



IMPROVING THE NUTRITIONAL VALUE OF WEANING SLURRIES BY *IMBRASIA truncata* CATERPILLAR MEAL

Germain MABOSSY-MOBOUNA¹, Arsène LENGA², Thérèse KINKELA³ and François MALAISSE^{4,5}

¹Laboratory of Nutrition and Human Food, Faculty of Science and Technology,
Marien Ngouabi University, Congo-Brazzaville

²Laboratory of Vertebrate and Invertebrate Bioecology, Faculty of Science and Technology,
Marien Ngouabi University, Congo-Brazzaville

³Multidisciplinary Team of Research in Food and Nutritional Resources (EPRAN),
Marien Ngouabi University, Congo-Brazzaville

⁴Biodiversity and Landscape Unity, Liège University, Gembloux Agro-Bio Tech, Belgium

⁵Botanical Garden Meise, Nieuwelaan 38, B-1860, Meise, Belgique

ARTICLE INFO

Article History:

Received 8th December, 2016

Received in revised form 6th January, 2017

Accepted 26th February, 2017

Published online 28th March, 2017

Key words:

Congo-Brazzaville, weaning slurries, nutritional value, *Imbrasiatruncata* caterpillar

ABSTRACT

Objective: The caterpillars of *Imbrasia truncata* are excellent vectors of essential amino acids, essential fatty acids and other micronutrients. The incorporation of their flours in Congolese infant weaning slurries will improve the nutritional value of these porridge in order to combat malnutrition.

Methodology and Results: Weaning meal based on *Imbrasia truncata* caterpillar flours was formulated using the Pearson Square method. The energy density (DE) was determined by combining all the nutrients providing energy and using the coefficients of Merril and Watt and also comparison of the essential amino acid composition with the FAO references.

Reference (2007) protein showed that the best formulation therefore seems to be that of the maize-caterpillar mixture which makes it possible to supply all the essential amino acids in sufficient quantities in the weaning slurry. However, in areas where corn is very scarce, the mixture of cassava flour and caterpillar flour may be suitable provided that the proportion of caterpillar meal is increased. These slurries have energy values ranging from 358 to 367 kcal per 100 g of dry matter.

All the results obtained show that the slurries formulated from *Imbrasia truncata* caterpillar meal are an important source of micronutrients which can contribute to the harmonious development of the infant during the weaning period.

Copyright©2017 Germain MABOSSY-MOBOUNA et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Breast milk is sufficient to cover the needs of the infant up to the age of 4 to 6 months, then it must be supplemented by feeding. However, cereals and tubers consumed in the Congo do not cover the protein and energy needs of the young child. In the Republic of the Congo, weaning meals are usually made from fermented maize meal in urban areas or fermented manioc flour in rural areas (Trèche et al., 1992). Early introduction of these porridge in the Congolese infant diet decreases the frequency of daily breastfeeding and, consequently, the supply of essential fatty acids, thus exposing them to malnutrition. Moreover, these slurries yield only 60kcal per 100g of porridge (Trèche et al., 1992), which exposes the infants to slump.

*Corresponding author: **Germain MABOSSY-MOBOUNA**
Laboratory of Nutrition and Human Food, Faculty of
Science and Technology, Marien Ngouabi University,
Congo-Brazzaville

Corn and cassava flours used in the preparation of weaning slurries in Congo are poor in α -linolenic acid (Nitou et al., 2012). Infants receiving only these porridge have a deficit in this fatty acid, the consequences of which are dramatic. Indeed, dietary deficiency in α -linolenic acid induces behavioral and cognitive deficits, particularly in learning, memorization and habituation (Bourre, 2004). It alters cerebral development and disrupts the composition of brain cell membranes (neurons, oligodendrocytes, astrocytes), myelin and nerve endings (Bourre et al., 1989; Bourse, 2004). In addition, this deficiency leads to poor blood flow, decreased dioxygen intake, an abnormal immune response associated with an increased tendency to inflammation, and developmental disorders and psychiatric illnesses such as depression and schizophrenia (Geiser, 2008).

