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Research Application Summary

Potential of locally formulated micronutrient based flour for routine enrichment of complementary foods in northern Uganda: A review

Ugada, A.M., Okidi, L. & Ongeng, D.

Department of Food Science and Postharvest Technology, Faculty of Agriculture and Environment, Gulu University, P.O Box 166, Gulu, Uganda
Corresponding Author:duncanongeng@hotmail.com

Abstract

Micronutrient deficiencies are a threat to nutritional status and overall health of children 6-24 months old. Apparently, poor diets are known as the number-one driver of the global burden of disease among children, especially in low and middle-income countries. Intake of iron, calcium, and zinc among children 6-24 months in Acholi sub-region of Uganda has been found low despite availability of nutritious locally available foods which remain underutilized. It is therefore extremely important to unravel the potential of locally available and accessible foods that are rich in iron, calcium and zinc in improving micronutrient intake in this age group. This paper focused on iron rich beans, silver fish, and amaranth grains as potential sources of iron, calcium and zinc. An extensive review of existing literature from online platform was done. Evidence shows that iron rich beans, amaranth grains, and silver fish contain all the three micronutrients (iron, calcium and zinc), and have good acceptability scores. Therefore, these foods have potential of complimenting one another when formulated into micronutrient based flour and used for routine enrichment of complementary foods of children 6-24 months thus improving micronutrient intake.

Key words: Calcium, children 6-24 months, complementary foods, Iron, local fooda, Northern Uganda, Zinc

Résumé

Les carences en micronutriments menacent l'état nutritionnel et la santé générale des enfants de 6 à 24 mois. Apparemment, une mauvaise alimentation est connue comme le principal moteur de la charge mondiale de morbidité chez les enfants, en particulier dans les pays à revenu faible et intermédiaire. L'apport de fer, de calcium et de zinc chez les enfants de 6 à 24 mois dans la sous-région Acholi de l'Ouganda s'est avéré faible malgré la disponibilité d'aliments nutritifs disponibles localement qui restent sous-utilisés. Il est donc extrêmement important de découvrir le potentiel des aliments disponibles et accessibles localement qui sont riches en fer, en calcium et en zinc pour améliorer l'apport en micronutriments dans ce groupe d'âge. Cet article s'est concentré sur les haricots riches en fer, le petit poisson et les grains d'amarante en tant que sources potentielles de fer, de calcium et de zinc. Une revue approfondie de la littérature existante sur la plateforme en ligne a été effectuée. Les preuves montrent que les haricots riches en fer, les grains d'amarante et le petit poisson contiennent les trois micronutriments (fer, calcium et zinc) et ont de bons scores d'acceptabilité. Par conséquent, ces aliments ont le potentiel de se compléter lorsqu'ils sont formulés dans une farine à base de micronutriments et utilisés pour l'enrichissement de routine des aliments complémentaires des enfants de 6 à 24 mois, améliorant ainsi l'apport en micronutriments.

Mots clés : Calcium, enfants de 6-24 mois, aliments complémentaires, Fer, aliments locaux, Nord de l'Ouganda, Zinc

Background

Acholi sub-region in Northern Uganda is a rural community in which majority of household are resource-constrained thus unable to access commercial nutritious food products for complementary feeding. This could possibly explain why children from rural households such as in Acholi sub region of Northern Uganda, are more vulnerable to micronutrient deficiencies. For example, the prevalence of anemia is higher in rural areas (54%) than urban areas (48%) with Acholi sub region having 78% prevalence (UBOS, 2017). On the other hand, mean intake of zinc in Northern Uganda ranged from 0.40-5.35 and 1.2-6.8 mg/day for children 6-8 and 9-11 months, respectively, which accounted for only 23 and 43% of estimated zinc needs from complementary feeding, respectively (Acheng, 2014). Lastly, prevalence of nutritional rickets, which is associated with calcium deficiency was 9.5% among children admitted with severe pneumonia at Mulago national hospital (Piloya *et al*., 2018). Whereas there is no specific data of prevalence of rickets among children in Northern Uganda, these findings from the country's national referral hospital show that the problem is affecting children across the country including Northern Uganda. This figure is likely to be even higher since not all sick children are taken to national hospital. Apparently, the peak incidence of rickets occur among infants and young children 6-23 months old (World Health Organization [WHO], 2019), which involves the target population for this review. Therefore, the prevailing cases of micronutrient deficiencies are an indication that intake of iron, calcium and zinc among children 6-24 months in Northern Uganda is below the recommended dietary allowances (RDA) (Brown *et al*., 2012). Apparently, there exist nutritious foods in Acholi sub-region of Uganda which are locally available and accessible yet underutilized. These foods are rich in iron, calcium and zinc, and could provide a better way of tackling micronutrient deficiencies in this sub-region.

