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Variations in Chemical Composition Value of Adults and Nymphs Desert Locust, *Schistocerca gregaria* Forskal (Orthoptera: Acrididae)

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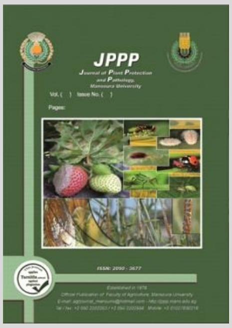

ABSTRACT

Recently, interest in the benefits of insects for food and feed has increased, while desert locusts are rich in nutrients and can be easily grown sustainably, even though locusts classified as pests that ruin crops. This study aims to investigate the chemical content, nutritional content and amino acid (AA) profile in adults and nymphs of the desert locust *Schistocerca gregaria* Forskal (Orthoptera: Acrididae), such as crude protein (CP), crude fat (CF), total carbohydrate (TC), crude fiber (CF), ash, gross energy and minerals content. The analysis indicates that the presence of crude protein, crude fat, total carbohydrate, crude fiber, ash, dry matter and moisture content were (56.79 and 65.92%), (28.82 and 15.15%), (2.98 and 4.59%), (7.9 and 7.92%), (3.51 and 6.42%), (42.34 and 32.46%), and (57.66 and 67.54 %), gross energy content was (498.45 and 418.37 kcal), respectively in adults and nymphs. Generally, the results in both adults and nymphs showed that non-essential AA were the dominant ones of AA, followed by essential then semi-essential AA. Minerals represented by P (87.44 and 91.35), K (6732.78 and 7826.96), Ca (33.8 and 50.7) and Mg (13.56 and 18.24) ppm in adults and nymphs, respectively.

Keywords: *Schistocerca gregaria; crude proteins; crude fats; total carbohydrate; fiber; ash and amino acid*

INTRODUCTION

As reported by the Food and Agriculture Organization (FAO) reports (FAO, 2010), in 2050 the world population is estimated at nine billion, this led to a rise of up to 70 % in global food supply relative to our existing food requirements. Traditional protein sources will not be adequate for the world population, so alternative solutions, like insects, will, therefore, be required. Insect consumption in many parts of the world is not a new concept. For thousands of years, human beings have consumed insects in some circumstances emergency, a staple, and delicacies. Insects are part of the conventional diet of at least two billion people worldwide. Evaluations of the figure of insect species that are consumable by people differ, but globally more than 1900 insect species have been recorded as edible in articles. Internationally, the most widely eaten insects are beetles Coleoptera 31%, caterpillars Lepidoptera 18% and bees, wasps and ants Hymenoptera 14%, grasshoppers, locusts and crickets Orthoptera 13%, cicadas, leafhoppers, planthoppers, scale insects and true bugs Hemiptera 10% termites Isoptera 3%, dragonflies Odonata 3%, flies Diptera 2% and other orders 5% (FAO, 2013). Insects usage can also help to decrease the harmful effects of domestic animal mass-production on the environment, as insects breeding takes up much less space and cause less contamination. Nevertheless, given all the ecosystem and nutritional benefits provided by entomophagy, insect foods are improbable to become a common alternative for dining in the short term. However, there is considerable potential to widen the market for edible insects by incorporating insect proteins into supplements, processed foods and animal feeds. Insects are highly nutritious as a food source and a valuable source of protein, fat, minerals, and nutrients. Certain species have the same or even more proteins than beef or fish. Most insects, particularly in larvae instar, are rich in fat and contain substantial ratios of AA and important minerals and vitamins. (FAO, 2010). *S. gregaria*, *Locusta migratoria*, L., *Nomadacris septemfasciata*, Serv. and *Locustana pardalina*, Wolker are usually edible in Africa. Like other insects, they are a significant provenance of food, contributing proteins and fats to the everyday diet, particularly in times of food disaster. Nevertheless, in many African countries, Middle Eastern and Asian countries, locusts are found tasty and consumed in plenty. From the year 2000, the growth of aquaculture in Africa and Asia has a quest for alternative protein sources so they examined locusts and grasshoppers for catfish and tilapia.