To avoid deficiencies in α -linolenic acid and its long-chain derivatives and to allow normal development of the infant

during the weaning period, complementary foods suitable for meeting the nutritional needs of infants and older children should be included in their Ration. In most cases, traditional basic foods in the Congo are supplemented with milk powder to improve the nutritional quality of the porridge. This food is often imported and raises the problem of its availability. In addition, it is generally beyond the reach of mothers from disadvantaged backgrounds. It is therefore important to use local foods that are available, accessible and of good nutritional value.

Because of their high nutritional value, *Imbrasia truncata* caterpillars can be mixed with corn or cassava flour to supplement infant porridge to combat protein-energy malnutrition and some micronutrient deficiencies. The caterpillars of *Imbrasia truncata* have a certain number of assets to develop a nutritional strategy which consists of valorising them in order to fight against these scourges. These caterpillars are rich in proteins containing all essential amino acids, essential fatty acids (-linolenic acid and linoleic acid) and mineral elements (Mabossy-Mobouna *et al.*, 2017, Kodondi *et al.*, 1987b). They also contain all the vitamins in appreciable quantities (Kodondi *et al.*, 1987b, Finke, 2005).

MATERIAL AND METHODOLOGY

Method of formulating the slurries

The weaning slurry is made from a staple food that must be combined with a supplement that balances the protein ration according to the needs of the child. To do this, we used the Pearson square method (Figure 1). The level of protein required in the slurry is placed centrally and the protein content of each food is placed on the corners of the left side of the square. The proportion of each food in the slurry is determined by subtracting the smallest number from the largest by following the diagonal of the square. The proportion of each food is given on the right side of the square

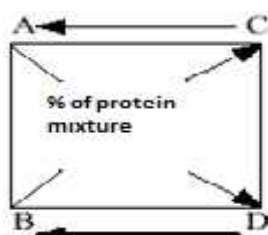


Figure 1 Pearson Square (Maurice & Lavigne, 2013).

The protein content of food A (staple food) must be lower and that of feed B (crawlers) higher than that of the desired mixture. The values in C (part of the staple feed in the mixture) and in D (part of the caterpillars in the mixture) are the result of two subtractions made diagonally taking into account the value of the center.

$$\% \text{ of food A} = [C \div (C + D)] \times 100$$

$$\% \text{ of food B} = [D \div (C + D)] \times 100$$

Energy value

The energy density (DE) was determined by combining all the nutrients providing energy and using the coefficients of Merrill and Watt (1955).

DE = 4G + 4P + 9L with:
G = mass of carbohydrates ((g);

P = mass of proteins (g);
L = mass of lipids (g).

The energy density was calculated using the nutrient quantity data obtained by Adrian *et al.* (1995) for maize and cassava, and by Mabossy-Mobouna *et al.* (2017) for the caterpillars of *Imbrasia truncata*.

Evaluation of chemical index

Chemical indices were calculated on the basis of FAO / UNU/ WHO data (2007). This calculation gives, according to NGUDI *et al.* (2003), a correct prediction of the amount of protein needed to meet essential amino acid requirements during growth.

The chemical index of an amino acid is calculated using the formula below:

$$\text{Chemical index} = (\text{mg of amino acid in 1 g of analyzed protein}) / (\text{mg of amino acid in 1 g of reference protein}) \times 100$$

The amino acid which has the lowest index is the limiting amino acid of the protein studied.

Processing of data

Data processing was carried out using the Epi info, XL stat and Excel 2007 software. Processing of the harvested data, input and production of the raw tables was done with the software Epi info.6.04 and Excel 2007. The quantitative variables are expressed as mean (x) ± standard deviation (s) while indicating extreme values (minimum and maximum). Qualitative variables are expressed in numbers and percentages. The comparison of the calculated percentage and the percentage read on the Student table is done by Student's statistical test at (k-1) degree of freedom, with a significance threshold of 5%.

