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Nutritional qualities of edible caterpillars *Cirina butyrospermi* in southwestern of Burkina Faso

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ABSTRACT: The caterpillar of *Cirina butyrospermi* represents a food source in southwestern of Burkina Faso. The proximate composition, minerals, amino acids and fatty acids of this insect were investigated. The results showed that *Cirina butyrospermi* caterpillars contained high protein (62.74%) and moderated lipid (14.34%) contents. The low percentages of ash and chitin (around 5%) were observed for this caterpillar. Minerals were mainly represented by potassium (1160 mg/100g), and iron (12.97 mg/100g) was the predominant trace element. 47.64% of the total amino acids in *C. butyrospermi* were essential amino acids. Linolenic acid (35.82%) and stearic acid (35.40%) were the most abundant fatty acids. According to its nutritional value, the caterpillar of *Cirina butyrospermi* is a potential source of protein, fat and minerals for human and animal feeding.

KEYWORDS: *Cirina butyrospermi* caterpillar, proximate composition, amino acid, fatty acid, mineral.

1 INTRODUCTION

The majority of the hungry people live in developing regions. Africa remains the region with the highest prevalence of undernourishment [1]. The 2012 edition of The State of Food and Agriculture 2013 made a powerful case for investing in agriculture to reduce poverty and hunger [2]. However, aquaculture which is one of the most rapidly increasing food production systems in the world [3], uses high quantities of protein sources for fish feeding. In consequence, it is indispensable to investigate the alternative resources to replace conventional protein sources for human and cultured animals.

Lately insects have received wide attention as a potential alternate major source of protein [4], due to their nutritional content comparable to conventional livestock and fish. The crude protein content of insects ranges from 40 to 75% on dry weight basis, with beneficial amino acid profile, and a variable fat content [5]. Insects are also valuable sources of minerals and vitamins [6]. They have a high biodiversity with higher feed conversion efficiency than cattle [7], [5].

Insects constitute the most abundant multicellular organisms on planet Earth and are more than 70% of all species. Their actual number is believed to range from 2.5 and 10 million, but only one million species have been classified and named [8]. Within the insects orders; Coleoptera, Hymenoptera, Orthoptera, and Lepidoptera (caterpillars) represent 80% of edible species [9]. In the order of Lepidoptera, the family of Saturniidae takes the first place with 109 different species eaten by human [10].

Like *Cirina forda*, *Cirina Butyrospermi* (*Vuillet)* is a lepidopterous insect. They belong to *Cirina* genus and to saturniidae family. The occurrence of *Cirina* species mostly coincides with the expansion of the shea tree (*Vitellaria paradoxa*) [11], which grows across the African savannah landscape from Senegal to Uganda and Ethiopia [12]. In addition to *Vitellaria paradoxa, C. forda* feeds on leaves of *Eurytropheum suavelens* [13] and *Burkea Africana* [14], while C. *Butyrospermi* feeds exclusively on leaves of *Vitellaria paradoxa.* The caterpillars of this butterfly are harvested in the rain season (June to August) and marketed throughout the year in southwestern of Bukina Faso.

The caterpillars of *C. butyrospermi*, known as chitoumou in bôbô (local language), are eaten by people in Bobo-Dioulasso (southwestern town of Burkina Faso) and are successfully been used in layer nutrition [15]. According to [14], they contain 63% of protein and 14% of lipid. In spite of this caterpillar's wide consumption, the information on its nutritional composition remain fragmentary. In addition, given to its high protein quantity which is comparable to fish meal, its availability and less expansive price, *C. butyrospermi* caterpillar could be used as ingredient to substitute conventional protein sources in the feeding of carnivorous animals such as Catfish. So, more details on this caterpillar's nutritional quality are essential to envisage its utilization in local food for fish in order to reduce the production cost. The aim of the present study is to assess the amino acids profile, fatty acids pattern, and mineral composition of *C. butyrospermi* caterpillar.

2 MATERIALS AND METHODS

2.1 SAMPLE PREPARATION

Caterpillars of *Cirina Butyrospermi* were handpicked from sheabutter trees (*Vitellaria paradoxa)* directly from the trunk, from or under soil, and were transported to the laboratory for identity confirmation. They were washed, precooked at 100^{o}C and dried in an oven at 60^{o}C for 72 hours. Dried larvae were ground and stored for biochemical analysis.

