NUTRITIONAL QUALITY EVALUATION OF COMPLEMENTARY FOODS FLOUR BASED ON EDIBLE CATERPILLARS: *BUNAEOPSIS AURANTIACA, IMBRASIA OYEMENSIS AND CIRINA FORDA* EATEN IN SOUTH KIVU PROVINCE, EASTERN D.R. CONGO

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Abstract
We assessed the nutritional quality of porridge flours based on local edible caterpillars and cereals to make receipts porridge for young children, compared to that of food product aid for the treatment of acute malnutrition of riparian population of the Congo Basin in general and South Kivu province in particular. The nutritional quality of selected foods was obtained from tropical Africa food composition tables. Recipes developed were balance referring to food standards Codex Alimentaruis FAO/WHO. Three (3) developed flours (RPC1, RPC2 and RPC3) composed subsequently of five (5) selected traditional foodstuffs, whose: three caterpillars: Bunaeopsis aurantiaca, Imbrasia oyemensis, Cirina forda and two cereals: sorghum (Sorghum bicolor) and white maize (Zea mays) result in this investigation. Caterpillars included in each of these porridge recipes are an important source of energy, aromatic amino acids (phenylalanine + tyrosine), lysine, leucine and threonine. Rich in polyunsaturated fatty acids: oleic acid C18: 1 ω9 and linoleic acid C18: 2 ω6, also in vitamins and mineral, and giving high nutritional recipes. The energy and protein value of three different recipes developed has been evaluated and it is more than CSB+ and that others of therapeutic food of acute malnutrition (x^2: 56.55; $p<0.0001$). The nutritional value of the recipes formulated are statistically similar to that of food aid products for the treatment of acute malnutrition ($p<0.001$) and can replace these firsts. Therefore these recipes porridge caterpillars are a rich source of energy and protein that can cover the needs of the malnourished body and ensure the sustainable decentralized countries reliance on exported food aid products accommodated the dietary management of malnutrition. Thus, in communities that are not accustomed to eating whole insects, pulp and pellets recipes could be better accept. Hence, their processing for use in the nutritional therapeutics centre, contribute to the fight against malnutrition.

Keywords: complementary food, edible caterpillar, nutritional quality, malnutrition, CSB+, Plumpynut

Received: 19.02.2019 Reviewed: 27.05.2019 Accepted: 05.06.2019

1. INTRODUCTION

Children are most vulnerable to poor nutritional status during the complementary feeding periods when both macro and micronutrients are insufficient to maintain growth and development, leading to malnutrition (Dewey & Brown, 2003). One way of sustainably reducing malnutrition is by using available traditional and indigenous plant and animal foods to prepare complementary foods that are both hygienically and nutritionally adequate to meet the needs of fast-growing infants and young children (WHO, 2008).

Different studies are envisaged in this issue by the associated clinical nutritionists and programs to identify the causes of the persistence and factors influencing malnutrition in Africa. WHO in 2001 and 2003 indicates that the main hypothesis is that malnutrition is the multi-deficiency causes: Malnutrition notion of Pluri- to deficiency (MPC), which requires additional food intake mineral-vitamin, diversification plans and contributions, based on the protocol supported by countries.

In D.R. Congo, there is the new innovations of the new protocol integrated management of acute malnutrition (PCIMA) using F75 therapeutic milk and therapeutic food ready for use (RUTF) for the nutritional treatment acute

malnutrition, but unfortunately this problem still persists yet, aid in the health sector programs and associated food aid continually making any big contributions, but almost all is dependent on the outside (Dominique, 2013). Rachel, (2013) relates to the D.R. Congo a significant element that is out of stock nutritional inputs is the major blockage to the continuity of nutritional services.

To improve the intake of protein and energy in developing countries, the solution will not come from the country's dependence for food aid products to additional distribution and/or therapeutic or classical breeding (Vantome, 2010 ; WHO, 2004). But we must turn to alternative solutions: the crop, livestock and human consumption insects are one of these solutions (Lavalette, 2013; Dominique, 2013). Malaisse in 2014; Adegbola *et al.* (2013) reported that of all insects, the human consumption of Lepidoptera or "Lepideroptérophagy" is experiencing a growing interest in Africa. Their consumption broadens the base of the diet, diversified diet and helps to prevent nutritional deficiencies and to maintain the power balance.

In some communities in South Kivu, entomophagy (the practice of eating insects) has been common and widespread depending on the availability of the insects and the ability to trap them for use (Muvundja *et al.*, 2013; Ombeni and Munyuli, 2016; Ombeni *et al.*, 2018). Insect species such that *Imbrasia* spp., *Bunaeopsis aurantiaca, Cirina forda, Tagoropsis* sp. and *Cinabra* sp. very rich in protein, essential amino-acids and fatty acids respectively, calcium and iron are given to people with anemia and pregnant women had their breakfast, where their introduction into popular local flour (FAO, 2004; Munyuli, 2000; Muvundja *et al.*, 2013; Ombeni and Munyuli, 2016; Ombeni *et al.*, 2018). A flour native caterpillar is mixed with popular local flour to prepare porridge in the fight against child malnutrition (FAO, 2004).

This practice was used for the first time in South Kivu province by religious sisters, involved in the treatment of malnutrition, but none determination of the nutritional quality of these recipes has never been done to date, is nevertheless they are a nutritional and food arsenal in the fight against malnutrition riparian communities of South Kivu (Ombeni, 2015). Insects are a new source of protein for human food can meet the protein and energy needs of the population and replace the food aid products, reports Ms. Lavalette, (2013).

Despite the economic, nutritional and medicinal of caterpillars' porridge recipes, apparently no research on their nutritional quality had been conducted in South Kivu. The persistence of such neglect will increase the erosion of their food resources with immediate consequences knowledge about the nutritional status and food security of populations, especially those in rural areas.

Thus, the present study's main objective is to establish the comparison between the nutritional quality of the recipes flour caterpillars consumed in South Kivu and that of destination to additional products and/or therapeutic food aid used by the nutritional units in DR Congo for the treatment of acute malnutrition. Then, the rate in macro and micronutrients such mixtures will be assessed to contribute to their valuation as part of the nutritional rehabilitation of our vulnerable populations. The goal is to put in light of the population and health sector programs, partners in the fight against malnutrition communities, nutrient rich recipes caterpillars consumed in South Kivu (Muvundja *et al.*, 2013; Adegbola *et al.*, 2013, Ombeni *et al.*, 2018).

Finally, it will be a lasting solution to the issue of malnutrition remains an obstacle to development (WHO, 2003; Stevenson *et al.*, 2007) for human consumption recipes of caterpillars; traditional foods considered minor by other neighboring ethnic groups and people of the middle class in South Kivu province, but rather it is of high nutritional value that can enable people to produce their own products high nutrition premises for the treatment of malnutrition ensuring decentralization of the country (Muvundja *et al.*, 2013; Dominique, 2013; Ombeni, 2015, Ombeni and Munyuli,

2016; Ombeni *et al.*, 2018).

