



Nutritional Quality of Formulated Complementary Foods and their Biological Effects for Tackling Malnutrition in Sub-Saharan Africa (SSA) Countries

Wilfred Damndja Ngaha^{1*}, Richard Aba Ejoh², Edith Nig Fombang¹ and William Dzusuo Tedom¹

¹*Department of Food Sciences and Nutrition, National School of Agro-Industrial Sciences, The University of Ngaoundere, P.O.BOX 455, Ngaoundere, Cameroon.*

²*Department of Nutrition Food and Bioresource Technology, College of Technology, The University of Bamenda, P.O.BOX 39, Bamili, Cameroon.*

Authors' contributions

This work was carried out in collaboration among all authors. Author WDN designed the study, structured and wrote the first draft of the manuscript. Author WDT made the literature review, synthesized the articles downloaded and assisted in the design of the work. Authors RAE and ENF supervised the work from the design of the study to the write up and editing of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Toddlers malnutrition is a health problem in developing countries like those found in Sub-Saharan Africa. Owing to prevalence of poverty, families are generally not able to afford the commercial complementary foods available in the market stalls, since such complementary foods are imported and made from non-local foodstuffs. In order to overcome these issues, FAO/WHO recommends the use of local foodstuffs in formulation of complementary foods and defines the virtues that the complementary foods should possess. In this light, researchers in Sub-Saharan Africa have proposed several formulations of complementary foods. The present work reviews these research findings on complementary foods available in the Sub-Saharan Africa utilizing the local food materials, the treatment that is required to be meted to such food ingredients, nutritional quality of

*Corresponding author: Email: ngaha.wilfred@gmail.com;

formulated complementary foods and ultimately their biological effects. The limitations of the research work, if any, has been highlighted and the means to take such research forward that would be helpful in the production and commercialization of cost-effective complementary foods possessing requisite nutritional quality and biological effects as per dietary norms laid down by competent authorities.

Keywords: *Toddlers malnutrition; Sub-Saharan African countries; complementary foods; local foodstuffs; nutritional quality; biological effects.*

1. INTRODUCTION

Sub-Saharan Africa (SSA) is one of the economically backward regions of the world, with 34 out of 49 countries of this area belonging to the Least Developed Countries (LDC), where half of the population lives below the poverty line of 1.25 US dollar per person per day [1]. Owing to such situation, majority of the families are unable to afford purchasing complementary food (CF) for their children beyond the age of 6 months (when CF is introduced in toddler's diet), possibly paving way to toddler malnutrition, one of major health problem in these countries [2]. Toddlers malnutrition in SSA is generally a problem and can be categorized into three groups: protein-calorie malnutrition, vitamin A deficiency (VAD), and iron deficiency viz., anemia (IDA). These deficiencies are reported in 23.2 %, 39.9 % [3] and 9.8 % of children under 5 years of age [2], SSA being one of the most affected areas of the world. Despite the existence of a nutritional policy by the authorities and nongovernmental organizations in these countries (food fortification with Vitamin A, distribution of iron tablets to pregnant women free of cost) [4], toddler malnutrition still remains a public health problem. This situation contributes to keep this region in a vicious poverty circle since such toddlers, who will be growing up to assume as the pillar of development, will become an additional source of financial burden due to such precarious malnutrition (stunted growth, proneness to disease due to compromised immune system, deceleration of cognitive development, anemia and possible death) [5]. Since the poor nutritional quality of CF used is a major cause of infant malnutrition [6], it is these CF which are targeted in order to alleviate toddler malnutrition. Despite the numerous CF found on market stalls in SSA, they are generally imported from northern countries, and are made from non-local foodstuffs, are found in urban areas, are expensive, and thus are only affordable to few families only [4]. The most important part of SSA's population live in rural areas with 78% hailing from economic backward class [7]. In

order to increase the accessibility of CF to such stakeholders and to rationalize the financial cost of these CF, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) recommend the use of locally available foodstuffs, rich in essential nutrients for such formulations [8]. In this context, CF are expected to supply (per 100 g of CF) 400 kcal, 68 % of carbohydrates (of which 81 % as simple sugars), 13 % of proteins (with a minimal digestibility of 7 %), 7% fat, 5 % fibers, 7 mg iron and 350 µg vitamin A [9]. Since a single foodstuff cannot fulfill all these requirements, the CF can be formulated by mixing varying proportions of locally processed foodstuffs. The present review therefore intends to analyze local foodstuffs which have been used for formulation of CF in SSA, the effects of processing on their nutritional composition, the nutritional quality of formulated CF and their biological effects. The review also intends to point out the limitations of these studies, and finally proposes the way forward to contribute to the alleviation of toddlers' malnutrition in SSA.

