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Research Application Summary

Improving protein and micronutrient quality of cassava meal for application in primary school feeding in Uganda

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Abstract

The potential of Soybeans and silver fish (Mukene) to improve the protein and micronutrient content of 'Gari' for application in primary school feeding in rural areas was investigated in north and north eastern Uganda. Three different formulations of Gari-Soy, Gari-Mukene at 30%, 20% and 10% inclusion levels respectively and Gari-Soy-Mukene composites at 60, 30, 10%; 70, 15, 15%; 75, 20, 5% combination levels respectively were developed and evaluated for nutritional composition and acceptability by primary school children. Results showed that fortification with Soy and Mukene significantly increased the protein content from 2.18 to 23.29%. The level of calcium, zinc, iron and phosphorus increased from 0.56 to 1.16 %, 0.00 to 0.05, 0.04 to 0.12 % and 0.06 to 0.93 %, respectively. Consumer acceptability evaluation conducted with primary school children showed that the 70 % Gari-30 Soy composite was the most accepted followed by 80 % Gari-20 % Soy and 70% Gari-25% Soy-5% Mukene while 70 % Gari-30 % Mukene was the least accepted. These results indicate that Soy and Mukene have great potential for application in improving protein and micronutrient quality of Gari to improve protein and micronutrient intake among primary school children in rural areas in Uganda.

Key words: Gari, micronutrient content improvement, protein, rural primary school feeding, silver fish, Soy, Uganda

Résumé

Le potentiel du soja et du poisson (Mukene) pour améliorer la teneur en protéine et en micronutriments du «Gari» pour son utilisation dans les programmes alimentaires des écoles dans les zones rurales a été étudié au Nord et Nord-est de l'Ouganda. Trois formulations différentes de Gari-Soja, Gari-Mukene à des niveaux d'intégration respectivement de 30%, 20%, et 10%, et des composés de Gari-Soja-mukene dans des proportions de 60%, 30%, 10%; et 70%, 15%,15% ont été respectivement développés et évalués pour la composition nutritionnelle et l'acceptabilité par les enfants des écoles primaires. Les résultats ont montré que l'enrichissement avec le Soja et le Mukene a augmenté de manière significative la teneur en protéines de 2,18 à 23,29%. Le niveau du calcium, du zinc, du fer et du phosphore a augmenté respectivement de 0,56 à 1,16%, 0,00 à 0,05, 0,04 à 0,12% et de 0,06 à 0,93%. L''évaluation de l'acceptabilité des consommateurs menée avec les enfants du primaire a montré que la combinaison de 70% Gari-30% Soya a été la plus acceptée suivie par les combinaisons de 80% Gari-20% soja et 70% Gari-25% Soya-5% Mukene tandis que la combinaison de 70% Gari-30% Mukene était le moins accepté. Ces résultats indiquent que le soja et le Mukene ont un grand potentiel pour une utilisation dans l'amélioration de la protéine et la qualité du Gari en micronutriments pour améliorer les protéines et l'apport en micronutriments chez les écoliers du primaire dans les zones rurales en Ouganda.

Mots clés : Gari, Amélioration du contenu en micronutriments, protéine, alimentation dans les écoles primaires en milieu rurales, poisson, soja, Ouganda

Introduction

Inadequate nutrition has been recognised as one of the greatest impediments to the fulfilment of full human potential. It affects over one billion people world over with majority being in developing countries (Barrett, 2010). The central tenet of nutrition in human capacity development is based on the fact that deficiencies in essential nutrients affects at individual level, both the mental and physical status, thus resulting in poor health and poor work performance (Frederic, 2012). Increasing numbers of children in developing countries have been enrolled in primary schools in the past decades (Powell *et al.,* 1998). However, their achievement levels have often been disappointing due to different causal factors. Hunger, poor nutrition, and poor health have been directly linked to inadequate cognitive development and low educational attainment of school learners (Nkhoma *et al.,* 2013). This implies that nutrition of children in primary schools should be given due consideration.