Many researchers have documented the nutritional properties of eatable insects such as (Elagba, 2015). Locust is considered to be edible and classified to be high in protein, dry matter, minerals and vitamins (Finke, 2002).

Required protein needs for adults every day, as defined by (The biennial expert consultations), are estimated at 0.72-0.75 gm/kg/day, or 10% of the daily energy intake, somewhat lower for females than for males (WHO/FAO/UNU 2004). FAO, (2010), reported that twenty AA are the essential structure of proteins that play a significant role in human metabolism. So eight AA are essential for adults and ten for children, the eight of the twenty standard AA, Threonine (Thr), Valine (Val), Methionine (Met), Isoleucine (Ile), Leucine (Leu), Phenylalanine (Phe), Lysine (Lys), and Tryptophan (Trp),

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are not synthesized by organisms, therefore, necessity is gained from nutrition as they are considered essential for natural growing and good healthiness.

The present research was undertaken to evaluate the chemical content, nutritional content and AA profile of the desert locust. *S. Gregaria* adults and nymphs were used to assess its nutritional value and to provide the justification for the usage of locust as food and feed.

MATERIALS AND METHODS

1. Mass rearing of insect and preparation

Mass rearing of *S. gregaria* was granted from the Department of Locust and Grasshopper, Plant Protection Research Institute, Agricultural Research Center (A.R.C.), Dokki, Giza, EGYPT, adults and nymphs were continually bred for many progeny under the conditions of the laboratory, as illustrated by (Vanden Broeck *et al*., 1998).

2. Sample preparation

All samples were dried in an oven at 58-60°C for 48-72h after removing of legs and wings. Dry samples were crushed then ground in an electrical grinder then stored in a plastic bag at 5°C until used.

3. Chemical analysis

The analyses of CP, CF, TC, CF, ash, gross energy, amino acids and minerals content were performed out at Agricultural Research Center (A.R.C.) calculated by the Association of Official Analytical Chemists AOAC (2012). Moisture determination was by drying method. The Energy values were calculated using the factors 4 for protein and total carbohydrate, but 9 for fat (Fox and Cameroon 1989).

4. Determination of minerals contents

Phosphorus, Potassium, Calcium, and magnesium, minerals concentrations were determined in dried samples; using Optima 2000 DV inductively coupled plasma spectrometer, (PerkinElmer). Concentrations were recorded based on calibration curves developed using inductively coupled plasma (ICP) (merk) standard in reference to AOAC. (2012).

RESULTS AND DISCUSSION

1. Chemical composition

Chemical analysis of desert locust, *S. gregaria*, adults and nymphs are shown in Table 1. It revealed that the highest quantity of CP, TC, ash, and moisture content was found in nymphs as 65.92%, 4.59%, 6.42%, and 67.54%, respectively and they were lowest in adults 56.79%, 2.98%, 3.51%, and 57.66%, respectively. But the reverse occurs in CF content and dry matter, represented by the highest percentage of 28.82% and 42.34%, respectively in adults and the lowest percentage of 15.15% and 32.46%, respectively in nymphs, also energy contribution was highest in adults than nymphs 498.45 and 418.37 Kcal, respectively; fiber content was 7.9 in both.

Table 1. Chemical analysis and energy in the total body homogenate of adults and nymphs desert locust, *S. gregaria* based on dry matter (g/100g of dry matter).