2. LOCAL FOODSTUFFS USED IN CF IN SSA AND THEIR PROCESSING ASPECTS

2.1 Local Foodstuffs Used in Complementary Foods in SSA Subheading

When considering the nutritional requirement of a good CF as defined by FAO/WHO [9], it is obvious that it should mainly contain sources of carbohydrates, proteins, minerals and vitamins. In this respect, since starchy foodstuffs are the most favoured ingredients in SSA [10], they have been used by several formulators as the main source of carbohydrates. Starchy foodstuffs used are mainly cereals, roots and tubers. Cereals used include Millet (*Pennisetum glaucum*), maize (*Zea mays*), and sorghum (*Sorghum bicolor*) [11,12,13,14,15]. Tubers and roots used are sweet potatoes (*Ipomea batatas*) [16,17,18],

cassava (*Manihot esculenta* Crantz) [19,20], yam (*Dioscorea cayenensis* and *Dioscorea alata*) [21,22] and taro (*Colocassia esculenta*) [23,24]. Amongst cereals, maize is the predominant one, while cassava is the favoured tuber. Cereals are mostly used in sahelian countries of SSA, while tubers and roots have been mostly used in tropical countries. This is obvious since in SSA, cereals are mostly cultivated in sahelian areas while cassava is mainly grown in tropical areas [10].

Legumes have been mainly used as the source of proteins by various formulators of CF, notably soybean (*Glycine max*) [13,17,22,25], cowpea (*Vigna unguiculata*) [26,27], groundnut (*Arachis hypogaea*) [28,29], voandzou (*Vigna subterranea*) [30] and seral varieties of beans (kidney, red, Fava) (*Phaseolus vulgaris*) [31,32]. Soyabean is the favoured legume for the preparation of CF. Some leguminous plants, which are also known to be locally available and have simple processing requirements (like voandzou viz., Bambara groundnut [*Vigna subterranea*]), remain sparsely used in CF formulation, despite their high content of proteins (17.2 to 19.7 g / 100 g DM) and low in anti-nutritional factors such as tannins (174.7 to 196.3 mg/100g) and oxalates (10.5 to 12.2 mg/100g) [28,33,34]. Fishes and other sea food as the source of protein has been used scarcely [11,32,35,36], and this can be justified by the fact that this class of proteins is generally not affordable for families with low-income.

Since fruits like papaw (*Carica papaya*) and mango (*Mangifera indica*), vegetables like carrot (*Daucus carota*) and pumpkin (*Cucurbita pepo*), and leafy vegetables like moringa (*Moringa oleifera*), baobab (*Adansonia digitata*), cassava (*Manihot esculenta*) are rich in minerals (iron, calcium, magnesium, etc.) and provitamin A (α and β - carotene, β - cryptoxanthin), they have been used to tackle iron and vitamin A deficiencies [21,37,38,39,40,41].

Generally, in many of these studies, a specific type of toddlers' malnutrition is targeted and thus resulting CF are only made from some class of foodstuffs which are only able to partially fulfill the requirements as defined by FAO/WHO [8]. In this context, protein rich foods and starchy foods are mainly used for protein-energy malnutrition, matrix containing provitamin A are used for tackling VAD, and matrix containing minerals

(viz., calcium, iron), as enumerated in the two previous paragraphs, are used to tackle mineral deficiencies [42]. Toddlers' malnutrition is an overall problem which can be only resolved through the fulfillment of the requirements of judiciously prepared CF, because there is generally a strong relationship between different types of deficiencies [43]. The diversity of foodstuffs used in formulating a CF is another limitation, since where they become too important, the overall product become expensive. Thus, another approach in the formulation of CF is to use foodstuffs which can supply sufficient quantities of many nutrients of interest, reducing the number of food matrices involved, and then the cost of production. In this respect, some yellow and orange foodstuffs (yellow maize [*Zea mays*], orange-flesh sweet potatoes [*Ipomea batatas*] and pumpkin) have been used as the sources of carbohydrates and carotenoids [18,40]. Leafy vegetable (Moringa [*Moringa oleifera*] and spinach [*Spinacia oleracea*]) have been used as the sources of minerals, carotenoids, and sometimes proteins [41].