RESULTS

Test for the formulation of weaning meal based on Imbrasia truncata caterpillars

The formulation of weaning meals is intended for children from 6 to 11 months with a daily protein requirement of 10g. The method used is based on the principle of food supplementation to improve the nutritional value of weaning meals made from local foods (cassava and maize) with a proportion of each feed in flour formulated at 10% protein.

Table I shows the proportion of each feed in the flour obtained, containing 10% protein.

Table I Proportion of foods in formulated flour containing 10% protein

Proportion in the mixture	Corn-caterpillar flour	Cassava-caterpillar flour
Parts of starchy food	61	61
Parts of caterpillars	1.5	9
% of the starchy food	97.6%	87.14%
% of caterpillars	2.4%	12.86%

This table shows that to obtain a mixture containing 10% protein, we must mix 61 parts of maize and 1.5 parts of caterpillars or 61 parts of cassava and 9 parts of caterpillars. The composition of each flour in percent is 97.6% maize and 2.4% caterpillars or 87.14% cassava and 12.86% caterpillars. When corn is replaced with cassava, more protein supplementation is required because its protein content is low.

Improving The Nutritional Value Of Weaning Slurries By *Imbrasia Truncata* caterpillar Meal

Since it is easier to obtain cassava than maize, we can formulate a flour by taking 2 parts of cassava (1.2%) and one part of corn (8.5%). The protein-weighted average of the starchy foods in the mixture is: $(2 \times 1, 2 + 1 \times 8, 5) / 3 = 3.63\%$. Table II shows the proportion of each feed in this mixture

Table II Proportion of food in cassava-maize-caterpillar flour with 10% protein

Proportion in the mixture		Flour starchy foods-caterpillars
Parts of starchy foods		61
Parts of caterpillars		6
% of starchy foods	Cassava	60.69%
	Maize	30.35%
% of caterpillars		8.96%

The number of parts of the caterpillars decreases slightly when cassava is mixed with another starchy food containing a fairly high level of protein.

Macronutrient composition and energy value of formulated flours

Referring to the composition table of foods and the shares of each food in the formulated mixtures, we evaluated their macronutrient composition and energy value. Table III shows the results of the calculations carried out for 100 g of dry matter of each mixture. The starchy foods used contain 86% carbohydrates for cassava, 74% carbohydrates and 4% lipids for corn.

Table III Macronutrient composition and energy value of formulated flours

Mixtures	Carbohydrates (%)	Protides (%)	Fat (%)	Energy value (Kcal)
Maize- Caterpillar	72.22	10	4.26	367.38
Cassava-caterpillars	75.13	10	1.96	358.84
Maize-cassava-caterpillars	74.77	10	2.75	363.83

This table shows that the correct formulation from the energy point of view is that of maize-caterpillars followed by the maize-cassava-caterpillar mixture then of Cassava-caterpillars has a slightly lower energy value. The differences in the energy values of the three formulations are not very significant ($p > 0.05$).

Required quantities of flours formulated

The results in Table III show that per 100 g of dried mixture of flour from each mixture, energy intake is less than half the recommended daily intake (760 to 970 kcal) for children between 6 and 11 Months if they ate only these porridge. To fill this energy gap, Table IV shows the required quantities of formulated flours for the child who is no longer breastfed.

Table IV Required daily quantities of formulated flours.

Mixtures	Required quantities (g / d)
Maize-Caterpillars	207 to 264
Cassava-caterpillars	212 to 270
Maize-cassava-caterpillars	209 to 267

The number of daily meals should be determined taking into account the stomach capacity of the infants.

