RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (2) : 1043 - 1049.
Available from *http://repository.ruforum.org*

Research Application Summary

Application of edible insects in enriching complementary foods made from common plant sources

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Abstract

Complementary foods in most sub-Saharan African countries are deficient in protein, essential minerals and vitamins resulting to sub-optimal growth and increased premature deaths among children below five years of age. This calls for action to develop home based enrichment of traditional complementary foods by exploiting the available and cheap animal protein like edible insects. A study was carried out in Kagera and Morogoro regions of Tanzania to develop a nutritious, affordable and acceptable complementary food from soybean, sweetpotatoes and longhorn grasshoppers-senene (*Ruspolia baileyi)*. Soybeans were soaked, germinated for 36 h at 29°C, dried, mildly roasted and milled to obtain flour which was mixed with senene flour and sweetpotato flour at different ratios (CF01:25% senene: 35% soybeans: 40% sweetpotato, CF02: 20% senene: 40% soybeans: 40% sweetpotato and CF03: 15% senene: 35% soybeans: 50% sweet potato). Proximate analysis of the formulated foods was done using standard methods. Results showed that there were significant differences in crude protein, fat and ash contents among the samples ($P<0.05$). The highest crude protein (36.84%) and ash contents (3.93%) were found in soybean flour while senene flour had the highest fat levels (62.15%). Energyn analysis results revealed that senene flour had the highest energy levels (675.87kcal/100g) while sweet potato flour had the least energy. Among the three formulations of composite flours, CF01 had significantly higher protein, fat and energy levels ($p<0.05$) and above WHO recommendations for complementary foods. Sensory evaluation results showed that all flours were acceptable. CF01 had superior attributes in texture and overall acceptability having the highest mean score of 4.3 on a 5 points hedonic scale . These results suggest that senene is a protein rich ingredient useful in enriching plant based complementary foods. Exploitation of this cheap source of nutrients for complementary food formulation will be useful for the resource poor farmers.

Keywords: Composite flours, germinated soybeans, senene, sweet potato

Résumé

Dans la plupart des pays d'Afrique subsaharienne, les aliments complémentaires sont déficients en protéines, en minéraux essentiels et en vitamines, ce qui entraîne une croissance sous-optimale et des décès prématurés accrus chez les enfants âgés de moins de cinq ans. Cette situation appelle à l'action pour développer l'enrichissement d'aliments

complémentaires traditionnels à domicile, à partir de protéines animales disponibles et bon marché comme les insectes comestibles. Une étude a été menée dans les régions de Kagera et Morogoro en Tanzanie pour développer un complément alimentaire nutritif acceptable et à bas prix, à partir du soja, de la patate douce et des sauterelles-senene (Ruspolia baileyi). Le soja a été trempé, germé pendant 36 h à 29 ° C, séché, grillé légèrement et moulu pour obtenir de la farine qui a été mélangée avec de la farine de senene et de la farine de patate douce à différents ratios (CF01: 25% de senene: 35% de soja: 40% de patate douce, CF02 : 20% de senene: 40% de soja: 40% de patate douce et CF03: 15% de senene: 35% de soja: 50% de patate douce). L'analyse immédiate des aliments formulés a été effectuée en utilisant des méthodes standard. Les résultats ont montré qu'il existe de différences significatives entre les teneurs en protéines brutes, graisse et cendres des échantillons (P <0,05). La protéine brute (36,84%) et la teneur en cendres (3,93%) les plus élevés ont été observés dans la farine de soja, tandis que la farine de senene avait le taux de graisse le plus élevé (62,15%). Les résultats de l'analyse énergétique ont révélé que la farine de senene avait les teneurs énergétiques les plus élevés (675,87 kcal / 100 g) alors que la farine de patate douce était le moins riche en énergie. Parmi les trois formulations de farines composites, le CF01 possédait des niveaux de protéines, de graisses et d'énergie (p <0,05) significativement plus élevés et supérieurs aux recommandations de l'OMS en matière d'aliments complémentaires. Les résultats de l'évaluation sensorielle ont montré que toutes les farines étaient acceptables. CF01 avait des attributs supérieurs en acceptabilité globale et en texture ayant le score moyen le plus élevé de 4,3 sur une échelle hédonique de 5 points. Ces résultats suggèrent que le senene est un ingrédient riche en protéines utile pour l'enrichissement des aliments complémentaires à base de plantes. L'exploitation de cette source moins coûteuse de nutriments pour la formulation d'aliments complémentaires sera utile pour les agriculteurs pauvres.

Mots-clés: Farines composites, soja germée, senene, patate douce

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Background

Stunting is a major development challenge in Tanzania with 34.7% of children under five years of age being affected. Further, of the 34.7% affected, 11.5 % are severely stunted, 69 % are anemic and 24% are vitamin A deficient (UNICEF, 2009; TFNC, 2014). The country is ranked third last in stunting in sub-Saharan Africa after Ethiopia and the Democratic Republic of Congo.