Parameters	Crude protein (%)	Crude fat (%)	Total Carbohydrate (%)	Crude fiber (%)	Ash (%)	Dry Matter (%)	Moisture (%)	Energy (kcal)
Adults	56.79	28.82	2.98	7.9	3.51	42.34	57.66	498.45
Nymphs	65.92	15.15	4.59	7.9	6.42	32.46	67.54	418.37

Zielińska *et al*., 2015, determined the content of nutritive value in adult locust *S. gregaria* protein, fat, fiber, ash and carbohydrate were 76, 12.97, 2.53, 3.33 and 1.7%, respectively and energy 432 kcal/100g. Also, Gibreil and Idris (1997) recorded that desert locust *S. gregaria* meal had higher crude protein (89 v. 45%), and energy (2714 v. 2000 kcal/kg) but lower carbohydrate (3.9 v. 4.8%) than super-concentrate diets broiler meal, while, Adeyemo *et al*., (2008) noted, the evaluation of desert locust meal in CP, TC, fiber and ash were 52.3%, 12%, 19% and 10% respectively of dry matter basis. Variation in the outcomes of several reviews of research might be due to the variations in instars development of locust species, and different seasons among the year when samples were collected, as well as, Cyprial (2014) reported that the effect of the seasons on locusts protein was 18.3% during the hot dry season and 96.7% during the rainy season as a non-conventional animal protein. The protein percentage was 76% in *S. gregaria*, much the same values for *S. histrio* 77% and somewhat lower for *Schistocerca* sp 61% were shown by Ramos-Elorduy *et al*., (1997). Elagba (2015) studied the chemical analyses of *Locusta migratoria* showed that the dry matter, CP, CF, TC, fiber, ash and moisture content were 96.2%, 50.42%, 19.62%, 4.78%, 15.65%, 6.24% and 3.8% respectively. Calories in the migratory locust were 490.8 Kcal/100g. As predicted, *L. migratoria*, as many insects, had small amounts of ash due to the absence of internal calcified skeleton presented in vertebrates. It is also documented that soft-bodied insects produce less fiber than hard exoskeleton insects, Finke (2008). Data correspond to five types of grasshoppers *Sphenarium histrio*, (Gerstaecker), *Sphenarium purpurascens* (Charpentier), *Taeniopoda eques*, (Burmeister), *Melanoplus femurrubrum*, (DeGeer) and *Schistocerca* spp in Mexico was in moisture from 35.29%-43.19% and dry matter from 56.81% -64.71% of dry matter basis. The determined protein content of grasshoppers was very high, from 62.5-77.25%; total fat was low in four species from 4.71-6.2%, except *S.* spp that content 16.0%; fiber from 7.08%-11.15%; and low TC was 6.66-9.59% (Virginia *et al*., 2015). Likewise Kehinde *et al.*, (2017) stated, the content of adult female *Zonocerus variegatus* had higher nutritional values than adult male in CP, dry matter, CF, ash, fiber and TC was 17.28 and 14.96, 38.35 and 33.04, 1.18 and 1.00, 1.05 and 0.91, 1.14 and 1.03 and 17.73 and 15.14 (g/100g) respectively. In contrary to our results, (Ademolu *et al.*, 2010) stated that the adult of *Zonocerus* contains a lower fat than the nymphes. (Ademolu *et al*., 2011) mentioned that the mature female of *Zonocerus* content importantly higher in CP, TC, CF and ash than the mature male contents, which mainly for reproduction and during the early somatic stage, the female mobilizes resources and nutrients in preparation of this energy-sapping process. In addition to Chapman (1990) who reported that the protein is also strongly required during egg maturation and vitellogenesis in females.