Chemical Index of Formulated Flours

The evaluation of the chemical index of formulated flours should take into account the proportion of each feed in the

mixture. For each essential amino acid in the mixture, the amounts determined in the foods in this mixture were added and divided by that of the 2007 (FAO reference) protein for children aged 6 to 11 months. Table V shows the result of the calculations performed.

Table V Chemical index of *Imbrasia truncata* caterpillar formulations

Amino Acids	Maize-Caterpillars	Cassava - Caterpillars	Maize - Cassava Caterpillars
Isoleucine	108.75	77.50	88.125
Leucine	146.81	51.44	87.12
Lysine	50.52	61.66	56.40
Sulfurated amino acids	103.57	41.96	66.96
Aromatic amino acids	159.61	136.73	144.42
Threonine	113.54	98.87	104.032
Tryptophan	87.06	131.65	116.47
Valine	101.39	65.93	79.42

Table V shows that the maize-caterpillar mixture has two limiting amino acids (lysine and tryptophan) but has a low percentage deficiency. The primary limiting amino acid of this mixture is lysine, 50.52% of the reference protein. This chemical index is interesting. Indeed, the maize which has for amino acid limiting lysine is increased by the complementation of the proteins of caterpillars, rich in lysine. The deficiency in these amino acids is marked in the cassava-caterpillar mixture except for lysine.

The best formulation therefore seems to be that of the maize-caterpillar mixture which makes it possible to supply all the essential amino acids in sufficient quantities in the weaning slurry.

DISCUSSION OF RESULTS

Maize has a low protein (8.5%) and lipid (4%) content with a ratio of $Ca / P < 1$; lysine and tryptophan are limiting amino acids. The complementation of the maize porridge by the incorporation of *Imbrasia truncata* caterpillar meal will improve the nutritional value of its protein. In addition, histidine and arginine, essential amino acids for infants are very well represented in the caterpillar proteins of *Imbrasia truncata*.

In maize, -linolenic acid is present in the trace state. Its abundance in the caterpillars of *Imbrasia truncata* (42.63%) will make it possible to supplement the corn porridge and to bring the essential fatty acids of the ω 3 family to the infant.

The richness of the caterpillars of *Imbrasia truncata* in zinc largely allows to cover the daily needs of a child which are of the order of 5 to 10 mg. Indeed, after 6 months, zinc is often deficient in breast milk; its deficiency leads to stunting. Mixing the corn flour with *Imbrasia truncata* caterpillar meal will enrich the zinc content of the porridge. Similarly, the caterpillars of *Imbrasia truncata* are rich in copper, a trace element involved in bone mineralization.

This complementation will not make it possible to have a ratio $Ca / P = 1$, so it will be essential to associate with this mixture a food rich in calcium such as spinach or orange juice (Adrian *et al.*, 1995).

Since corn production is low, the weaning slurry in the rural areas of Congo is often made from fermented cassava flour. It turns out that cassava is very low in protein (1.2%) and lipids are in the form of traces, exposing the infant who consumes it to malnutrition. The complementation of the cassava slurry by

the incorporation of *Imbrasia truncata* caterpillar meal will increase the protein content of this slurry and provide essential fatty acids; the nutritional value of this porridge will be improved and the infant will be warned of cases of protein-energy malnutrition. However, sulfur amino acids are deficient at 52% in cassava and at 37.5% in caterpillars of *Imbrasia truncata*. They will thus constitute the limiting factor of this formulation.