Dewey and Vitta (2013) reported that the use of food-based approach to improving dietary quality through routine consumption of nutrient rich food is generally a long-term solution for undernutrition. Agreeably, use of locally available food sources serves as a sustainable and effective means to improve nutritional quality of foods among economically disadvantaged vulnerable groups (Trichopoulou *et al.,* 2007). The objective of this review was therefore to determine the potential of amaranth grains, iron rich beans and silver fish in alleviating micronutrient undernutrition in Acholi sub-region, Northern Uganda.

Food types, availability and associated acceptability

Amaranth grains. Amaranth is a widely distributed, short-lived herb occurring in temperate and tropical regions (Muyonga *et al.,* 2008). This plant, classified as pseudo cereal, has ability to grow in dry and semi-dry areas due to its drought tolerant characteristics (Bhattarai, 2018), an attribute that could possibly explain why it is readily available all-year-round in Northern Uganda.

In Uganda, grain amaranth was first introduced in 2005 by Volunteer Efforts for Development Concerns (VEDCO), a non-governmental organization (Muyonga *et al*., 2008).

The main grain species of amaranth are *A. hypochondriacus, A. cruentus,* and *A. caudatus* (Knorr *et al.,* 1985). However, production and consumption of amaranth in Northern Uganda and most parts of the country is largely inclined towards the leafy amaranth types, with limited production of grain amaranth types which could otherwise be processed and utilized into different products (Namazzi *et al.,* 2015) such as micronutrient based flour. However, despite the dominance of leafy amaranth type in the region, some households grow grain amaranth. This is an indicator that the soils and climate in Northern Uganda are equally favorable for cultivation of grain amaranth. Therefore, nutrition education is required to enlighten the community on benefits of grain amaranth such as potential to form micronutrient based flour out of it. Unlocking market potential for grain amaranth could also act as an incentive for households in Northern Uganda to be more committed towards production of grain amaranth (Namazzi *et al.,* 2015). This would give producer households an opportunity to sell surplus while allowing households that depend on market pathway to get access to this nutritious food hence addressing both availability and accessibility, which are important pillars of food security.

Amaranth grain is endowed with many nutrients. Besides iron, calcium and zinc, it is also rich in carbohydrates, protein, carotenoid, dietary fiber, vitamin C, thiamine, riboflavin, and unsaturated fatty acids. Additionally, the grain also contain essential bioactive compounds such as anthocyanin, lutein, and other phenolic compounds (Bhattarai, 2018). Micronutrient composition of amaranth grains grown in Uganda is shown in Table 1 below.

Table 1. Micronutrient composition of amaranth grains

Target micronutrient	Content (mg/100g)
Iron	17.4
Calcium	175
Zinc	3.7

Source: www.eap.mcgill.ca/CPAT_1.htm

Studies involving incorporation of grain amaranth in foods for children resulted into acceptable products containing up to 70% amaranth flour. Other experiments also resulted into acceptable products when pure amaranth flour (100%) was used (Muyonga *et al*., 2008). In another study, Mugalavai (2013) reported that cereal staples made from amaranth and maize flours in the ratio of 80:20 respectively had the highest acceptability for porridge and 'Ugali'. Based on these findings, products such as soups, porridge, cakes, and posho can be made using amaranth flour for complementary feeding. Thus, amaranth grains have great potential in improving micronutrient intake among children when harnessed into products that can be consumed routinely as complementary foods.

Iron rich beans. Iron rich beans, also known as high iron beans were first released by the Government of Uganda in 2016. This was a national strategy to tackle malnutrition and reduce anemia among vulnerable population groups, and to serve as a cheap source of nutrients among resource-constrained communities (RURAL 21, 2016). Household production and consumption of beans in Northern Uganda is about 127 kg/season and 3 days/week, respectively (Larochelle *et al.,* 2015). This is a fair pattern that could improve further if households are educated on the nutritional value of beans, especially, the iron rich beans. Despite their richness in micronutrients, and accessibility, iron rich beans remain underutilized in Northern Uganda. Table 2 below shows iron, calcium and zinc content of iron rich beans.