Following the launch of the Universal Primary Education (UPE) program by the Government of Uganda in 1997, primary school enrolment increased from about three million children in 1996 to 8.3 million in 2009 and as of 2011 most primary-school age children in Uganda attended school (Korugyendo and Benson, 2011). Notwithstanding the fact that the effects of under nutrition in children are long-term and irreversible (Potts and Nagujja, 2007), poor socio-economic conditions in many rural parts of Uganda such as those in north and north-eastern regions has made it difficult for children in primary schools in such areas to receive nutritious foods required to enable them comprehend and perform well in school (Acham *et al.,* 2012). In order to reduce hunger and nutritional constrains in rural primary schools, there is need for nutritional innovations in food products derived from cheap and locally available food resources within the community so as to exploit local potential for nutritional interventions specifically targeting school feeding in rural areas (Korugyendo and Benson, 2011).

Gari, a granulated cassava food product designed for making instant porridge has a high potential for application as a cheap food for school feeding in rural areas in north and north eastern Uganda. This is because its main raw material, cassava, is widely cultivated and consumed in the region both as a food security and a commercial crop (MAAIF, 2011). One major limitation associated with Gari is that the product is basically starch and very low in protein (1.2%), deficient in essential amino acids and other micronutrients of public health importance such as calcium, iron, zinc, and Phosphorous (Eke *et al*., 2008). Therefore, without enrichment with other micronutrient and protein-rich sources Gari still remains unsuitable for feeding school children as a base diet. Soy and silver fish (Mukene) are locally available protein and micronutrient-rich food resources that can be used to improve nutritional quality of Gari. Soy is a complete protein source, rich in fat soluble vitamins (A, D, E, K) and phosphorus (Yin *et al.,* 2011), while mukene is also good source of proteins, minerals (e.g. calcium and phosphorus), and energy due to the high lipid content. It has a balanced amino acid profile and is particularly rich in methionine and lysine that are deficient in Soybean. This implies that a combination of Soybeans and Mukene when used for Gari fortification allows for nutrient complementary benefits. The objective of this study was therefore to investigate the potential of Soybeans and Mukene to improve the protein and micronutrient contents of Gari and evaluate the acceptability of the nutritionally improved Gari among primary school children in rural areas of north and north eastern Uganda.

Study Description

The study was conducted in two districts (Gulu and Lira) and four districts (Kaberamaido, Soroti, Katakwi and Amuria) in north and north Eastern Uganda, respectively. These areas are typical of economically disadvantaged areas in Uganda. Using a participatory community engagement approach, local experience and expertise, and locally fabricated equipment, a method for producing nutritionally enriched Gari at the community level was developed together with the community at Ngetta farmer field school in Lira District. This was followed by evaluation of sensory attributes and consumer acceptability of the nutritionally improved products by rural primary school children in the stated districts.

Nutritional improvement of Gari and Sensory evaluation

Different formulations of Gari-Soy, Gari-Mukene, (at 10, 20 and 30%, inclusion levels of Mukene) and Gari-Soy-Mukene (at 30-10, 15-15, and 20-50% inclusion levels of Soy-Mukene) were designed using Excel and Harvest Plus Food Composition Table (Christine *et al.,* 2012). Nutritionally enriched Gari was then produced following the method of Oluwamukomi and Adeyemi (2012) with modification to take care of local conditions at the farmer field school. The Proximate composition and mineral content were determined according to the standard methods reported by Eke *et al*. (2008). Porridge samples were made from various formulations and evaluated for sensory attributes (colour, texture, aroma, taste) and acceptability by the primary school pupils (attending classes from primary five and above) using a 5-point hedonic scale.

Statistical analysis

All statistical analyses were performed using the Statistical Analysis for Social Scientist (SPSS) version 20.0 package. One-way ANOVA was used to test the effect of soy and mukene addition on protein and mineral content, sensory properties and overall acceptability of Gari. The means were separated by Duncan's Multiple Range Tests at 5 % ($P \leq 0.05$).

Results

The effect of Soy and or Mukene addition on protein and mineral content of Gari is presented in Table 1. The protein content of Gari significantly increased ($p<0.05$) with higher levels of Soy and Mukene inclusion, rising from 2.18% in pure Gari to 23.29% in the Gari-Soy-Mukene composite. A significant enhancement ($p<0.05$) in the ash content was observed in the Soy and Mukene enriched Gari, with increased levels of both Soy and Mukene inclusion resulting in significantly higher ash content up to 3.03% and 5.81% respectively, while the Gari-Soy-Mukene composites also had increased ash level compared to the control (1.4%).