When considered alone, plant parts (leaves, fruits, roots) used for the formulation of CF are rich in specific nutrients Table 1. But since they are plants, they also contain many anti-nutrients (trypsin inhibitors, phytates, oxalates, tannins, fibers, etc) which have to be removed using certain treatments since they reduce the digestibility of proteins as well as the bioavailability of vitamins and minerals (phytates and oxalates inhibit absorption of iron, calcium and zinc, while fibers inhibit absorption of vitamin A) through the inhibition of digestive enzymes (e.g. trypsin to digest protein) involved in the catabolism of nutrients, complexation and chelation of some other nutrients [44]. It is for these reasons that treatments are generally applied to each ingredient used in the formulation before any mixture can be made.

2.2 Treatments Meted to Food Sources Used in CF Formulation

Technological treatments which have been applied by the researchers in SSA on individual matrix used in the formulation of CF include soaking, blanching germination, fermentation, blanching and roasting [25,28,40,41,42,49]. The use of these treatments in SSA can be justified by the fact that they are commonly applied at household level.

Table 1. Nutrient content of some natural/dried* foodstuffs used in the preparation of CF in Sub Saharan Africa (per 100g)

Foodstuff	Water (g)	Sugars (g)	Protein (g)	Fats (g)	Iron (mg)	Carotenoids (mg)	References
Yellow Maize	11.30±0.3	72.60±1.2	10.30±0.7	4.90±0.2	-	3.10±0.4	[45]
Sorghum	8.30±0.02	75.74±0.03	10.46±0.9	3.50±0.03	0.17±0.01	-	[42]
Cassava	59.68	39.06	1.36	0.28	0.27	-	[46]
OSP***	4.80±0.04	89.37±0.2	2.80±0.0	1.30±0.1	-	18.00±0.04**	[16,47]
Soyabean	7.65±0.01	23.75±0.01	43.00±0.01	17.35±0.02	0.17±0.01	-	[42]
Groundnut	1.86±0.03	17.32±0.13	27.50±0.02	51.11±0.53	-	-	[26]
Pumpkin flesh	5.32±1.13	56.55±2.02	7.27±1.16	2.85±0.24	2.05±0.21	37.43±6.3	[40]
Moringa leaves	7.60±0.6	53.40±2.3	20.30±1.0	8.50±0.5	16,67±0,3	9.99±0.01	[48]
Spinach leaves	5.29±0.3	26.04±2.1	16.81±2.2	3.75±0.7	38.40±1.0	3.08±1.9	[41]

-: Not determined; * Cassava is fresh (natural) and all the other foodstuffs are dried; ** mg β-Carotene Equivalent / 100g; ***OSP: Orange Sweet Potato

2.2.1 Soaking

Soaking is generally carried out alone, mainly on legumes, or combined with other treatments (germination, fermentation, and/or cooking), on cereals, usually at ambient temperature, its period varying from 8 h to as long as 72 h [25,28]. When used on legumes such as soybean and beans, it allows lowering in the flatulence factors (stachyose, raffinose, verbascose, and oligosaccharides). The decrease in stachyose and raffinose has been reported to range from 18 to 75 %, while lowering in oligosaccharides could be accomplished ranging from 25 to 64 % [50]. These components are eliminated through their solubilization and diffusion in the soaking medium [51]. Since they are not the only soluble components, there is also a decrease of some nutrients during soaking, and this decrease is dependent on soaking time. In this respect, it has been shown that the soaking of soybean (72h) leads to a decrease in the protein content of 22.17%, and the soaking of Bambara groundnut (4h) leads to a decrease of 9.7 % of minerals [25,28]. 24 h seems to be the optimal soaking time for a significant reduction of tannins in soybean [25]. From all these studies, it is obvious that the optimum soaking time and temperature for the maximal reduction of anti-nutrients at the same time minimizing the loss of nutrients has not been determined for the legumes used.