Rogelio *et al.,* (2019) evaluated the composition of *Schistocerca piceifrons*, Walker, (Orthoptera: Acrididae) in adults as follows: moisture, dry matter and protein content were 65.84%, 34.15% and 80.26% respectively, fat, ash and fiber content were 6.21, 3.35 and 12.56/100g basis on dry matter, respectively. Such results suggest using locust content to improve food products with higher nutritional value. Anand *et al*., (2008) found that Acridids provide continuous feed resources in animal nutrition. Grasshopper meal had 76% of CP, with high calories 4.7-7kcal/g, CF and TC were 6-7.5% and 3.6-7.5% respectively. Ghosh and Mandal (2019) revealed that the replacement of fish meal by grasshopper meal, *Oxya hyla hyla* in diets of *Labeo rohita* fingerlings did not have an effect on growth. Hence, the grasshopper maybe a novel protein-rich ingredient in the aqua-feed formulation, it has protein 64.67% of dry matter. Broilers fed on *S. gregaria* meal developed without any physiological disturbance. (Adeyemo *et al.,* 2008). Also, Nginya *et al*., (2019) reported that the grasshoppers *Ruspolia nitidula*, (Scopoli) known as 'nsenene', desert locusts *S. gregaria* and reared African grasshoppers *Acanthacris ruficornis* could be used as an alternative in poultry diets.

2. Mineral content of *S. gregaria*

Minerals content in the total body homogenate of adults and nymphs desert locust, *S. gregaria* showed in Table 2. Results in Table 2 demonstrated that the content of the following minerals for adults and nymphs of desert locust, *S. gregaria* which were lower in adults than nymphs in P (87.44 and 91.35), K (6732.78 and 7826.96), Ca (33.8 and 50.7) and Mg (13.56 and 18.24) ppm respectively, compared with recommended daily intake by WHO, (WHO/FAO/UNU, 2004).

Table 2. Mineral content in the total body homogenate of adults and nymphs desert locust, *S. gregaria* based on dry matter.

Macro minerals (ppm)	Adult	Nymphs	Recommended daily intake (mg/day) for adults (WHO/FAO/UNU, 2004)
Phosphorus P	87.44	91.35	700
Potassium K	6732.78	7826.96	4700
Calcium Ca	33.8	50.7	1000-1300
Magnesium Mg	13.56	18.24	220-260

Zielińska *et al*., 2015, reported that the minerals have a significant role in biological developments. Micronutrient deficiencies, which are common in various developing countries, can have major adverse health consequences, contributing to impairments in growth, immune function, mental and physical development. The recommended dietary allowance (RDA) and adequate intake are generally used to quantify suggested daily intake of minerals. *S. gregaria* was significantly high in magnesium, and the mineral content was compared to (RDA) range of minerals for adults (mg/day). The content of *S. gregaria* from K, Mg and Ca was 749, 82, and 70 mg/100g dry weight respectively; in compared to (RDA) was K, Mg, and Ca was 4700, 220–260 and 1000–1300 mg/day respectively. (Kehinde *et al.,* 2017) reported that the body of adult males of *Z. Variegatus* had higher mineral content than the adult females body, Ca had the highest concentration in male compared to female (78.3 and 72.5) mg/100g respectively. But, (Ademolu *et al.,* 2017) results showed that the *Z. variegatus* at the adult stage in both males and females had high mineral composition with Ca. High Ca in females at this stage of development is due to the role of calcium in the egg formation. In contrary to Finke and Oonincx (2014) which found that grasshoppers are a poor source of calcium, because these insects do not have a mineralized skeleton. Elagba (2015) studied the minerals content in *L. migratoria*, high levels of phosphorus was 29.6 ppm of dry matter, while other minerals of barium, zinc, iron, copper, aluminum, manganese and boron had a range from 0.04 to 2.2 ppm of dry matter. Nevertheless, many insects had significant levels of macro-minerals. Insect mineral content may vary depending on the variability in food sources, seasons and populations of the same species living in the same general area. FAO (2010) reported that insects partially contain much more iron, zinc, and calcium than beef, pork, and chicken. Beef, pork and poultry have an iron content of 6, 1.5 and 1.2 mg/100g of dry weight, respectively, while the iron in *S. gregaria* was 8.38 mg/100g of dry weight.