Table 2. Micronutrient composition of iron rich beans

Target Micronutrient	Content(mg/100g)
Iron	10
Calcium	113
Zinc	33

HarvestPlus (2016); Buruchara (2019)

Candace *et al.* (2013) observed that majority of children (91-96%) liked the sensory attributes of sorghum-bean composite porridge including the color, appearance, taste, and thickness, and over 75% of them found it highly acceptable in the ratio of 40.7:59.3 for sorghum and bean flours, respectively. Additionally, in bean-based nutrient-enriched puffed snacks, an optimal formulation of 82.03, 10, 5, and 2.97 for beans, maize, orange fleshed sweet potatoes, and amaranth, respectively resulted into average acceptability of 6 on a 9-point hedonic scale (Natabirwa *et al.,* 2020). The authors attributed high content of iron and zinc (4.83 and 1.51 mg/100g for iron and zinc, respectively) to the high proportion beans in the formulation. Lastly, in efforts to evaluate nutritional and sensory properties of maize-bean composite in Uganda, the blend in the ratio of 4:1 for maize to bean flours respectively, had the highest acceptability level (Kikafunda *et al.,* 2007). This ratio translates to 20% bean flour inclusion in the composite.

Beans have shown diverse results regarding acceptability studies. This could possibly be due to the specific type of beans used in studies. However, this is an insight that iron rich beans can be consumed by children hence qualifying for inclusion in micronutrient based flour for complementary feeding.

Silver fish (*Rastrineobola argentea*). Silver fish, locally known as mukene is a pelagic fish species that is popular in Northern Uganda. This animal-source food is relatively affordable in the region thus making it accessible by resource-constrained rural households, and a good candidate for complementary food. For instance, a 9 kg tin of dried silver fish is sold for about UShs.9,000 (US$ 5.30) (Kabahenda and Hüsken, 2009). Since 2009, production of silver fish for human consumption has increased sharply. Today, local consumers across the country (including Northern Uganda) who had previously attached a negative social attitude towards consumption of silver fish have embraced it as part of their diet (Masette and Kwetegyeka, 2013). Composition of target micronutrients in silver fish in Uganda is shown in Table 3.

Table 3. Micronutrient composition of silver fish

Target Micronutrient	Content(mg/100g)
Iron	8.18-10.91
Calcium	1556.4-1866.5
Zinc	4.07-10.25

Kabahenda *et al*. (2011)

In a study involving fortification of cassava flour with Soy and Silver fish in Northern Uganda, it was observed that children chose the product with 5% silver fish as the most preferred product (Elolu and Ongeng, 2020). On the other hand, Chambo *et al*. (2017) reported that inclusion of 5-15% tilapia meal in rolls is effective to increase mineral matter in the rolls. The authors recommended that use of tilapia up to 10% would result into acceptable products. This conform to the recommendation of Abraha *et al*. (2018) who stated that inclusion of fishmeal in food products up to 10% yields acceptable products.

Silver fish have a strong scent that is likely to override other ingredients in a food product if formulation is not carefully done. Following the recommendations above from previous studies, it is possible to utilize the nutrients in silverfish with respect to acceptable levels, especially when preparing food for children. Additionally, appropriate community based processing methods such as adequate drying could help reduce the strong scent (Kabahenda and Hüsken, 2009).

Discharge of heavy metal pollutants from industries, urban settlements, and agricultural sources into water bodies pose a threat of heavy metal contamination on silver fish as observed by high levels of cadmium (99.3%) above the permissible limit (Mbabazi and Wasswa, 2010). In another study, it was reported that dichloro-diphenyl-trichloroethane (DDT) was the most frequently detected residue (0.147-0.506 µg/kg) in Silver fish harvested from L.Victoria and L.Kyoga though below the FAO recommended limit of 5000 µg/kg (Nnamuyomba *et al*., 2014). These findings expose a concern for the government of Uganda to execute stringent measures to ensure that wastes are treated properly before release into water bodies. Such measures are key in ensuring silver fish is safe for human consumption. Microbiologically, silver fish has been found to be of low microbial quality as evidenced by values ranging from 2.48-8.61 log cfu/g, 0.36-3.09 log MPN/g, 0.36-3.04 log MPN/g and 0.10-6.66 log cfu/g for total plate counts, total coliforms, *E. coli* and *A. aureus* counts, respectively (Andrew *et al*., 2020). The authors recommended practice of high standards of hygiene during processing, storage, and distribution of silver fish across the country.