Table 1: The effect of Soy and or Mukene addition on protein, ash, calcium, iron, zinc and phosphorus contents (%) of Gari

Sample Description	Protein	Ash	Calcium	Iron	Zinc	Phosphorus
Control-100%	2.18±0.00^{a}	1.41±0.02^{a}	0.556±0.020^{a}	0.044±0.000^{a}	0.0012±0.001^{a}	0.066±0.019^{a}
Gari-Soy						
70:30	16.69±0.03^{d}	3.03±0.06^{d}	0.754±0.020^{d}	0.084±0.002^{e}	0.0024±0.002^{b}	0.256±0.004^{e}
80:20	11.45±2.15^{c}	2.61±0.15^{c}	0.675±0.020^{c}	0.077±0.000^{c}	0.0014±0.001^{a}	0.190±0.009^{d}
90:10	7.69±0.38^{b}	2.10±0.05^{b}	0.594±0.000^{b}	0.063±0.000^{b}	0.0013±0.001^{a}	0.123±0.009^{b}
Gari-Mukene						
70:30	19.87±0.36^{e}	5.81±0.38^{g}	1.162±0.020^{h}	0.109±0.000^{i}	0.0049±0.005^{d}	0.928±0.020^{h}
80:20	16.53±0.41^{d}	4.68±0.0^{f}	1.118±0.020^{i}	0.086±0.000^{f}	0.0037±0.004^{c}	0.562±0.000^{g}
90:10	8.39±0.43^{b}	2.93±0.06^{cd}	0.868±0.039^{fg}	0.081±0.001^{d}	0.0027±0.003^{b}	0.311±0.019^{e}
Gari-Soy-Mukene						
60:30:10	23.29±0.42^{f}	4.22±0.08^{e}	0.905±0.020^{g}	0.116±0.000^{g}	0.0045±0.002^{d}	0.404±0.009^{f}
70:15:15	19.84±0.39^{e}	3.91±0.11^{e}	0.867±0.020f^{g}	0.104±0.000^{h}	0.0039±0.001^{c}	0.395±0.009^{f}
75:20:5	15.10±0.17^{d}	3.11±0.00^{d}	0.833±0.020^{e}	0.098±0.000^{g}	0.0023±0.002^{b}	0.227±0.009^{c}

Values are means + SD of three replicates. Mean scores with different superscripts within the same column are significantly different ($P< 0.05$).

Soy and Mukene enrichment improved the micronutrient content of Gari with the mean values for calcium ranging from 0.556% to 1.162%, iron from 0.044% to 1.116%, zinc from 0.0012% to 0.0049% and phosphorus from 0.066% to 0.928% for pure Gari and fortified Gari respectively. The mean values estimated for all the minerals studied showed significantly higher mineral contents in the fortified Gari. The calcium, iron, zinc and phosphorus levels increased significantly with higher levels of Soy and Mukene inclusion, with formulations of highest Soy and Mukene inclusion levels having the highest mineral composition. The Gari-Soy-Mukene composites had the highest iron content but also with significantly (p<0.05) enhanced levels of calcium, zinc and phosphorus compared to the 100% Gari. However the Gari-Mukene formulations had the highest phosphorus content which increased with higher levels of Mukene inclusion.

Results for consumer scores on the degree of preference for the sensory attributes and acceptability of the Gari as affected by Soy and or Mukene addition is presented in Table 2. Soy enriched Gari (70: 30) had the best sensory ratings in terms of aroma, texture, taste and overall acceptability, respectively. However, pure Gari (100% cassava) was best preferred in terms of colour. There were significant differences (p<0.05) in the colour and aroma ratings between the control and Soy enriched samples as well as Soy-Mukene enriched Gari formulations with the Mukene enriched Gari (70:30) least preferred in terms of aroma and colour.

Table 2: Consumer scores for the sensory attributes and acceptability of Gari enriched diets