2.2.2 Germination

Germination is carried out on legumes and cereals for specific conditions (viz., temperature and time). During germination, the hydrolysis of proteins and starch occurs, and this allows improvement in the digestibility of the food material [52]. The hydrolysis also increases the dry matter content, the bioavailability of minerals (iron, zinc, etc.) [53]. There is also a reduction in the anti-nutrients; reduction ranging from 12.6 to 72.0 % for tannins, from 17.4 to 96.0 % for phytic acid, and from 31.0 to 53.6 % for trypsin inhibitor after 24 to 96 h of germination of cowpea seeds (*Vigna unguiculata*), beans (*Phaseolus vulgaris*) and maize (*Zea mays*) [27,54,55]. However, optimization of germination conditions (temperature and time) with respect to nutrients and anti-nutrients of some foodstuffs to be used in formulation of CF, notably legumes, still to be done.

2.2.3 Fermentation

Fermentation has been mainly performed on cereals and tubers which are used as source of

carbohydrates in the formulation of CF, under controlled atmosphere with lactic acid microorganisms (*Lactobacillus plantarum*, *Aspergillus niger* and *Bacillus subtilis*) [40,56]. It allows improving the digestibility of starch as well as the bioavailability of some minerals like magnesium, phosphorus, calcium and iron [40,56]. Since the hydrolysis of starch by lactobacillus occurs during fermentation, there is an increase in the dry matter and simple sugars [40,57,58]. Also, there is a decrease in the anti-nutrient content; the decrease ranging from 64.7% to 74.7 % for phytates when applied on pumpkin pulp and pearl millet [40,59]. Moreover, during fermentation with microorganisms like *Lactobacillus*, *Leuconostoc* and *Lactococcus*, there is production of flavoring components such as lactate, propionate, butyrate acetate, 1-propanol, isoamyle acetate, ethyl acetate, 3-methyl-1-butanol and acetoine, which improve the acceptability of the resulting flour [57].

2.2.4 Blanching

Blanching is generally carried out on leafy vegetables (moringa leaves, spinach, cassava leaves, baobab leaves) at temperatures ranging from 70°C to 100 °C and period varying from 1 to 15 min [48,60]. Two types of blanching may be performed viz., (a) immersion blanching and (b) steam-blanching [61]. The latter is recommended since it leads to the reduction of losses of soluble components such as proteins and minerals [62,63]. Blanching of leafy vegetables leads to the decrease in anti-nutrients (phytates [between 33.3 and 46.7%], oxalates [between 58.3 and 71.3%], and tannins [between 40.8 and 74.1%]) and increase of minerals and proteins level [41,49,64]. The major advantage of this treatment is that iron is generally stable to blanching treatment (i.e. 100 °C for 3 min) [64]. It seems that generally, the quality of other nutrients of interest like sugar, protein and vitamin A is not significantly affected during blanching of food materials [41,48].

2.2.5 Roasting

Roasting, carried out usually on legumes (groundnut, soybean), maybe carried out at about 100°C during a period less than 10 minutes, where it aims at developing organoleptic and nutritional characteristics [65]. Since precooking is done during this treatment, it improves the digestibility of proteins [66], destroys or inactivates trypsin and protein inhibitors (soya bean) [67], and decreases phytic

acid content of legumes [68]. When roasting is done at 121°C during 15 min, the destruction of protein-inhibitor in soya bean is cent percent [67]. When roasting cereals (viz., maize), the process reduces phytic acid content by 15.0 to 42.0% [68]. However, this treatment should be controlled depending on the matrix since it has been shown that roasting of maize at 110°C for 10 min leads to a reduction of protein content by 35.5% [69]. This shows that the optimum conditions for roasting treatment (temperature and time) permits controlling the losses of nutrients and ensures destruction of anti-nutrients in case of legumes or cereals.

It is clear that although all these treatments reduce anti-nutrient (phytates, tannins, oxalates and protein inhibitors) content of plant parts used in the formulation of CF, some treatments lead to losses of nutrients (soaking, germination, and immersion blanching) while other treatments have supplementary role: improvement in the digestibility of proteins and carbohydrates and improvement of the palatability of food matrix (roasting and fermentation). However, it is worth noting that optimum conditions (for soaking, roasting, and germination) which can lead to maximum tackling of anti-nutrients and minimum losses of nutrients of interest such as proteins and minerals needs to be determined. Moreover, since these treatments causes the decrease in anti-nutrient content of foodstuffs, the study of the effect of combined treatments on the nutritional quality of each food matrix may be another interesting area of research.

3. QUALITY OF COMPLEMENTARY FOODS AVAILABLE IN SSA

In general, CF formulated in different regions of SSA target a specific type of malnutrition prevailing there. In this respect, formulated CF either target protein-calorie deficiency, VAD or Iron deficiency.