3. Amino acid profile

Both adults and nymphs analyzed contained more than 55% protein. Protein characterization by amino acid profile revealed in Table (3), for adults and nymphs of the desert locust *S. gregaria*, it has the same results with (El-Shennawy, 2019) which is, the non-essential amino acids were the dominant ones of AA, followed by essential then semi-essential AA. In general, Table 3 shown the total concentration of amino acids in *S. gregaria*, was higher in nymphs than adults, total amino acids “essential, semi-essential and nonessential” was (16.27 and 15.40), (4.95 and 4.60), and (27.01 and 25.17) mg/100g protein respectively. Adults and nymphs of *S. gregaria* were examined to provide semi satisfactory levels of the necessary AA compared with the preschool and mature requirements indicated by the WHO/FAO/UNU pattern (WHO/FAO/UNU 1985 and WHO 2007). The essential AA can not be synthesized by the human body but can be supplied only by food (WHO, 2007 and Finke and Oonincx 2014). Also, Zielińska *et al*., (2015) observed that the highest component of the nutrient content of insects was proteins. But, the quality of the insect proteins compared with other animal and plant proteins have to be measured by the composition of AA. Anand *et al*., (2008) reported the grasshopper meal contains high proteins but low in AA. Contrary, (Wang *et al*., 2007) stated a higher AA profile in grasshoppers than a fish meal; the discrepancy can be attributed to differing in species, processing, and storage of grasshoppers. Phenylalanine plays an important role in many biochemical processes including the synthesis of neurotransmitters, thyroxine, and melanin (Stargrove *et al*., 2007).

Table 3. Concentration of amino acids (mg/100mg) in the total body homogenate of adults and nymphs desert locust, *S. gregaria*

	Amino acids	Nymphs		Adult		WHO/FAO/ UNU 1985.		Amino acid requirements in humans who 2007
		AA conc.	%	AA conc.	%	Pre-school	Adult	
Essential	Threonine (THR)	2.04	12.55	1.80	11.67	3.4	0.9	2.3
	Valine (VAL)	3.32	20.4	3.09	20.09	3.5	1.3	3.9
	Methionine (MET)	0.85	5.22	0.94	6.10			1.6
	Isoleucine (ILE)	2.13	13.12	2.09	13.59	2.8	1.3	3.0
	Leucine (LEU)	3.54	21.79	3.53	22.97	6.6	1.9	5.9
	Phenylalanine (PHE)	1.6	9.82	1.45	9.42	-	-	-
	Lysine (LYS)	2.78	17.1	2.49	16.16	5.8	1.6	4.5
	Sum	16.27	-	15.40	-	24.6	7	21.2
	Average	2.32	-	2.25	-	4.1	1.4	3.5
Semi-essential	Histidine (HIS)	1.21	24.41	1.11	24.12	1.9	1.6	1.5
	Arginine (ARG)	2.75	55.54	2.55	55.28	-	-	-
	Cystine (CYS)	1	20.05	0.95	20.60	-	-	6.0
	Sum	4.95	-	4.60	-	-	-	-
	Average	1.65	-	1.54	-	-	-	-
Nonessential	Aspartic acid (ASP)	3.9	14.45	3.47	13.76	-	-	-
	Serine (SER)	2.07	7.67	1.75	6.92	-	-	-
	Glutamic acid (GLU)	5.85	21.67	5.13	20.35	-	-	-
	Glycine (GLY)	2.77	10.26	2.59	10.30	-	-	-
	Alanine (ALA)	6.68	24.72	7.03	27.97	-	-	-
	Tyrosine (TYR)	2.59	9.62	2.16	8.59	-	-	-
	Proline (PRO)	3.14	11.61	3.04	12.10	-	-	-
	Sum	27.01	-	25.17	-	-	-	-
	Average	3.86	-	3.60	-	-	-	-

conc.= concentration

Compared with the standard (WHO/FAO/UNU 1985)