Most complementary foods in Africa (including among others; cereal porridges from millet, sorghum, maize, rice and tubers such as cassava, yams and potatoes) are plant based characterized with low nutrient bioavailability due to the presence of multiple anti-nutrients (Mamiro *et al.,* 2004; Gewa and Leslie, 2015). Soybean flour though highly challenged with presence of anti-nutrients like phytates, is among the products increasingly adopted for complementary feeding in Tanzania. It has been reported to be a good source of protein, lipid and other essential nutrients (Mosha *et al.,* 2000). Germination is among common used techniques in preparation of complementary feeding cereals, but

its application in legumes such as soybeans has been neglected despite its potential to significantly reduce levels of anti-nutrients (Vernaza *et al.,* 2012). Sweet potatoes are among weather independent tubers, with good sensory attributes commonly used as a complementary food in different African communities (Amagloh, 2012).

Edible insects being among cheap animal protein source, have adequate amounts of energy, protein and essential micronutrients with most insects meeting the amino acid requirements for humans (Rumpold and Schl, 2013; Kinyuru *et al.,* 2012). Such insects like longhorn grasshoppers commonly known as senene, are widely harvested and consumed as a traditional snack in regions around the Lake Victoria crescent. It has been shown that 100g of senene flour can provide the RDA for protein, zinc, vitamin A and iron to children under 5 years of age (Kinyuru, 2009). However, nutritional benefits of these insects have not been adequately tapped in fighting stunting and micronutrients deficiency common in sub-Saharan Africa. Therefore, enriching complementary foods with such nutritious edible insects like senene is a way towards reducing protein energy malnutrition and micronutrient deficiency among the Tanzanian children below 5 years of age. This study therefore focused on development of nutritious complementary foods from *senene* flour, germinated soybeans and sweetpotatoes as a technique towards increasing the availability of appropriate complementary foods in Tanzania.

Study description

The study was conducted in two regions of Tanzania. fried senene samples were collected from Bukoba central market in Kagera region, soybeans and a yellow fleshed local sweetpotato samples from Morogoro municipal market, while preparation and nutrient analysis were carried out at Sokoine University of Agriculture Food laboratory in Morogoro region. Semeki variety of soybean obtained from Turiani Morogoro was sorted, washed and soaked in cold tap water for six hours before germination for 36 hours at 29°C.Germinated soybeans were de-hulled, washed and solar dried to 5% moisture content then toasted at 260°C for four minutes to enhance flavor.

Sweetpotatoes were sorted, washed, hand peeled, sliced 3mm pricesthen blanched in boiling water for three minutes and solar dried to 3% moisture content. Fried senene were oven dried at 60°C for 24hours. The three ingredients were individually milled, sieved in 1mm sieve and proximate composition performed on them following AOAC 2003 standard methods.

A market survey was conducted around Morogoro Municipal to select commonly used composite flour which was also analysed and rated against formed formulations. Three composite flours with three different ratios were developed with the help of Nutrisurvey software (2007) version and WHO guide for complementary feeding of year 2001. Accordingly three formulations were made: CF01 (25% senene: 35% soybeans: 40% sweetpotato), CF02 (20% senene: 40% soybeans: 40% sweet potato), and CF03 (15% senene: 35% soybeans: 50% sweet potato). The three formulations were tested for acceptability by 32 panelists aged between 20-35 years, using 5 point hedonic scale with 5= like extremely, 1= dislike extremely and 3= neither like nor dislike.

Proximate composition results were statistically analysed using SPSS (Version 21) while sensory evaluation results were analysed using R software (Version 3.3.0).

Results and Discussion

Proximate composition and energy levels of developed flours

Table 1 presents proximate composition and energy levels of senene flour, sweet potato flour, soybean flour and of selected commonly used composite flour from the market. There was a significant difference in crude protein, fat and ash contents among the samples ($P<0.05$). The highest crude protein (36.84%) and ash contents (3.93%) were found in soybean flour while senene flour had the highest fat levels (62.15%). Senene flour had the highestenergy levels (675.87kcal/100g) and the least was found in sweetpotato flour.