2.2 PROXIMATE COMPOSITION, MINERAL, AMINO ACIDS AND FATTY ACIDS ANALYSING

Protein, lipid, moisture and ash contents were determined using method of [16]. Percentage of nitrogen free extract (NFE) was obtained by difference applying the formula: 100 % - (% protein + % lipid + % ash + % fiber). The chitin was determined according to [17]. The Gross energy was calculated on the basis of 4 Kcalg^{-1} for protein; 9 Kcalg^{-1} for lipid and 4 Kcalg^{-1} for carbohydrate [18].

Phosphorus (P) was determined colorimetrically using the Bausch & Lomb Spectronic 70 Electrophotocolorimeter, sodium bicarbonate was use as extractant [19]. Potassium (K) was determined using the standard flame emission photometer. Other minerals such as calcium (Ca), Magnesium (Mg), Iron (Fe), Manganese (Mn), Copper (Cu), Zink (Zn), Cadmium (Cd) and plumb (Pb) were estimated by Perkin-Elmer (model 403) atomic absorption spectrophotometer.

Amino acids of *C. butyrospermi* caterpillar meal were determined after preliminary acid hydrolysis of the sample in 6N HCl at 110 °C for 24 hours. The resulting hydrolyzate was filtered and injected to the HPLC (WATERS Alliance e2695) with fluorescence detection [20]. The HPLC operation was move phase A (1.39g Sodium acetate trihydrate/ 90 µg Triethylamine/ 1.5 ml Tetrahydrofuran/ pH: 7.2), move phase B (1.36 g sodium acetate trihydrate/ 200ml acetonitrile/200 ml MeOH /pH: 7.2), the rate flow was 1 ml/minute, detector: fluorescence λ excitation was 340 nm and λ emission was 450 nm. Tryptophan was not determined because of its destruction during acid hydrolysis.

Total lipid was extracted according to [21] for fatty acids analysis. Fatty acids were analyzed according to [22] by using a gas chromatograph (WATERS Agilent, model HP 6890N) coupled by mass spectrometer (Quattro micro GC, MICROMASS), with a split injector (1:10) at 250°C, a bonded silica capillary column (30 m x 0.25 mm x 0.25 µm, model DB5-MS) and non-polar stationary phase of 5%phenyl 95%methylpolysiloxane. Helium was used as the carrier gas (a constant velocity of 1.0 ml/min). The column temperature program started at 150°C, was firstly ramped at 1.3°C/min to 220°C, then from 220°C to 260°C at 40°C/min and held at 260°C for 5 min. Triplicate determinations were carried out in each case. Data were expressed as means ± SD (n=3).

3 RESULTS

The proximate composition of *Cirina butyrospermi* caterpillar is given in Table 1. This composition expressed on dry matter basis, revealed high level of crude protein (62.74%). The percentage of crude fat and carbohydrate were of moderate level (8-15%), while chitin and ash were low (around 5%). A total of ten minerals were estimated. The mineral analysis (Table 2) indicated high concentration of potassium (1160 mg/100g). The main trace element present in caterpillar of *C. butyrospermi* was iron (12.97 mg/100g). The heavy metals like lead and cadmium were not present in *C. butyrospermi* caterpillar. Table 3 showed the amino acid profile of *C. butyrospermi* caterpillar. 47.64% of the total amino acids in *C. butyrospermi* were essential amino acids. The predominant essential amino acid was lysine (6.13 g/100g protein). Concerning the non-essential amino acids, glutamic acid (13.28 g/100g protein) was the highest. The least amino acid was cysteine (1.24 g/100g protein). Seventeen fatty acids were detected in *C. butyrospermi* caterpillar (Table 4). The result indicated that *C. butyrospermi* contained high contents of saturated fatty acids (56.49%) and polyunsaturated fatty acids (40.56%), and low content of monounsaturated fatty acids (1.03%). The predominant saturated fatty acid was stearic acid while linolenic acid was the major polyunsaturated fatty acid.