Sample Description	Colour	Aroma	Texture	Taste	Overall acceptability
Control (100:0)	3.43 ± 1.37^{f}	3.37 ± 1.27^{e}	2.59 ± 3.09^{a}	3.27 ± 3.09^{cd}	3.10 ± 1.30^{bcd}
Gari-Soy					
70:30	3.34 ± 1.18^{f}	3.42 ± 1.12^{e}	3.51 ± 0.97^{c}	3.32 ± 1.16^{d}	3.46 ± 1.10^{e}
80:20	3.10 ± 1.22^{de}	3.24 ± 1.15^{e}	3.30 ± 0.99^{bc}	3.30 ± 1.02^{d}	3.41 ± 0.98^{de}
90:10	2.65 ± 1.29^{a}	3.16 ± 1.22^{de}	2.72 ± 1.15^{a}	3.02 ± 1.21^{bc}	3.02 ± 1.12^{bc}
Gari-Mukene					
70:30	2.37 ± 1.12^{ab}	2.46 ± 1.35^{a}	2.63 ± 1.24^{a}	2.42 ± 1.31^{a}	2.46 ± 1.19^{a}
80:20	2.78 ± 1.20^{bcd}	2.80 ± 1.23^{bc}	3.03 ± 1.21^{b}	2.69 ± 1.20^{ab}	2.85 ± 1.24^{b}
90:10	2.59 ± 1.17^{ab}	2.79 ± 1.27^{bc}	2.68 ± 1.30^{a}	2.79 ± 1.28^{ab}	2.82 ± 1.25^{b}
Gari-Soy-Mukene					
60:30:10	2.70 ± 1.44^{bc}	2.87 ± 1.38^{bcd}	3.02 ± 1.20^{b}	2.93 ± 1.36^{bcd}	2.80 ± 1.30^{b}
70:15:15	3.02 ± 1.37^{cde}	2.68 ± 1.25^{ab}	3.33 ± 1.24^{bc}	2.85 ± 1.37^{bc}	2.89 ± 1.26^{b}
75:20:5	3.02 ± 1.34^{cde}	3.12 ± 1.27^{de}	3.20 ± 1.18^{b}	3.13 ± 1.33^{bcd}	3.25 ± 1.30^{cde}

Values are Means + SD of scores of parameters for different formulations. Mean scores with different superscripts within the same column are significantly different (P< 0.05)

Attributes of the Soy enriched Gari formulations were the most preferred while those of Mukene enriched Gari formulation was least preferred. Overall acceptability was highest for the Soy enriched formulations (irrespective of the level of Soy addition), followed by the Soy-Mukene enriched formulation (70:25:5), while the Mukene enriched formulation (70:30%) was least preferred. There were no significant differences (P>0.05) in the level of overall acceptability between the control (pure Gari) and Soy-Mukene enriched formulations or Mukene enriched formulations.

Discussions

Previous studies conducted with Soy to improve the protein content of Gari demonstrated enhanced protein content only up to 19.1% (Samuel *et al.,* 2012). However, enrichment levels achieved using a combination of Soy and Mukene in the current study are higher than the levels reported in previous studies. This observation demonstrates nutritional advantage in terms of protein that the Gari-Soy-Mukene composite have over conventional Gari produced from cassava alone or the Gari-Soy composite. The fortified samples had better levels of minerals compared to the unfortified sample. This can be attributed to the high mineral profile of fish (Toppe *et al*., 2007) and Soy (Eke *et al*., 2008). The high ash contents of the Gari-Soy or Gari-Soy-Mukene or gari-mukene compared to pure Gari therefore, demonstrates the potential of Mukene and Soy at improving the micronutrient content of Gari. This is well illustrated by the higher calcium, iron, zinc and phosphorous contents of the composite samples compared to the control (pure Gari). The high mineral contents of the composite samples are desirable from nutritional point of view because high mineral contents have been demonstrated to enhance nutrient intake (Sandström, 2001)

Colour, aroma, taste and texture are key sensory attributes of food that affect consumer acceptability (Udofia *et al*., 2011). Enrichment with Soy generally improved the sensory attributes of Gari, hence better acceptability. The relatively low scores for Gari-Mukene formulations in terms of aroma and overall acceptability could be due to off flavors produced by the oxidation of lipid components of fish, while the high aroma scores can be attributed to the good flavors of roasted Soy that enhances the overall acceptability of both the Gari-Soy and Gari-Soy-Mukene formulations. It is very clear that a combination of Soy and Mukene results in Gari with the highest protein and mineral content (Table1), but the presence of Mukene affects negatively the acceptability of the product. This is a subject of future research.

Conclusion

This study has demonstrated that: (i) a combination of Soy and Mukene enhances the protein and mineral content of Gari compared to Soy or Mukene alone; (ii) presence of soy enhances the acceptability of Gari; and (iii) presence of Mukene negatively affects the acceptability of Gari. It can therefore be concluded that: (i) a combination of Mukene and Soy has a superior potential for improving the protein and micronutrient content of Gari for application in primary school feeding in rural areas; and (ii) more work needs to done to remove undesirable fish odour that negatively affects consumer acceptability of the Gari-Mukene-Soy composite.

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