3.1 Quality of CF Formulated to Target Protein-calorie Deficiency

With respect to CF targeting protein-calorie malnutrition, those which have been formulated are made principally formulated ($\geq 50\%$) with maize flour [12,13,15,70], and/or soybean (germinated, fermented, or roasted), pea (*Pisum sativum*) (roasted) or groundnuts (*Arachis hypogaea*) (roasted or boiled) [13,15,19]. The use of cassava as the major or principal

component (49.0 to 52.0 %) leads to heavy and viscous gruels (speed of flow 0.00 mm / 30 s) with low energy density (75.64 ± 1.4 kcal / 100 mL). This energy density increases (87.48 ± 2.6 kcal / 100 mL) and viscous character decreases (speed of flow 230 mm / 30 s) with the addition of malted maize [19,20]. The use of malted seeds seems to obtain CF with gruels which have high energy density, and fluidity accrues from the presence of amylase enzyme in the flours [13,15,20]. The resulting CF generally fulfils protein and energy requirements of 13% and 400 kcal respectively specified by FAO/WHO. However, only few workers have performed sensory analysis of the formulated CF they had come up with, and those who had performed the sensory characterization [12,15], comparison of their developed formulated blends was not made with commercially available CF. For instance, formulated CF with *Moringa oleifera* leaves flour had a greenish color and despite its ability to fulfill the requirements in terms of proteins and energy, their acceptability may be questionable, since this color is different from CF used at the household.

3.2 Quality of CF Formulated to Tackle Vitamin A Deficiency

Plant foods with high provitamin A content (pumpkin pulp [*Cucurbita pepo*], yellow-flesh and orange-flesh sweet potatoes [*Ipomea batatas*]) have been used in the formulation of CF to target VAD; their inclusion varying from 25.0 to 50.0 % [17]. By using such ingredients, requirements of the formulated CF in terms of vitamin A (350 μ g per 100g as specified by FAO/WHO) were fulfilled [16,17]. All the formulated CF were acceptable sensorily, showing that the use of such ingredients in the formulation of CF should be encouraged. Based on one study [16], the CF formulated with sweet potato, soybean and sorghum flours was more acceptable sensorily than the commercial one named "Vie VITA VITE". This shows that VAD, which is a public health problem, can be tackled by this approach using local foodstuffs rich in provitamin A and appreciated by the populations. This is also interesting since some of the foodstuffs (pumpkin pulp) are rich in carbohydrates and minerals and thus can be used as source of these nutrients too. It was shown that 25.0 % is the incorporation rate of orange flesh sweet potato to obtain the highest acceptable CF [17]. However, studies on the shelf life of those formulated CF are still in view.

Table 2. Some formulated complementary food targeted for toddlers available in sub Saharan Africa with their composition and energy value (per 100g)

Blend in formulated food	Sugars (g)	Protein (g)	Fats (g)	Iron (mg)	Provitamin A (mg)	Energy (kcal)	References
Rice / Fava bean / OSP* / Peanut oil	67.82	17.89±1.20	10.35±0.76	9.71±0.12	62.10±4.3	436.0	[73]
Millet / Soybean / crayfish	68.70±0.05	16.90±0.02	7.00±0.2	-	-	405.4	[35]
Maize / Chickpea / Amaranth grain	68.80±0.04	16.39±0.07	7.10±0.08	15.16±0.03	-	404.7	[74]
Maize / Pawpaw / Red bean / Mackerel Fish	58.04±0.74	17.88±1.42	4.46±0.84	23.08±0.82	-	363.8	[32]
Sweet potato / Soybean / Sorghum	63.91±0.24	19.51±0.18	7.55±0.02	-	-	401.6	[16]
Cassava / Soybean / Maize	61.00	14.00	10.00	-	-	390.0	[20]
Sweet potato / Maize / Soybean	71.13	14.97	6.35	13.57	6.65	389.6	[17]
Millet / Plantain / Soybean	58.99	17.09	11.05	2.22	-	403.8	[14]
Banana / Cowpea / Peanut	68.16±0.38	16.89±0.21	8.38±0.01	3.00	-	415.6	[26]
Sorghum / Soybean / Plantain / Roselle calyces / Moringa	32.87±0.01	12.07±0.01	5.09±0.01	0.62±0.01	-	225.6	[42]