Table 1. Proximate composition (%) and Energy analysis

Flour Samples	***Crude protein (%)***	***Crude fat (%)***	***Ash (%)***	***Crude fibre (%)***	***Carbohydrate (%)***	***Moisture (%)***	***Energy (kcal/100g)***
Senene	28.45±1.03^{c} 6	2.15±0.24^{d} 3	.15±0.17^{b} 5	.56±0.06^{c} 1	.16±0.3^{a} 1	.11±0.1^{a} 6	75.87±1.95^{d}
Soybean	36.84±2.7^{d} 1	9.58±0.3^{c} 3	.93±0.06^{c} 4	.04±0.43^{b} 3	5.61±3.1^{b} 5	.29±0.13^{d} 4	66.07±0.48^{c}
Sweet potato	3.35±0.3^{a} 0	.41±0.04^{a} 2	.45±0.1^{a} 1	2.18±0.4^{d} 8	1.61±0.5^{c} 1	.72±0.15^{b} 3	43.52±1.87^{a}
From market	7.49±1.03^{b} 4	.17±0.36^{b} 2	.44±0.07^{a} 3	.80±0.09^{a} 8	2.09±01.13^{c} 3	.31±0.1^{c} 3	95.87±2.16^{b}

All values except moisture content expressed as means ± SE on dry matter basis
Values on the same column followed by the same letter are not significantly different ($p > 0.05$).

Fat levels observed in senene flour rank higher than those reported in literature (48-49%) (Kinyuru *et al.,* 2009; Siulapwa *et al.,* 2014). High fat content in senene flour can be attributed to the preparation method used by senene traders (deep frying). Energy levels were low in sweetpotato flour and market flour (343.52kcal/100g and 395.87kcal/100g, respectively). These were attributed to high levels of carbohydrates of 81.6% and 82.09% as well as low fat contents of 0.41% and 4.17% respectively. Crude protein, fat, ash, fibre and carbohydrate contents of soybean flour were in-line with those reported in literature (Lokuruka, 2010; Muzzarelli *et al.,* 2012; Arueya and Osundahunsi, 2015). Crude fibre content was slightly lower (4.04%) than that reported by Muzzarelli *et al.* (2012) of 18%. This can be a result of the germination process which was carried out in this study to reduce anti-nutrients levels. Protein, fat, carbohydrate and energy contents of three formulated composite flours are shown in Table 2.

Table 2. Protein, fat, carbohydrate and Energy analysis of formulation ratios

Code	Formulation ratio (w/w %)	Protein	Fat	Carbohydrate	Energy
	Senene: Soybeans: Sweetpotato	(g/100g)	(g/100g)	(g/100g)	(kcal/100g)
CF01	*25:35:40*	21	22.5	39	469
CF02	*20:40:40*	21.5	20.4	42	458.6
CF03	*15:35:50*	18.6	16.3	53.1	435

All three formulations had nutrients and energy levels superior to commonly used flour and contained ideal amounts for complementary foods (Lutter and Dewey, 2003) and WHO (2002). A 100g of the product is able to provide energy, fat and protein levels above that recommended for 6 to 11 months children and more than 80% of that recommended for 12 to 23 months old children. CF01 with 25% senene, 35% soybean and 40% sweet potato has the highest protein, fat and energy levels. The protein found in senene is reported to contain all essential amino acids (Siulapwa *et al.,* 2014; Skau *et al*., (2015). This makes senene a suitable ingredient for complementary feeding in children.

The three formulations of composite flour showed no significant difference in appearance color and smell. This explains that addition of senene did not cause strange sensory attributes to consumers. Meanwhile, CF03 was statistically similar to commonly used flour in all tested attributes while CF01 had superior attributes in texture and overall acceptability with the highest mean score of 4.3 on 5 point hedonic scale (AS2542.1. 1-2005). CF01 did not pose strange sensory attributes as its mean scores were statistically similar to commonly used market flour in appearance,colour and smell. Formulated composite flours can therefore be recommended for adoption and commercialization to mothers and entrepreneurs respectively.

Sensory evaluation

Sensory attributes of the product are presented in Table 3.

Table 3. Sensory attributes od three formulated ratios

Sample	Attribute				
	Appearance	Color	Smell	Texture	Overall
CF01	4.1±0.8^{a}	3.9±0.9^{a}	3.9±0.8^{a}	4.2±0.8^{b}	4.3±0.6^{b}
CF02	3.8±1.0^{a}	3.4±1.4^{a}	3.7±1.2^{a}	3.4±1.0^{a}	3.7±1.0^{a}
CF03	3.7±1.0^{a}	3.7±0.9^{a}	3.8±1.1^{a}	3.6±0.8^{ab}	3.9±0.9^{ab}
Market flour	4.0±0.7^{a}	4.1±0.7^{a}	3.9±1.1^{a}	3.9±1.8^{ab}	4.1±0.7^{ab}

Values presented as arithmetic means ± SD (n = 32).
Means in column of each sample with different superscript letters are significantly different at $p<0.05$.

Acknowledgement

Thanks are due to the Innovative Agricultural Research Initiative (iAGRI) and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) for the opportunity and funding to undertake this study. This paper is a cotribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

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