2. MATERIALS AND METHODS

Study area

This research was conducted near the capital of Mwenga most renowned in harvesting, consumption and marketing of caterpillars. Mwenga territory (study area) is one of the territories of South Kivu province (DR Congo), in third with an area of 11,172 Km^2 after Shabunda and Fizi. Constituting six communities, it is characterized by a sub-mountain equatorial climate and precipitation will reach 2000mm/3000mm.an^{-1} and are well distributed throughout the year but with a relative minimum in June and July (Doumenge *et al.*, 1997). Average temperatures are between 17.5ºC (at Mwana station) and 22.2ºC (at Kamituga station) (Prigogine, 1978). The Itombwe Mountains are one of the most important critical sites for the conservation of biological diversity of the Democratic Republic of Congo and covers one of the richest regions in plant species in the country and perhaps Africa (Doumenge and Schilter, 1990). Vegetation map proposed by Doumenge *et al.* (1997), it appears that the Mwenga territory is dominated by sub-montane and secondary forests with increasing human impacts (impacts of agricultural activities, mining and domestic).

The variability of tree species and habitat type offers opportunities in this area for a wide biodiversity and wild edible species.

Samples

The materials used in this study are the databases (tables) of the composition nutrient:

(i) Local dried caterpillars (Bunaeopsis aurantiaca, Imbrasia oyemensis and Cirina forda) commonly known as Lega "Milanga", "Takumombo" and “Misigi or Bikerekere” respectively, sold in territories markets of the South Kivu province (Bukavu) DR Congo. These are species of the order Lepidoptera (Saturniidae family), available twice a year in the markets (January-February and May-September) and can be stored for long to make flour.

(ii) The Ready to Use Therapeutic Food (RUTF) used by the nutritional units of the DRC for the dietary management of patients with acute malnutrition (WHO, 2001; Pronanut-RDC, 2012; Unicef, 2005):

Therapeutic milk F75: specially designed for the early days of treatment for severe malnutrition. It allows initiating healing and restoring nutritional balance.

Therapeutic milk F100: specially designed for the dietary management of severe malnutrition. Rapid nutritional recovery. Including nutritional and energy value is equivalent to that of the dough Peanut Plumpy'nut®. Currently milk T. F-100 is replaced by the Plumpy'nut® in Therapeutic Units Ambulatory DR Congo (Pronanut-RDC, 2012).

Plumpy'nut®: is a therapeutic food ready for use (RUTF Ready to Use Therapeutic Food), especially dedicated to treating severe malnutrition at home (under medical supervision). It is composed including peanut paste, skimmed milk, sugar, complex minerals + vitamins, etc. It also allows the nutritional recovery fast.

BP 100 is an RUTF compress. This is a solid form of the F-100.

The Unimix/Corn Soya Blend CSB+: is a farinaceous mixture (80% corn, 20% soybean) enriched (minerals and vitamins) and precooked. This product contains no sugar, oil (Mark and Cindy, 2012; Nutriset, 2014). Or by the use of blends local flour (Mixture, Corn-Soya = MMS+, Corn-Soybean, Sorghum=MASOSO+) or Ready-to-Use Supplementary Food (RUSF) of Nutritional Supplementary Units (NSU). To these mixtures were added (+) oil and sugar in the preparation of premixes for the enrichment of the slurry carbohydrate and fat (Pronanut-RDC, 2012).

The calculator machine had helped convert some amounts of certain food nutrients per 100 g of the reference food following the conversion factor method.

Data sources

Data on the composition of foods from this investigation are obtained either directly in laboratories that analyze food, either from the literature: scientific publications and existing

tropical Africa composition tables. The compilation of literature is tempting because it does not require significant funding and allows rapid collection of information. But the foods that treat scientific publications, mostly foreign, are not always representative of those actually produced or consumed in the same country (DR Congo).

The documentation of the literature from 1658 to 2015 through the research done already in entomophagy on the nutritional quality of caterpillars consumed in Central Africa and South-Kivu in particular. Specifically those of the order lepidoptera belonging to the family of saturniidae, allowed us to establish a summary table of the nutritional composition of the caterpillars making parties in this investigation. These caterpillars flour was mixed with popular cereal flours with added oil, sugar to increase the energy value, vitamin, taste and a pinch of salt to ensure its preservation, to prepare slurry to fight against child malnutrition (FAO, 2004).

The documents consultation from 1950 to 2014, approaching the subject of under nutrition (undernourishment) in DR Congo and the use of databases considerations quality of the nutritional composition of essential products in the house after this Nutriset study were used; presentation of the main Nutriset products "Food designed for the dietetic treatment of severe malnutrition," as the course of research papers on acute malnutrition and the impact of aid programs associated with this situation in DR Congo was interesting for us to identify the extent of malnutrition in South Kivu, the impact of food aid programs and show a picture of the nutritional value of Nutriset products respectively. The nutritional composition per 100g of each ingredient (reference food) incorporated in each recipe was established (WFP, 2010). If the nutritional composition of table food a further quantity of the reference product is given, use the conversion method by using the method of three single or conversion factors were considered.

On field investigation

An entomologist's interview with local experts and nutritionists to provide the necessary practical elements not yet published in a scientific paper from their professional experience relevant to eat bugs and state place of malnutrition South Kivu, DRC.

An ethno-biological investigation and Gastronomische recipes caterpillars, followed by a semi-structural interview near the community were conducted in the most reputable Mwenga territory of the province in the harvest and consumption of caterpillars. Harvesting on field information was conducted in September 2015 and January 2016, availability period of caterpillars to territorial markets of South Kivu, in order to identify the most able and collected caterpillars keep for later use in local flour as porridge for malnourished children.

The sample consisted of 384 households (384 people) chosen by lot to different degrees and according to survey standards (and representative random sample) by sectors/communities constituting the territory. This method was already used by Lohr in 1999. In each household one person was chosen to answer questions (either mother or daughter 18 years over age) (Table 1).

Conversion of the amount per 100 g of a reference food

Refer to Codex food standards food FAO/WHO (2013); 100g (%DM) of the nutritional composition of each reference food compared in this investigation was used:

i) For therapeutic milk F75 and F100, we used the account table quality nutritional composition of Nutriset products where one indicates the nutrient content contained in 100ml and the amount and Maximum Minimum content of nutrients in these products meant for similar target groups (World Food Program, 2010).

Converting the data amount of each of nutrients contained in 100 ml of F75 and F100 therapeutic milk quantity per 100 g of the therapeutic milk powder was performed by the method of conversion factors. Except for the content ranges of these lipid products, where the value in the composition tables is given as a percentage of total energy (36% for milk and 53% F75 to F100 therapeutic milk).