Table 1. Proximate Composition Of Cirina Butyrospermi Caterpillar (g/100g dry weight)

Parameters	Composition
Dry matter	95.66 ± 0.26
Crude Protein	62.74 ± 0.43
Crude lipid	14.51± 0.11
Chitin (Fiber)	5.02 ± 0.09
NFE (carbohydrate)	12.63 ± 0.21
Ash	5.10 ± 0.15
Energy (Kcal/100g)	432

NFE: Nitrogen Free Extract, data are mean values ± SD (n=3)

Table 2. Mineral Composition Of Cirina Butyrospermi Caterpillar (mg/100g)

Minerals	Composition
P	390 ± 12
K	1160 ± 2.08
Ca	0210 ± 0.57
Mg	169 ± 1.53
Fe	12,97 ± 0.06
Mn	0,55 ± 0.01
Cu	0,13 ± 0.00
Zn	1,88 ± 0.01
Cd	0
Pb	0

Data are mean values ± SD (n=3)

4 DISCUSSION

The moisture content of 4.34% obtained in *C. butyrospermi* caterpillar was inferior to the value of 5.40% observed by [23] for the larva of *C. forda*, and was also lower than that reported for dry caterpillars [24]. This difference could be attributed to the drying method (sun-drying or oven-drying). Indeed, the caterpillars are harvested in the rainy season when the sun is not always available. Like this, sun-drying could slow the drying and also change the nutritional quality of the caterpillars. The low moisture obtained in this work reveals that dry caterpillars of *C. butyrospermi* can be stored for a long period without deterioration and spoilage. The crude protein percentage of *C. butyrospermi* caterpillar in this work (62.74%) was similar to 63% obtained for the same species by [14]. This protein content was higher than the values of 20.2%, 48.70% and 52.39% obtained respectively by [25], [26] and [27] for *Cirina forda*. It was not within the range of 15 to 60% reported for various forms of edible insects of Lepidoptera order from the state of Oaxaca Mexico [28]. Furthermore, protein, lipid and ash contents were within the range established for tropical Africa Saturniidae by [29]. The variations in the biochemical composition of insects may be due to the host tree, because the amounts of protein, fat, carbohydrate vary by species of insects and within the same species according to the nutritional qualities of the host tree's leaves [25], since insects have high feed conversion efficiency [5, 7]. Chitin is a major crude fiber in insects [30]. The chitin percentage of *C. butyrospermi* was lower than the values of 9.4% and 9.35% respectively observed for *C. forda* [28], [31] and for *Zonocerus variegatus* [32]. However, the chitin quantity in this study was higher than that obtained by [33] for silkworm's larvae (66.6 mg/Kg). Indeed, the chitin composition of insects varies among species and development phases [34]. For example, soft-bodied insects like silkworm larvae contain less chitin [35]. The amount of energy of food depends primarily on its lipid, protein and carbohydrate contents. The energy calculated for this caterpillar is 432 Kcal/100 g. This value was higher than the energy value of 387 Kcal/100g obtained for *C. forda* [23].

The ash content is indicative of the mineral content [5]. *C. butyrospermi* caterpillar was rich in essential minerals such as potassium, calcium, phosphorus and iron. The potassium, calcium and phosphorus contents observed for *C. Butyrospermi* were higher than those of *C. forda* which were respectively 65.04, 32.24 and 111.0 mg/100g [23]. The phosphorus content of 543 mg /100g for *Imbrasia belina* [35] was higher than that observed for *C. butyrospermi,* while the amount of potassium and calcium which were respectively 1032 and 174 mg/100g remained below to the values observed in this study. The value of iron obtained in this work is quite similar to the value of 12.85 mg/100g reported for *C. forda* [22], but inferior to the value of 31 mg/100g observed for *Imbrasia belina* [36] and higher than that of beef meat (6 mg/100 g) [37]. This variation may be due to differences in geographical locations and in dietary habits of insects, since the mineral contents reflect the animal's food sources.

One criterion to define protein quality is the amino acid composition [38]. Except arginine, threonine and serine which were lower, the amino acids pattern reported here was within the range established for tropical Africa Saturniidae by [29]. The percentage of essential amino acids in total amino acids determined for *C. butyrospermi* was 47.64%, and the ratio of essential amino acids to non-essential amino acids was 0.91. These values met the reference values of 40% and 0.6 recommended by [39]. This percentage was higher than the value of 44.97% reported for *C. forda* [23] but was inferior to the value of 53.99% obtained for *Imbrasia truncate* [40]. The percentage of savory amino acids (i.e., aspartatic and glutamic acids) of 29.83% was superior to the value of 23% observed for silkworm [41], while the percentage of sweet amino acids (i.e., glycine and alanine) of 11.67% was similar to the value of 12% obtained for silkworm by the same authors.