The energy value of our formulations is lower than that of the Musalec weaning flour (417kcal per 100g of flour) made in Burundi (Nsavyimana, 1995), Micaf flour (400kcal per 100g of flour) made in Cape Verde (Vera Cruz (Mourtapha Ibrahim, 1995), Misola flour (415 kcal per 100 g flour) made in Morocco (Aouraghe, 1995), Bitamin flour (406 kcal per 100 g flour) 420kcal per 100g of flour) manufactured in Burkina Faso (Soubeiga, 1995), Superlamin flour (414kcal per 100g dry matter) from Algeria (Trèche, 1995). However, it is almost identical to that of Sosoma flour (364kcal per 100g of flour) made in Rwanda (Mukamurenzi, 1995). Mothers in Central Africa provide an average of 543ml of milk per day, or about 380kcal (Vis et al., 1981). Supplementary feeding should therefore bring 380 to 590 kcal to children from 6 to 11 months, which requires an energy supplement of 13kcal for the maize-caterpillar formulation and 23kcal for the cassava-caterpillar formulation. This supplement can be easily obtained by adding 3g of vegetable oil or 6g of sucrose for 6 month old children.

The cassava-caterpillar formulation has the same limiting amino acid, sulfur-containing amino acid, as the Vitafort weaning flour formulated by ORSTOM / Agri-Congo (Tchibindat & Trèche, 1995). Our results are different from those of Soubeiga (1995), whose limiting amino acid of the Misola weaning flour is tryptophan to 64.7% of the reference protein.

In addition, all these weaning meals contain at least one legume (Trèche et al., 1995), which is not the case for our formulations.

Imbrasia truncata caterpillars containing all the vitamins in satisfactory amounts (Kodondi et al., 1987; Finke, 2005), these formulations would be suitable for the nutritional needs of the infant during the weaning period.

CONCLUSION

The caterpillars of *Imbrasia truncata* are thus excellent vectors of essential amino acids, essential fatty acids and other micronutrients; the incorporation of flour from these caterpillars in weaning slurries could ensure food safety for infants. It is therefore reasonable for these caterpillars to replace fish or meat in the diet of Congolese children from 6 to 11 months without causing them to lack protein, essential fatty acids and micronutrients. It seems necessary to study further the physico-chemical reactions occurring during the various stages of preparation of these slurries in order to propose the method of preparation whose nutritive value is optimum. This study therefore makes it possible to consider ways of research in the context of the valorization of local foods in order to improve the nutritional status of vulnerable groups.

Acknowledgement

The authors thank Professor Georges LOGNAY, Professor Aurore RICHEL and Engineer Philippe MAESEN for their generous help in the various chemical analyzes carried out in the general and organic chemistry laboratory of the University Faculty of Agronomic Sciences Gembloux in Belgium.

Bibliography

- Adrien J., Pofus J & Frangere R.- *La Science alimentaire de A à Z*. TecetDoc, Lavoisier, 1995: 477p.
- AOAC- *Official methods of Analysis* of AOAC International, 18th ed., AOAC International Arlington, 2003: 275p.
- Aouraghe M.-Evaluation du programme « ACTAMINES » de 1972 à 1993 au Maroc. In Trèche S., de Benoist B., Benbouzid D., Delpuech B, ed. *L'alimentation de complémentation du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995 : 189-196.
- Bourre J.M.- Acides gras oméga-3 alimentaires et neurophysiologie : Oléagineux, Corps Gras, Lipides. *Fondamental*, 2004; 11(4): 362-70.
- Bourre J.M., François M., Youyou A., Dumont O., Piciotti M., Pascal G. & Durand G.- The effects of dietary alpha-linolenic acid on the composition of nerve membranes, enzymatic activity, amplitude of electrophysiological parameters, resistance to poisons and performance of learning tasks in rats. *J Nutr*, 1989; 119: 1880-92.
- FAO/UNU/OMS - Protein and amino acid requirements in human nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation WHO Technical Report Series 935. WHO, Geneva, 2007: 284p.
- Finke M.D. - Nutrient composition of bee brood and its potential as human food. *Ecology of Food and Nutrition*, 2005; 44(4): 257-270.
- Geiser R. -Acidesgras pour la mère et l'enfant, 2008:4p. http://www.bag.adm./earnaehr_n.ch.
- Gokhan B.&Hikmet K. - Seasonal changes in proximate composition of some fish species from the Black sea. *Turk. J., Fish.*, 2011: 3-4.
- Kodondi K.K., Leclercq M. &Gaudin-Harding F. - Vitamin Estimations of Three Edible Species of Attacidae Caterpillars from Zaire. *Internat. J. Vit. Nutr. Res.*, 1987b; 57: 333-334.
- Mabossy-Mobouna G., Kinkela T. &Lenga A.- Apports nutritifs des chenilles d'*Imbrasiatruncata* consommées au Congo-Brazzaville. *Journal of Animal &Plant Sciences*, 2017; 31(3): 5050-5062.
- Maurice J. & Lavigne A. -L'alimentation animale à partir des ressources locales. Fredon Martinique, 2013:54p.
- Merril A.L. & Watt B.K.- Energy value of food, Basis, Washington, DC; United States Department of Agriculture, 1955: 74p.
- Moustapha Ibrahim H.- Bitamin : Farine de sevrage du Niger. In Trèche S., de Benoist B., Benbouzid D., Delpuech B, ed. *L'alimentation de complémentation du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995 : 197-198.
- Mukamurenzi E.-Sosom : Farine de sevrage du Rwanda. In Trèche S., de Benoist B., Benbouzid D., Delpuech B, ed. *L'alimentation de complémentation du jeune*

- enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995 : 199-202.
- Ngudi D., Kuo Y.H. & Lambien F. - Amino acid profiles and protein quality of cooked cassava or 'saka-saka'. *J.Sci. Agri.* 2003; 83, 529-534.
- Nitou J.G., Enzonga-Yoca J.A., Bouanga-Kalou G., Niamayoua R. K., Nzikou J.M., Itoua-Okouango S., Elenga M., Matos L., Mvoula-Tsieri M. & Siloi Th. - Evaluation de l'état nutritionnel des mères allaitantes et de leurs nourrissons au Congo. *Journal of Animal & Plant Sciences*, 2012; 13(1): 1687-1697.
- Nsavyimana J.B.- Muslac: Farine de sevrage du Burundi. In Trèche S., de Benoist B., Benbouzid D., Delpeuch B, ed. *L'alimentation de complément du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995 : 167-172.
- Soubeiga S.- Farine Misola au Burkina Faso. In Trèche S., de Benoist B., Benbouzid D., Delpeuch B, ed. *L'alimentation de complément du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995: 301-312
- Tchibindat F. & Trèche S.- Vitafort: Une farine infantile de haute densité énergétique au Congo. In Trèche S., de Benoist B., Benbouzid D., Delpeuch B, ed. *L'alimentation de complément du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995: 177-188
- Trèche S., de Benoist B., Benbouzid D., Delpeuch B. - *L'alimentation de complément du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995 : 391p.
- Trèche S., Giamarchi P., Pezennec S., Gallon G., Massamba J. - Les bouillies de sevrage au Congo: composition, valeur nutritionnelle et modalités ' d'utilisation. *Communication présentée aux 5èmes Journées Internationales du GERM, Balaruc, France,; 23-27 Novembre 1992.*
- Vera Cruz E.- Farine MICAFA au Cap Vert. In Trèche S., de Benoist B., Benbouzid D., Delpeuch B, ed. *L'alimentation de complément du jeune enfant*, Paris, Editions ORSTOM, Collection Colloques et Séminaires, 1995: 173-176.
- Vis H.L., Hennart P. & Ruchababisha M.- L'allaitement en zone rurale pauvre. *Carnets de l'enfance*, 1981; 55-56: 171-189.

Please cite this article in press as:

Germain MABOSSY-MOBOUNA *et al* (2017), Improving The Nutritional Value Of Weaning Slurries By Imbrasia Truncata caterpillar Meal, *International Journal of Current Advanced Research*, 6(3), pp. 2634-2638. <http://dx.doi.org/10.24327/ijcar.2017.2638.0062>