Knowing that:

Therapeutic milk F75: 1sachet $\xrightarrow{Net\ weight}$ $102.5g$ $\xrightarrow{Dilution}$ $500ml$ H_2O $\xrightarrow{Solution\ volume}$ $600ml$ (either 0.6 liter of milk)

Therapeutic milk F100: 1sachet $\xrightarrow{Net\ weight}$ $114g$ $\xrightarrow{Dilution}$ $500ml$ H_2O $\xrightarrow{Solution\ volume}$ $600ml$ (either 0.6 liter of milk)

If, 102.5g → 600ml

Then, 100ml of milk F75 $\xrightarrow{Contains}$ $17.08g$ of powder

As, 17.08g F75 $\xrightarrow{Dilutes}$ $100ml$ H_2O

Thus, 100g F75 $\xrightarrow{Would\ dissolve}$ $585.5ml$ H_2O

Hence then all the contents of macronutrients and micronutrients for 100ml of the F-75, shown in the table nutritional composition was converted into quantity of nutrients per 100g of the dry powder therapeutic milk F-75 according to the following equation (Eq.1.) :

Eq.1. $\frac{Quantinty\ per\ 100ml \times Cte}{100}$, With Cte=585.5 and that for each nutrient

The content of this product in grams of lipid (fat) is not accurate in the composition tables Nutriset products, the next conversion was performed:

In 100ml of F75, lipids ⟶ 36% of total energy

If 100ml F75 ⟶ 75 kcal ⟶ 100%

So, 36% for fat ⟶ 27 Kcal

Like, 100g F75 ⟶ 439 Kcal ⟶ 100% (cfr. Eq.1.)

Thus, 36% energy ⟶ 158.08 Kcal

Energy conversation (Kcal) in grams of fat:

Lipid 1g ⟶ 9 Kcal

Hence, 158Kcal ⟶ 17.56g lipids

If, 114g → 600ml

Then, 100ml of milk F100 $\xrightarrow{Contains}$ 19.00g of powder

Like, 19.00g F100 $\xrightarrow{Dilutes}$ $100ml$ H_2O

Thus, 100g F100 $\xrightarrow{Would\ dissolve}$ $526.3ml\ of$ H_2O.

So, where all the macro and micronutrients content in 100ml of F100, shown in the table of nutritional composition was converted into the amount of nutrients per 100g of dry powder therapeutic milk F-100, according to the equation (Eq.2):

Eq.2 . $\frac{Quantinty\ per\ 100ml \times Cte}{100}$, with Cte=526.3. And that for each nutrient.

Note: Exception to the lipid content of F100 therapeutic milk.

Composition table indicates that:

In 100ml of F100, lipids ⟶ 36% of total energy

If 100ml F100 ⟶ 100 kcal ⟶ 100%

So, 36% for fat ⟶ 36 Kcal

Like, 100g F100 ⟶ 526.31 Kcal ⟶ 100% (cfr. Eq.2.)

Thus, 36% energy ⟶ 278.93 Kcal

Energy conversation (Kcal) in grams of fat:

Lipid 1g ⟶ 9 Kcal

Hence, 278.93 Kcal ⟶ 30.99g of lipids

2i) For Plumpy'nut, 1 bag of this food product at the plant and distributed in the Nutritional Therapeutic Unit has a net weight of 92g, 100g not reaching the reference weight using the method of three single was used to convert the amount given per 100g of food (Eq.3.), and this for each macronutrient (protein, fat, carbohydrates and also energy) contained in the mixture.

Eq.3. $\frac{Content\ per\ 92g \times 100}{92gr}$

All recipes were balanced according to food standards Codex Alimentarius standards committee FAO/WHO (2013), energy proportions that must bring each macronutrient in the normal ration compared to the total energy:

10 to 15% of energy for protein**!!** (At 20% for malnourished)

25 to 35% of the energy for lipids

50 to 55% of the energy for carbohydrates. There are peculiarities in these proportions for certain products in therapeutic delivery of malnutrition.

Sample distribution

Table 1: Sample distribution by communities and the number of selected households*

Territory	Selected communities	Total population	Number of households	Number of participants/Sector	Percentage (%)
	Luhwindja	5540	1108	7	1.82
	Basile	88448	17690	107	27.86
Mwenga	**Burhinyi**	9234	1847	11	2.86
	Luindi	112655	22531	136	35.42
	Itombwe	101546	20309	123	32,03
Total	**5**	317423	63485	384	100.00

**Interior Provincial Division, DRC, 2014*

Statistical analysis

Analysis of data was done using STATISTICA 6.0 software. Means were compared with the nonparametric Mann-Whitney *U* test. Chi-square tests were performed to compare categorical variables. Statistical significance was set at 5% ($p<0.05$).

3. RESULTS AND DISCUSSION

Overall composition of caterpillars recorded flour, incorporated in cereal flours

Three (3) caterpillars of lepidoptera order (family saturnidae) incorporated in local cereal flours have been identified. An amount of 100 g of flour, of: a) *Bunaeopsis aurantiaca*, commonly called "Milanga" consisted of 49g of protein, 24.2g fat, 4.5g carbohydrate giving an energy value of 433Kcal (Muvundja *et al.*, 2013). These excavators content in its profile 5 major essential amino acids: aromatic amino acids (phenylalanine + tyrosine) 5.23g/16N, lysine 2.40g, 2.33g leucine and threonine 2.17 g/16N. 24.19% fats contain saturated and unsaturated acids amounting to 50.05% and 47.78% respectively of the total fatty acids, and 2.16% of other unidentified acids. Rich in polyunsaturated fatty acids: oleic acid C18: 1 ω9 40.28% and linoleic acid C18: 2 ω6 6.58%. Saturated fatty acids are represented by 38.53% of stearic acid; most abundant monitoring palmitic acid 10.05% (Ombeni *et al.*, 2018).
b) *Imbrasia oyemensis*, commonly called "Tukumombo" contains 2.6g of ash, protein 57.7g, 23.7g of fats, 11.01g of carbohydrates and provides 477kcal/100g. c) the *Cirina forda* caterpillar, vernacular name "Bikerekere" consists of ash 8.7g, 20 g protein, 12.5g fat, carbohydrate 54.3g giving an energy value of 410kcal (Table 2).