-: Not determined; *Orange sweet potato

3.3 Quality of CF Formulated to Combat Iron Deficiency

Iron deficiency as well as other minerals (Ca, Mg, Zn) deficiency are tackled through the use of food sources that are rich in minerals such as spinach leaves [*Spinacia oleracea*], baobab fruit [*Adansonia digitata*] and nere seeds (*Parkia biglobosa*) have been used in the formulation of CF [71,72]. At proportions lower than 10%, WHO/FAO requirement for many divalent minerals (Fe, Ca, Mg, Mn, Zn, P) are fulfilled and the level of these minerals in resulting formulated CF is sometimes even higher than those of commercial CF [72]. However, studies on their sensory acceptability vis-a-vis commercially available CF has not been reported.

From all these studies and many other, besides that each formulation of CF is done for a specific type of deficiency, the chemical composition of the resulting formulated CF adjusted in a manner so as to ascertain whether the nutritional requirements are met for such deficiencies. All the WHO/FAO requirements need to be considered during the formulation of CF. Also, the chemical composition of formulated CF only takes into consideration their nutrient content Table 2, though, it has been shown that many commercial CF found in many African countries (Burkina Faso, Benin) have anti-nutrient components (phytates, oxalates, tannins) at levels higher than those recommended by FAO for food used in infant nutrition [72]. This shows that before any formulation is made, anti-nutrients should be removed or inactivated using requisite treatments and the remaining quantities assessed before blending of such ingredients, in order to avoid the biological side-effects of these anti-nutrients. Formulated CF with similar chemical composition might have different efficiencies with regard to foodstuffs and treatments which have been used. Hence, the biological effect of CF should be evaluated.

4. BIOLOGICAL EFFECTS OF COMPLEMENTARY FOODS IN SSA

Biological effects of CF have been assessed through in vivo studies on rats. In this respect, protein efficiency ratio (PER), Net Protein Ratio (NPR), real digestibility of proteins, weight of organs, and hematological parameters have been assessed based on feeding them with CF based on their body weight [22,32,39]. In some of these studies, comparison of the formulated

CF was carried out with commercially available ones (Cerelac® and Phophatine®) which are available in sub Saharan countries [32,36]. Generally, CF made from cereals (fermented maize, sorghum), a source of proteins (crayfish, groundnuts, fishmeal, chickpeas), and sometimes a source of vitamins (pawpaw and milk) and minerals (milk) have effects which are similar to those of commercial CF (Cerelac® and Phophatine®) with respect to PER, NPR, real digestibility, weight of organs as well as weight gain of the rats fed on such diet [32,36]. However, the PER of some formulated CF seemed to be lower than those recommended by FAO [39]. Despite the similar biological effects of commercial CF and formulated CF, comparison of their sensory characteristics was not carried out. Future research in this direction has to take sensory quality into cognizance in order to have desired marketability of formulated CF.

5. CONCLUSION

SSA is one of the regions of the world which is affected at higher rate by toddler malnutrition, especially protein-calorie, Vitamin A and iron deficiencies. Foodstuffs used in the formulation of CF in this region are starchy staples (cereals [mainly maize], roots and tubers), legumes (mainly soya beans), fruits (papaw, mango) and leaf portion of vegetables (baobab, moringa, spinach). These foodstuffs are generally processed through some treatments (soaking, germination, fermentation, blanching and roasting) in order to reduce their anti-nutrient content, improve digestibility of nutrients and bioavailability of minerals, and sometimes improve sensory properties. Resulting processed foodstuffs are used for the formulation of CF to target a specific type of malnutrition and the CF so obtained fulfils the nutritional requirements for the specific type of malnutrition that was to be tackled. Some of these CF have biological effects which are similar to those available commercially although their PER is lower than the recommended value. Several limitations are observed in research works which have been carried out in SSA as far as CF are concerned. The anti-nutrients levels of formulated CF are hardly being assessed. Moreover, all of the nutrients required to totally fulfill the requirements of a formulated CF are not being analyzed. The optimal conditions for maximum reduction of anti-nutrients for minimal losses of nutrients of the foodstuffs used for formulation of CF remain unknown for some interesting foodstuffs. In addition, the effects of combined treatments on

the nutritional quality of these foodstuffs, the shelf life of formulated CF, their sensory analysis, and their biological effects need to be systematically researched. Moreover, the comparison of formulated CF with those of the commercial according to nutritional, sensory and textural characteristics need to be considered.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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