Table 3. Amino Acid Composition Of Cirina Butyrospermi Caterpillar (g/100g Protein)

Amino acids	Composition
Arginine	4.86 ±1.02
Histidine	2.80 ± 0.29
Isoleucine	3.11 ± 0.47
Leucine	4.08 ± 0.72
Lysine	6.13 ± 1.03
Methionine	1.58 ± 0.21
Phenylalanine	3.45 ± 0.31
Threonine	2.31 ± 0.39
Valine	5.22 ± 0.34
Alanine	5.59 ± 0.81
Aspartic acid	7.28 ± 0.66
Cysteine	1.24 ± 0.41
Glutamic acid	13.72 ± 2.51
Glycine	2.63 ± 0.25
Proline	3.18 ± 0.33
Serine	1.66 ± 0.20
Tyrosine	1.55 ± 0.32
TEAAs	33.54
%TEAAs	47.65
TNEAAs	36.85
% TNEAAs	52.35
Ratio of TEAAs/TNEAAs	0.91

TEAAs: Total Essential amino acids; TNEAAs: Total Non-essential amino acids, data are mean values ± SD (n=3)

Table 4. Fatty Acid Composition Of Oil Extracted From Cirina Butyrospermi Caterpillar

Fatty acids	Composition
Lauric acid (12:0)	0.08 ± 0.01
Myristic acid (14:0)	0.60 ±0.03
Myristoleic acid (14:1)	0.46 ± 0.06
Pentadecylic acid (15:0)	0.28 ± 0.06
Palmitic acid (16:0)	17.94 ± 0.53
Margaric acid (17:0)	1.33 ±0.12
Stearic acid (18:0)	35.40 ± 1.90
Arachidic acid (20:0)	0.37 ± 0.04
Behenic acid (22:0)	0.03 ± 0.0
ΣSaturated fatty acids	56.49
Palmitoleic acid (16:1)	0.29 ±0.03
Margaroleic acid (17:1)	0.19 ± 0.02
Oleic acid (18:1)	0.41 ± 0.05
Gadoleic acid (20:1)	0.14±0.02
ΣMonounsaturated fatty acids	1.03
Linoleic acid (18:2)	4.5 ± 0.19
Linolenic acid (18:3)	35.82 ± 3.45
EPA (20:5)	0.17 ± 0.06
DHA (22:6)	0.07 ± 0.03
ΣPolyunsaturated fatty acids	40.56
Unknowns	1.92 ± 0.43

Data are mean values ± SD (n=3)

The high quantity of lysine obtained in this study is in disagreement with [42] who reported that tryptophan or lysine are the first limiting amino acids in the majority of edible insects. Some edible insects like crickets [43], [44] and lepidopterous species [45] were deficient in methionine, cyteine and lysine. Our results corroborate those of the above authors regarding the content of methionine and cysteine.

Insects are the considerable sources of fat. The composition of fatty acids differed among insects, even among those within the same taxonomic family [37] and within the same species according to the development phases. The percentages of saturated fatty acids (56.49%), monounsaturated fatty acids (1.03%) and polyunsaturated fatty acids (40.56%) of caterpillar of *C. butyrospermi* differed to the respective values of 31.6%, 14.6% and 54.8% obtained by [46] for *C. forda*. In this work, linolenic acid (35.82%) which is essential fatty acid, stearic acid (35.40%) and palmitic acid (17.84%) were the most abundant fatty acids. While, the predominant fatty acids for *C. forda* were linolenic acid (45.5%), stearic acid (16.0%) and oleic acid

(13.6%) [46]. Concerning *Imbrasia oyemensis* which also belongs to the Lepidoptera order, palmitic acid (45.97%), oleic acid (34.62%) and linoleic acid (11.22%) were the most abundant fatty acids [47].

5 CONCLUSION

The present study showed that the caterpillar of *C. butyrospermi* was a nutritious insect with high protein, moderate content of lipid, low percentage of chitin and ash. This caterpillar is rich in essentials amino acids, in essentials fatty acid, and in minerals like potassium and iron. Therefore, the caterpillar of *C. butyrospermi* is a potential source of protein, fat and minerals for humans and animals. Nevertheless, subsequent researches should evaluate eventual variations on *C. butyrospermi* nutritional qualities according to the ecology conditions (location) of the host tree, to the processing and harvesting methods. Moreover, the anti-nutritional factors of this insect could be investigated.

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