Table 2: Nutritional value per 100g of caterpillars available to South-Kivu markets used as flour (% over the dry matter)

Caterpillars used as flour						
Scientific name [Family]	**Vernacular names**	**Energy (Kcal/100g)**	**Protein (g)**	**Fat (g)**	**Carbs (g)**	**Mineral ash (g)**
1. *Bunaeopsis aurantiaca* ROTHSCHILD Saturniidae	Milanga (Lega), Malanga (Lingala), Bakanya (Swahili)	433	24.2	49	4.5	3.2
2. *Imbrasia oyemensis* ROUGEOT Saturniidae	Tukumombo (Lega), Liboyo (Lingala), Bihoyo (Ngando)	477	23.7	57.7	11.01	2.6
3. *Cirina forda* WESTWOOD Saturniidae	Misigi or Bikerekere (Lega), Ndanda (Lingala), Bihomi (Ngando)	410	12.5	20	54.3	8.7

These caterpillars' achievements forming the basis of these recipes are not at all surprising because Malaisse (2002) addressing the problem of Campeophagy in Africa, shows that globally, the order lepidoptera ranks first species consumed with 21 families identified. Malaisse and Latham (2014), and recently Malaisse *et al.*, (2016) also indicated that the human consumption of lepidoptera or "Lepideropterophagy" is experiencing a growing interest in Africa (Ramos-Elorduy *et al.*, 2011). Lisingo *et al.* (2010) in its systematic investigation of edible caterpillars in six localities of Kisangani district and Tshopo in Orientale Province of the DR Congo, discovering that fifteen edible caterpillars of species divided into three families were identified consumed, they add that dominance family saturniidae has been established. At South Kivu (study area) in three ethnic groups dominant province, *Ombeni* (2015) and still Ombeni and Munyuli (2016) reported that nine species of insects within four orders are consumed in Kivu, the order lepidoptera (Saturniidae) is the largest, with three caterpillars very popular: *Bunaeopsis aurantiaca, Imbrasia forda* (alias *Cirina forda*) (Badanaro *et al.*, 2014) and *Imbrasia oyemensis.* Read the paper Ombeni and Munyuli (2016) for more information about the nutritional value of caterpillars consumed in South Kivu province.

Adriaens (1953), Oberprieler (1993), Osasona and Olaofe (2010), Munvudja *et al.* (2013), Paiko *et al.* (2014), Foua Bi *et al.*(2015), these products address each of caterpillars included in the meaning of the nutritional quality, their low moisture and fat content separately. They suggest we can make flour. Foua Bi *et al.* (2015), exhibit the biochemical and nutritional composition of caterpillars' flour *Imbrasia oyemensis* dried, available to markets in Ivory Coast. In South Kivu, Muvundja *et al.* (2013) indicates the overall nutritional value of caterpillars *Bunaeopsis aurantiaca* in forest communities and in recent times Ombeni *et al.*, (2018) report their particular importance of amino-acids and fatty acids, Ombeni and Munyuli (2016) exhibit the frequency of consumption and availability of this caterpillar. The poverty moisture and fat of caterpillar B. *aurantiaca* allows them to dry quickly and prevent deterioration. Hence their incorporation into local popular flour as suggested by FAO (2004), Lavalette (2013), Dominique (2013), Ombeni (2015), Ombeni and Munyuli (2016), indicating that the sustainable fight malnutrition in community must be ensured by consumption and decentralized production of high nutritional value for the treatment of malnutrition using local products.

Indeed, after caterpillars census and nutritional quality evaluation of porridge recipes caterpillars prepared for malnourished children. Three recipes were identified, of which the first is based on meal caterpillars *Bunaeopsis aurantiaca*, sorghum and maize (called RPC1), the second component of caterpillars' flour *Imbrasia oyemensis* and maize (RPC2), and the third recipe ingredients like flour caterpillars *Cirina forda,* Sorghum and maize (RPC3).

In a manner very similar, adding the traditionally eaten insect powder in other poor protein foods to increase their nutritional value is not a new tradition. As examples, Thailand and Lao PDR, the dough spiced based giant Nepes *(Lethocerus indicus)* crushed and ground, is popular as a main ingredient (locally called "Jaew maeng da" in Lao Popular Democratic Republic and "nam phick" in Thailand). The taste of the giant nèpe is now artificially reproduced and the product is already available (FAO, 2013); In the US, "SOR-Mite", a sorghum-based mixture enriched with termites *(Macrotermes* spp.) is consumed in porridge for breakfast, lunch or dinner, depending on local preferences (Institute of Food Technologists, USA, 2011).

Availability Kenya Biscuits made from termites and based the lake flies, rolls, meatloaf them and sausages show great market potential (Ayieko *et al.*, 2012), and recently in Winfood

Cambodia-Kenya, making blends of amaranth seeds, corn, fish and termites *(Macrotermes subhyalinus)* (Winfood Kenya); rice, fish and spiders *(Haplopelma albostriatum)* (Winfood Cambodia); in order to develop nutritionally enhanced foods for infants and young children, and increasing the use of traditional foods (Nanna Roos, personal communication, 2016). Also, "Buqadilla" is observed in Dutch market; a food spicy Mexican-style legume (chickpeas) and 40% of small mealworms in several restaurants and canteens culturally acceptable by Western consumers (Van Huis *et al.*, 2012). In the markets of Ivory Coast and Katanga (DR Congo) observed commercialization of dried caterpillars flour I. *oyemensis*, B. *aurantiaca*, C. *forda*, etc. (Foua Bi *et al.*, 2015, Lisingo *et al.*, 2010).

"Crikizz" is another example of European based product insect; a spicy appetizer, blown, mealworms basic *(Tenebrio molitor:* Coleoptera) and cassava. The content of mealworms from 10 to 20% depending on the product ("classic" and "extreme") (FAO, 2013; Van Huis, 2013). Finally, as stated in the Haocheng Company in China, every year 200 tons of mealworms (*Tenebrio molitor*) dried are exported to Australia, Europe, North America and South-east Asia for human and animal consumption. The powder of these mealworms is incorporated in bread, flour, to instant noodles, pastries, cookies, candy and condiments (Haocheng mealworm Inc., 2012). Insects/caterpillars can also be consumed whole as flat and as an accompaniment, or made into medicinal supplements to strengthen the human immune system (Van Huis, 2013).

All these above examples shown, sufficiently prove that worldwide, flour insects/caterpillars is mixed in conventional products to fight against households food insecurity and malnutrition of people and these recipes are in full commercial traffic through the major companies. Exceptions to South Kivu province where these products are not present in the commercial circuit mean any involvement of intermediaries (Companies, Hotels, Restaurants, Supermarkets, etc.).

In the following paragraphs we will try to address each of these recipes in the direction of nutrient quality, biochemical quality of the caterpillars forming the basis of the recipe based on immediate chemical analysis results found by other researchers, and leading to a statistical comparison of the macronutrient content of recipes with the therapeutic products involved in the treatment of acute malnutrition (Table 6) following the recommendations of WHO and supported Protocol National malnutrition in Congo (PCIMA).

