (4): 358–369.
- Tanzania Demographic and Health Survey (TDHS). 2010. Demographic and Health Survey. Dar es Salaam, Tanzania: National Bureau of Statistics and ORC Macro.