Towards utilization of target local foods as micronutrient based flour

Nutrition education. Lack of dietary diversity, which is a proxy for nutritional quality of food has been associated with inadequate feeding practices and poor nutrition knowledge among caregivers (Waswa *et al*., 2015). The authors reported that child dietary diversity scores was 27% larger than it would have been if caregivers were not subjected to nutrition education. This imply that maternal nutrition knowledge is a strong determinant of child feeding practices and consequently nutritional status (Burchi, 2010). Besides caregivers, who are mostly women, it is also important to educate men on the importance of adequate complementary feeding. This would ensure support to women as well as proper choice of crops for planting, a decision that is mostly made by men as household heads. Accordingly, FAO recommends that agricultural systems must be linked with nutrition education in order to achieve food and nutrition security (Pepino, 2014). In Northern Uganda, one can easily notice that in most households, caregivers feed their children on thin watery starch porridges daily despite the availability of other diverse nutritious local foods that remain underutilized. This is an indication that nutrition education on complementary feeding is inadequate in this community. Therefore, in order to utilize amaranth grains, iron rich beans, and silver fish as a micronutrient based formulae, household nutrition education is required. This can be done by the government through extension officers, and non-governmental organizations.

Women empowerment. Kobina (2019) reported that children of mothers in formal employment had a positive association with achieving minimum dietary diversity and minimum acceptable diet. The author also stated that ownership of land by mothers had positive association with minimum dietary diversity and minimum meal frequency for their children. Formal employment could possibly imply that mothers have access to stable income hence ability to purchase diverse nutritious foods for their children. Similarly, Galiè *et al*. (2019) observed that three main women empowerment domains that are positively associated with food security and nutrition, particularly child dietary diversity. These domains were access to and control over resources, control and use of income, and extent and control of work time. Based on these findings, it can be seen that women empowerment enables mothers to purchase adequate and nutritious foods for their children, make good choice of crops to plant (those that are nutritious), and allows them adequate time to engage in optimal complementary feeding practices. Therefore, women empowerment is key to good nutrition of children (Niehof, 2016), and should be considered as a positive strategy towards utilization of locally available nutritious foods that have been underutilized in the past.

Government support. Achievement of zero hunger (including micronutrient deficiencies) requires effective public policies to influence the areas of demand and access through markets and supply. Accordingly, policies that target consumer demand for food include instruments that influence food preferences, consumer knowledge, and food safety whereas those that influence access to food include functional value chains, equitable markets, and good infrastructure (Qureshi *et al.,* 2015). Agreeably, Namazzi *et al*. (2015) reported that unlocking market potential for grain amaranth could also act as an incentive for households in Northern Uganda to be more committed towards production of grain amaranth. This would give producer households an opportunity to sell surplus while allowing households that depend on market pathway to get access to this nutritious food hence addressing both availability and accessibility, which are important pillars of food security. Furthermore, Hodge *et al*. (2015) observed that narrow focus on solely staple crop production (which in most cases are starches) and lack of incentives for improving nutrition in agricultural sector are some of the main barriers against nutrition-sensitive agriculture in East Africa.

Based on the findings above, it is important to note that Government support has significant impact on utilization of local nutritious foods, and consequently the nutritional status of a population. In light of the three foods under this review, the Government of Uganda under the Ministry of Agriculture, Animal Industry and Fisheries should support utilization of foods in question through deployment of extension officers to guide households on how to grow iron rich beans and amaranth following good agricultural practices. Additionally, the Government should set and execute policies that protect safety of foods such as proper handling of silver fish to avoid contamination by heavy metals and microorganism.

Conclusion

Overall, this review has demonstrated that amaranth grains, iron rich beans, and silver fish are rich in iron, calcium and zinc, and locally available in Northern Uganda. It has also revealed that these foods have scored above average in acceptability experiments within the recommended levels. Formulating amaranth-iron rich beans-silver fish micronutrient based flour for routine enrichment of complementary foods can alleviate micronutrient deficiencies as well as counter the challenge of accessibility among resource constrained households.

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