Macronutrient content of therapeutic and supplementary products of Nutritional Units DR Congo, after conversion to 100g of the food

To 100g of the reference food, a) the therapeutic milk F75 provides 439kcal to a protein content of 5.27g, 17.56g and 76.12g of lipids to carbohydrates (lactose). b) Therapeutic milk F100 provides 526kcal/100g contains 15.26g protein, 21.05g 30.99g of lipids and carbohydrates. c) Plumpy'nut provides 543kcal/100g from 13.15g proteins, 32.50g to 48.91g for lipids and carbohydrates. Finally, d) the mixture farinaceous CSB+/Unimix contains 380kcal to 18g of protein, 6g lipid and 60g of carbohydrates (Table 3).

Table 3: Content of macronutrients therapeutic products used in Nutritional Centers converted to 100g of food

Dietetic foods	Energy (Kcal/ 100g)	Protein (g)	Fat (g)	Sugar (g)
Therapeutic milk F75	439	5.27	17.56	76.12*
Therapeutic milk F100	526*	15.26*	21.05*	30.99
Plumpy'nut®	543*	13.15	32.50*	48.91
CSB+/Unimix	380	18.00*	6.00	60.00*

Macronutrients content (Variables: proteins, fats and carbohydrates) and the energy value of the caterpillars flour included in the slurries is statistically similar to that of therapeutic products for DR Congo nutritional centers, after application of the Chi^2 test based on 4 to 6 first products ($p<0.001$) (Table 4).

Nutritional value of recipe porridge caterpillars

A quantity of 100g porridge recipe made from flour: i) caterpillar *Bunaeopsis aurantiaca*-sorghum-maize (RPC1) is composed of proteins 13.90g; 16.09g of lipids; 53.10g of carbohydrates and thus provides an energy value of 412.81 kcal/100g in the proportions of 13.47% for proteins, 35.08% to 51.45% for lipids and carbohydrates. Flour recipe 2i) caterpillar *Imbrasia oyemensis* + maize (RPC2) consists of 15.34g of proteins, 31.25g of lipids, carbohydrates 44.80g giving 521.82kcal in proportions of 11.76% of the energy for protein, 53.90% of the energy for lipids and 34.34% of the energy for carbohydrates. The mealy mixture 3i) caterpillar *Cirina forda* + sorghum + maize (RPC3) is composed of proteins 15.53g, 14.06g of lipids, carbohydrates 56.58g providing 414.90 Kcal, in proportions of 14.97% of the energy for protein, 30.49% of the energy for fat and 54.54% of the energy for carbohydrates.

The comparative test applied to the components, the amount of ingredients and macronutrient content in slurries recipe caterpillars, exhibits a great similarity in nutritional and balanced diet meals ($p<0.0001$) (Table 5).

First, the RPCrecipe1 based flour caterpillars *Bunaeopsis aurantiaca* (49g Protein% DM) plus the mixture of poor popular flour protein (sorghum-maize) after balance of the diet it is an important energy source (413kcal) proteins (13.90g), lipids (16.09g) and carbohydrates (53.10g) per 100g of the recipe. These results are in convenience with those found by FAO (2004), which had recorded a high protein in the caterpillars, favoring their incorporation in poor flour protein to fight against child malnutrition. The RPC1 provides energy (412.81kcal/100g) in the proportion of 13.47% for proteins, 35.08% for lipids and 51.45% of the energy for carbohydrates. The percentage of energy that releases each macronutrient from this recipe is adhering to Codex Alimentarius FAO/WHO (2013) recommended intervals. They recommend that a balanced diet should provide energy in proportions 10 to 15% proteins, 25 to 35% of the energy provided by lipids and 50-55% of the energy provided by carbohydrates. Collins, (2004) indicated that the therapeutic food ready for use for the treatment of acute malnutrition bring between 520-550 kcal (energy per 100g), 10-12% of the energy for the protein, and 45-60% of the energy for fat (Vijay *et al.*, 2014). This recipe is balanced and provides the body with the recommended daily intake (RDI) of energy and protein function of age (Vasson and Jardel, 2005; Jacotot and Campillo, 2011; Schlienger, 2011).

Table 4: Comparison of the macronutrient content of the flour caterpillars and the Food Nutritional therapy of Units in DR Congo

Food products	Energy (kcal/100g)	Protein (g)	Fat (g)	Carbohydrate (g)
Flour *Bunaeopsis auriantiaca*	433.00	49.00	24.20	4.50
Flour *Imbrasia oyemensis*	477.00	57.70	23.70	11.01
Flour *Cirina forda*	410.00	20.00	12.50	54.30
Therapeutic milk F75	439.13	5.27	17.56	76.12
F100 therapeutic milk	526.31	15.26	30.99	22.11
Plumpy'Nut	543.00	13.15	32.50	48.91
Flour CSB+/Unimix	380.00	18.00	6.00	60.00
Statistics				
DF	6.00	6	6.00	6.00
Chi-square	91.9136	91.9136	26.5205	111412
P-value	<0.001	<0.001	<0.001	<0.001

Table 5: Model balanced ration per 100g of recipes porridge caterpillars mixed with local cereal flour

RPC1: porridge caterpillar$_1$ + sorghum+ maize					
Ingredients	**Amount (g)**	**Protein (g)**	**Fat (g)**	**Carbs (g)**	**Energy (kcal/100g)**
Caterpillars flour B. *aurantiaca*	15.00	7.35	3.63	0.68	64.77
Sorghum flour	25.00	2.75	0.80	14.83	77.50
Maize flour	40.00	3.80	1.76	27.60	141.44
Liquid oil	10.00	0.00	9.90	0.00	89.10
Sugar	10.00	0.00	0.00	10.00	40.00
Total (g)	100.00	13.90	16.09	53.10	412.81
Total (kcal)	-	55.60	144.81	212.40	412.81
Percentage (%)	-	13.47	35.08	51.45	100.00
DF	4.00	4.00	4.00	4.00	4.00
Chi-square	32.50	13.45	19.62	48.78	68.59
P-value	<0.0001	0009	0001	<0.0001	<0.0001
RPC2: porridge caterpillar$_2$ + maize					
Flour caterpillars I. *oyemensis*	20.00	11.54	4.74	2.20	97.63
Maize flour	40.00	3.80	1.76	27.60	141.44
Liquid oil	25.00	0.00	24.75	0.00	222.75
Sugar	15.00	0.00	0.00	15.00	60.00
Total (g)	100.00	15.34	31.25	44.80	521.82
Total (kcal)	-	61.36	281.25	179.21	521.82
Percentage (%)	-	11.76	53.90	34.34	100.00
DF	3	3	3	3	
Chi-square	32.5	14	23.1506	50.4303	43.7305
P-value	<0.0001	0003	<0.0001	<0.0001	<0.0001
RPC3: porridge caterpillar$_3$ + sorghum + maize					
Flour caterpillars *Cirina forda*	65.00	13.00	8.13	35.30	266.31
Sorghum flour	10.00	1.10	0.32	5.93	31.00
Maize flour	15.00	1.43	0.66	10.35	53.04
Oil	5.00	0.00	4.95	0.00	44.55
Sugar	5.00	0.00	0.00	5.00	20.00
Salt	-	0.00	0.00	0.00	0.00
Total (g)	100.00	15.34	31.25	44.80	521.82
Total (kcal)	-	61.36	281.25	179.21	521.82
Percentage (%)	-	11.76	53.90	34.34	100.00
DF	4	4	4	4	
Chi-square	130	39947	18.3378	68.3056	513982
P-value	<0.0001	<0.0001	0001	<0.0001	<0.0001

Second, the RPC2 recipe nutrient content based on flour of *Imbrasia oyemensis* is rich and balanced, referring to different values in the tables. Thus, the total energy content of 521.82 kcal/100 g of the flour RPC2 in proportions of 11.76% of the energy for protein, 53.90% of the energy for lipids and 34.34% of the energy for carbohydrates. The composition of proteins, lipids, and carbohydrates is 15.34g, 31.25g and 44.80g respectively 100g RPC2.

The proportion of the energy supplied by carbohydrates compose this recipe is approximate to that indicated by the WHO (1985, 2001); Nutriset Group, (2014) on the nutritional quality of Nutriset products, with 34.34% for the recipe RPC2 against about 40% for the product RUTF. But the amount of energy provided by lipids recipe RPC2 (53.90%) is superior to that derived food standards FAO/WHO (2013) on the same nutrient. They recommend that a balanced diet should provide 25 to 35% of energy for lipids.

This excess energy from fat would be justified by the flour RPC2 was designed and balanced for the purpose of having the nutritional composition similar to Plumpy'nut and F100 food aid products. This energy can be used by the body on these daily needs in the treatment of moderate acute malnutrition (UNTA) (Collins, 2003).

Comparing the nutritional quality of the slurry recipe caterpillars *I. oyemensis* more mixing maize flour with that ready to use therapeutic food (RUTF) for therapeutic delivery of food aid (Table 3), it turns out that the recipe RPC2 shows significant protein that Plumpy'nut with protein 15.34g against 13.15g respectively.

The animal *(Imbrasia oyemensis)* incorporated in the flour mixture is the source of this recipe in animal proteins both qualitatively and quantitatively, as its protein content is very high 57.7g/100g (Foua Bi *et al.*, 2015; Akpossan *et al.*, 2009). The essential function of a food protein is to meet the needs of nitrogen in the body and essential amino-acids (WHO, 1985).

Thus the recipe RPC2 can cover the daily needs of individual proteins according to age groups (Vasson and Jardel, 2005).

On the I. *oyemensis* quantity, amino-acid profile indicated by Foua Bi *et al.* (2015) to a total amino-acid 1109.88mg/g protein with essential amino-acids with an amount of 588.38mg/g protein. The histidine and glutamic acid have the highest concentrations, the lowest being isoleucine and methionine (sulfur amino acid) with respectively 5.58 and 0.418mg/g protein. This deficit can affect protein synthesis and cause disease because methionine helps fight against depression, behavioral disorders, hypertension, kidney problems and maintaining the fluidity of the cell membrane (WHO, 1985).

Hence the mixture of the caterpillar flour I. *oyemensis* in cereals rich in methionine in the diet optimizes its nutritional value (Foua Bi *et al.*, 2015). So the good nutritional quality of the recipe is obtained in the same protein intake which offsets any deficiencies in essential amino acids (Salaün, 2012).

Finally, in this study it appears a third recipe prepared by forest communities of South-Kivu based caterpillars' flour *Cirina forda*-sorghum-maize (RPC3).

After balancing the ration, the recipe RPC3 has an energy value of 415 kcal/100g, distributed to 14.97% of the energy for protein, 30.49% of the energy for lipids and 54.54% of the energy for carbohydrates. These values are within the ranges recommended by the Codex Alimentarius FAO/WHO (2013).

Concurrently, the Ministry of Health, DR Congo in collaboration with the National Nutrition Program (PRONANUT acronym) recommends that recipe for the preparation of porridge with local products for the dietary management of moderate acute malnutrition must respect the contributions energy of 15 to 20% of the energy provided by the proteins, 30 to 35% of the energy provided by lipids and 50-55% of the energy provided by carbohydrates. He added that the ration should be dense enough energy (100 kcal per 100 ml) and micronutrients to meet the nutritional needs, the dry ration should bring between 1000 and 1200Kcal/day/person. And must consist of a mixture of cereal flours and legume micronutrient fortified, enriched with vitamin A oil and sugar (Pronanut-RDC, 2012, 2010).

Recipe RPC3 is an excellent source of protein, fat and carbohydrates, as indicated by the tables presented above. Osasona and Olaofe, (2010); Adepoju *et al.* (2013) reveals that *Cirina forda* caterpillar forms the basis of animal protein, fats and carbohydrates of this recipe is a good source of protein and lipid, hence its incorporation into popular foods can be an additional source of food fortification. The result of the analysis will make mineral *C. forda* useful in the formulation of human foods which may however need to be fortified with iron and calcium. The RPC3 flour is also rich in minerals, because the caterpillar forming the basis of the recipe contains in mg/100 g dry weight Showed Potassium (47.6 ± 0.1)>Phosphorus (45.9 ± 0.6)>Sodium (44.4 ± 0.1)>Magnesium (43.8 ± 0.4)>Zinc (24.2 ± 0.2)>Calcium (12.9 ± 0.2)>Iron (1.3) (Osasona and Olaofe, 2010).

IASCNC (2009) ; Mark *et al.* (2012) showed that 100g of flour CSB+/UNIMIX contains 380 kcal of energy, 18g protein, 6g fat. 60g Carbohydrate, Vitamin A-1700 IU, Riboflavin-0.5mg, Pantothenic acid-3mg, Phosphorous-600mg, Sodium-300mg, Vitamin D-200, 8mg Niacin, Folate-0.2mg, magnesium-100mg, Potassium-700mg, 8 IU Vitamin E.

The recipe porridge caterpillars (RPC1, RPC2 and RPC3) eaten in South-Kivu province have

content similar to those macronutrient Therapeutic Products of malnutrition in DR Congo feeding centers ($p<0.0001$), with test values X^2 categories of important variables compared. The compared variables are statistically highly significant: Energy (X^2: 56.55; $p<0.0001$), proteins (X^2: 30.46; $p<0.0001$) and lipids (X^2: 31.39; $p<0.0001$). Only Carbohydrates variable is not significant (X^2: 7.13; $p=0.309$) (Table 6).

By comparing the energy content and macronutrient of RPC1 with that of the F75 and F100 therapeutic milk for 100g of the product used, it turns out that the RPC2 recipe is much richer in protein than therapeutic milk F75 with 13.90g of protein for against RPC1 5.27g of protein for F75 (X^2: 30.46; $p<0.0001$), but a value in the region of protein that F100 (15.26g). The energy content of the recipe RPC1 (413kcal) is approximate to that of therapeutic milk F75 (439kcal), but the F100 is more energy (526kcal) these first two products (X^2: 56.55; $p<0.0001$). Muvundja *et al.* (2013) indicates that the caterpillar meal *Bunaeopsis aurantiaca* integral to the recipe RPC1, like other edible caterpillars, a rich source of animal protein and is therefore very significant and content in its profile 5 major essential amino acids: aromatic amino acids (phenylalanine + tyrosine) 5.23g/16N, lysine 2.40g, 2.33g leucine and threonine 2.17 g/16N. 24.19% fats contain saturated and unsaturated acids amounting to 50.05% and 47.78% respectively of the total fatty acids, and 2.16% of other unidentified acids. Rich in polyunsaturated fatty acids: oleic acid C18: 1 ω9 40.28% and linoleic acid C18: 2 ω6 6.58%. Saturated fatty acids are represented by 38.53% of stearic acid; most abundant monitoring palmitic acid 10.05% (Ombeni *et al.*, 2018).

Ann *et al.* (2004); Santini *et al.* (2013) reported that 100ml therapeutic milk F75 contains 75 kcal of energy, 0.9g protein, 36% of energy from fat, and contain lactose 1.3g (carbohydrate). The Ministry of Public Health, DR Congo (Pronanut-RDC, 2012; 2010; 2005) recommends for the treatment of severe acute malnutrition, the patient should receive therapeutic milk F75 (with the exception of cases referred to an observation period related stagnant weight loss or weight for no known reason but with preserved appetite). When medical complications are mastered and the patient has found his appetite, we go to the RUTF to prepare it for a supported in Unity Outpatient Nutritional Therapeutics (UNTA). To screen the recommended protocol using therapeutic milk F100 (100ml →100kcal) for the nutritional treatment in phase2 of severe acute malnutrition, but now it is replaced by the Plumpy'Nut (RUTF 1sachet: 92g→500kcal) (Menon *et al.*, 2007; Manary, 2005; Dubey and Bhattacharya, 2011).

This nutritional food (exported and not available) may be replaced by the recipe RPC1 (local and available) in the nutritional treatment of severe acute malnutrition in its second phase, since its protein content, fat, carbohydrates and energy is approximate to her Ready to Use Therapeutic Food (RUTF) ($p<0.0001$).

Dominique, (2013) shows that in France the production of recipes available local flour can replace high nutrition food for treating malnutrition. He shows a manufacturing procedure in pediatric services and the cost of these foods compared to the high cost of food aid products.

The content of the recipe RPC1 lipid, carbohydrates and energy: 31.25g of fat, 44.80g carbs giving 522Kcal is similar to plumpy'nut with 32.50g, 48.91g and provides 543Kcal respectively (X^2: 56.55; $p<0.0001$). This recipe can replace the high cost of Plumpy'nut (purchase price $3000/ton) and other RUTF (BP100, BP5, Sprinkles ... purchase price $ 10,000/ton) (Dominique, 2013) on its lower cost, availability and its potential in protein, lipid, carbohydrate, and energy, which can cover the needs of the malnourished body (170kcal/kg/day and 130kcal/kg/day) in the outpatient and intensive nutritional unit (UNTA and UNTI) DR Congo respectively (Pronanut-RDC, 2012; 2010; Collins, 2003). However this rate is consistent with that of FAO (2004) (522Kcal) noted that high energy content in flour food caterpillars encouraging their inclusion within the baby food (Collins, 2003).

Table 6: Nutritional quality comparison of South-Kivu caterpillar recipes and the food nutritional therapy of DR Congo Nutritional Centers

Products	Macronutrient content per 100 g of the reference food			
	Energy (Kcal/100g)	Protein (g)	Fat (g)	Carbs (g)
RPC1	413	13.90	16.09	53.10
RPC2	432	14.83	16.31	56.50
RPC3	415	15.53	14.06	56.58
Milk T. F75	439	5.27	17.56	76.12
T. milk F100	526	15.26	21.05	30.99
Plumpy'nut®	543	13.15	32.50	48.91
CSB+/Unimix	380	18.00	6.00	60.00
	Statistics			
DF	6	6	6	6.00
Chi-square	56.5504	30.4619	31.3954	7.13527
P-value	<0.0001	<0.0001	<0.0001	0309

Legend: RPC1, 2, 3: mixture of flour R (Recipe), P (Porridge), C (Caterpillar) *Bunaeopsis aurantiaca*$_1$, *Imbrasia oyemensis*$_2$, *Cirina forda*$_3$; CSB+: Corn Soya Blend plus

Comparing the content of macronutrients for 100g recipe RPC3 and that of the product Nutriset CSB+/UNIMIX to additional distribution or Ready-To-Use Supplementary Food (RUSF) for acute malnutrition, it appears that the RPC3 is more energy and lipid the product CSB+/Unimix (RUSF) with 415Kcal and 380Kcal cons against 14.06g and 6.00g for lipids respectively. The protein and carbohydrates is similar, with 15.53g of protein to the recipe C. *forda* against Protein 18.00g for the CSB+ and 56.58g against carbs 60.00g respectively (X^2: 31.39; p<0.0001). This recipe can replace the CSB+, Unimix of exported food aid products, high cost (purchase price<$600/ton) (Dominique, 2013) by its availability, cost and power to cover daily energy requirement (100kcal per 100 ml) of patients with moderate acute malnutrition (1000 and 1200Kcal/day/person) supported by the Nutritional Supplementary Units (NSU).

This study means that these recipes porridge based caterpillars *Bunaeopsis aurantiaca*, *Imbrasia oyemensis* and *Cirina forda* for malnourished people consumed by the forest peoples of South-Kivu province who eat these meals of insects during specific periods of the year are of exceptional nutritional quality. After balancing of recipe (RPC1, RPC2 and RPC3) the results thus demonstrate that they provide energy, protein, fat and carbohydrates according to standard norms of food codex Joint FAO/WHO (2013). Because of their high nutritional value in some recipes of the region, this recipe can replace food aid exports and high cost additional distribution and/or therapeutic in Congo Nutritional Units. These caterpillars flour was mixed with popular flour with added oil, sugar to increase the energy value, vitamin, taste and a pinch of salt to ensure its preservation, to prepare slurry to fight against child malnutrition (FAO, 2004).

Partial conclusion

This study was interested in the rich cuisine and food ground into flour that could be reconstituted into porridge for child feeding as recommended by Codex alimentarius: recipes porridge caterpillars of lepidoptera order prepared by the riparian population of the Congo basin in general and South Kivu province in particular in the fight against poor nutritional status (malnutrition) of population. Given that among the reasons for the persistence of acute malnutrition in Congo are at the top the low participation of domestic sectors: agriculture, education, environment, economy, etc.; inadequate food consumption i.e. poor essential nutrients; insufficient access to food are also part of the causal model and level of nutrition units; breaking therapeutic inputs handicaps nutrition services (Rachelle, 2013; Unicef *et al.*, 2007; Unicef, 2005; Pronanut-RDC, 2012; 2010; 2005).

The problem, however, is that the main ingredients blended fortified foods (FBF) of

emergency food aid (such as soy mixture CSB+) do not generally part of the traditional diet, or, in many countries, are not available locally, which makes them unsuitable nutritional perspectives, social and environmental, particularly in the context of sustainable diets (FAO, 2010b). Considering the protein content and micronutrient many edible insects, their minimal environmental impact, availability, cost and especially their cultural acceptance in the vast majority in developing countries where food insecurity is the main problem, their use in the FBF worth considering (Perez-Exposito and Klein, 2009). Reason about the principal objective of this study main purpose to establish the comparison between the nutritional value of recipes using flour caterpillars consumed by rural communities of South Kivu and the distribution of additional products and/or therapeutic food aid nutritional Units used by the Democratic Republic of Congo for the treatment of acute malnutrition. In order to make light of the population and health sector programs, partners in the fight against malnutrition communities, nutrient rich recipes caterpillars consumed in South Kivu, to permanently resolve the issue of malnutrition remains an obstacle to development in DR Congo.

Since, cereals usually consumed in many African countries have low nutrient i.e. poor in protein and fat and lacks several essential amino acids, such as lysine. For this reason, these cereals enriched with flour caterpillars easily harvested and available in their period seems appropriate. It was so therefore found that of all the edible caterpillars in South Kivu, only three are used as flour, including chenille *Bunaeopsis aurantiaca, Imbrasia oyemensis* and *Cirina forda* (Lepidoptera: Saturniidae) introduced in recipes RPC1, RPC2 and RPC3 respectively. This practice was used for the first time by the regional religious sisters involved in the treatment of malnutrition in communities.

After equilibration following the food standards of the Codex Alimentarius FAO/WHO, recipe porridge for people malnourished basis of the above-local tracks indicated incorporated in local cereal flours are an important source of energy, protein, vitamins and minerals of qualitative and quantitative perspective. Flour caterpillars there are introduced at the base of this nutrient richness. Their consumption is diversifying the diet to malnourished meets the nutritional needs of malnourished body as support phases and provides energy in the ration in accordance with health standards, as indicated by the discussion below high presented.

By comparing the nutrient content of caterpillar's porridge recipe and that therapeutic food for malnutrition. It appears that only 100g recipe RPC1 (made with flour caterpillar B. *aurantiaca*, sorghum and maize) has an adjoining nutritional value to that contained in small sachets 102.5g and 114g therapeutic milk F75 and F100 respectively. Besides the protein content of this recipe is interesting as compared to that of therapeutic milks.

Similarly, the nutritional value per 100g recipe RPC2 (made from flour I. *oyemensis* caterpillars and maize) is similar to that contained in a sachet (92g) of Plumpy'nut Nutriset products, BP100 and BP5. Finally, the recipe RPC3 (made with flour caterpillar C. *forda*, sorghum and maize) has a similar nutrient content than food aid product for the additional treatment of patients with moderate malnutrition (CSB+/Unimix). This recipe is much more energy and protein as porridge made of food aid CSB+ flour.

Contrary to the fact that this dish is considered traditional food of low importance by the people of the middle class and other nearby communities, but rather high nutritional value meal. Because of their high nutritional value in some recipes of the region, they can replace receipts of food aid exports and high cost additional distribution and/or therapeutic (CSB+/Unimix, Plumpy'nut, F75 and F100 therapeutic milk) Nutritional Units of Congo.

Thus, these floury mixture (recipe RPC1, RPC2 and RPC3) can be prepared by nutritionists in their health institution following

the amounts recommended in this study and address the needs of patients in the nutritional treatment acute malnutrition in the breakdown of food aid inputs. Make any kind incorporated into the flour mixtures are well fine. The use of these local recipes could solve the problem of breaking therapeutic inputs of malnutrition in Congo.

These recipes porridge based caterpillars consumed by South Kivu communities, can also be used by Nutritional Units (UNS, UNTA and UNTI) DRC and cover the energy and protein needs of patients Supported by these services. Hence this practice could ensure the dependence of the region's Nutritional Units for their own production of high nutrition food for treating malnutrition.

4. CONCLUSION

All three foods based on caterpillars ground into flour that could be reconstituted into porridge for child feeding as recommended by Codex alimentarius were nutritionally significant by the target population and may be developed further and be used for efficacy trial. Despite the differences, it is important to notice all the food scored reasonably high in the parameters tested.

Given the results obtained we should recommend:

1. For the Nutrition health programs partners in the fight/prevent malnutrition of the rural population; promote the use of these local caterpillar recipes to ensure the sustainability of nutrition services in the management of cases and solve the problem of breaking inputs therapeutic observed under most of Nutritional Units in DRC (Rachelle, 2013);
2. Ministry of Public Health, to enhance the consumption of these caterpillars porridge recipes to ensure the prevention and treatment of malnutrition through traditional local foodstuffs (Ombeni *et al.*, 2018; Ombeni and Munyuli, 2016; Ombeni, 2015);
3. National Program of Nutrition to Inform, educate and to communicate with the general population of incorporating flour caterpillars in popular cereal flours for improving nutritional status, and to fight against child malnutrition (FAO, 2004) following the recipe from model proposed use of local products in the treatment of malnutrition (Dominique, 2013);
4. A community favor the use of flour caterpillars *Bunaeopsis aurantiaca, Imbrasia oyemensis* and *Cirina forda* in popular flour if the preparation of the slurry against child malnutrition;
5. The caterpillar mix flour B. *auriantiaca* and I. *oyemensis* with flour from local cereals to diversify the diet, to balance the ration for malnourished and compensation foods limiting factor (Salaün, 2012).

The valuation of the consumption of the recipes porridge local caterpillars of flour consumed by an ethnic group in South Kivu will have a positive impact in reducing the malnutrition and under nutrition in DR Congo and South Kivu in particular.

Acknowledgments

The authors would like to express sincere thanks to the following individuals for making this project successful: Mr. Mutumoyi, Faculty of Sciences Institute of Development (IFSD) Kamituga for its assistance in the collection of specimens of caterpillar integral studied recipes and Nutritionist Mr. René Nyaminani, Dept. of Nutrition and Dietetics of Bukavu Institute of Higher Education in Medical Techniques "ISTM-Bukavu», South Kivu (DRC) for his contribution in balancing children's meal recipes.

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