Zielińska *et al*., 2015, determined the amino acid in *S. gregaria*, Ile, Leu, Lys, Met, Cys, Phe, Tyr, Thr, Val, His, Asp, Ser, Glu, Pro, Gly, Ala and Arg were 28.2, 77.7, 35.1, 8.2, 3.6, 18.7, 3.31, 35.5, 56.6, 20.6, 66.1, 33.7, 107.5, 67.1, 49.4, 88.8, and 39.8 in mg/g protein. In addition to, (Gibreil and Idris 1997) recorded that the amino acids profile of locust meal *S. gregaria* contained Arg, Gly, His, Leu, Ile, Lys, Phe, Thr, Tyr and Val were 2.76, 3.5, 0.98, 3.39, 2.21, 1.97, 1.51, 1.81, 3.11 and 3.26% of dry matter. The Lys acid was lower in *M. femrrubrum* D, while, Glu acid was high and has a significant role in nutrition in all species of *S. purpurascens* Ch; *T. eques* B; *M. femurrubrum* D; *Schistocerca* spp except *S. histrio* S. (Virginia *et al*., 2015). Insect proteins seem to be poor in Met and Cys, but high in the others, especially Lys and Thr. (Zielińska *et al*., 2015) reported that the content of AA indicated by others researchers are diverse and mostly presented as an average for an order of insects, because of their abundance, many species have not been examined. Also, it should be mentioned that because the methods used could differ and some studies may not define the stage of growth or physiological status of the individuals under-examined, there is some challenge in comparing these outcomes with others. It can be assumed that insects in general and the species analyzed in special are rich in proteins and represent a valuable alternative protein source. In addition, the species investigated offer satisfactory rates of the desired essential AA.

CONCLUSION

The results indicated that the quantity of nutritional value in desert locust *S. gregaria,* adults and nymphs, which might be considered as a good potential source for food and feed. The hygienic practices are required and must apply. Spreading by the insecticides should be avoided, harvesting insects for humans, poultry and fish, caused to decreases the use of insecticides, leads to limit the use of hazardous chemicals, hence exposure to food and feed to chemicals. Extra examination of the nutritive composition such as fatty acids, micro minerals, and vitamins should be undertaken for real evaluations.

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تغيرات قيم المحتوى الكيميائي في الحشرات الكاملة والحوريات للجراد الصحراوي ***Schistocerca gregaria*, Forskal (Orthoptera: Acrididae)**

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في الآونة الأخيرة، ازداد الاهتمام بفوائد الحشرات في الغذاء والأعلاف، على الرغم من ان الجراد الصحراوي غني بالمواد المغذية ويمكن اكثاره بسهولة الا انه يتم تصنيفه على أنه من الآفات المدمرة للمحاصيل. تهدف هذه الدراسة إلى فحص التركيب الكيميائي، المحتوى الغذائي والاحماض الامينية للجراد الصحراوي (*Schistocerca gregaria* Forskal (Orthoptera: Acrididae في كل من الحشرات الكاملة والحوريات، مثل البروتينات والدهون والكربوهيدرات والالياف والرماد والطاقة والاحماض الامينية والمعادن. تشير التحاليل إلى أن محتوى الحشرة من البروتين كان (56.79 و65.92٪)، ومن الدهون (28.82 و15.15٪) ومن الكربوهيدرات (2.98 و4.59٪)، ومن الألياف (7.9 و7.92٪)، ومن الرماد (3.51 و6.42٪)، من المادة جافة (42.34 و32.46٪)، ومن محتوى الرطوبة (57.66 و67.54٪)، ومن محتوى الطاقة (498.45 و418.37) من السعرات الحرارية في كل من الحشرات الكاملة والحوريات على التوالي. بصفة عامة اظهرت النتائج في كل من الحشرات الكاملة والحوريات أن النسبة الأكبر كانت للأحماض الامينية غير الضرورية، يليها الأحماض الأمينية الضرورية، فالشبه ضرورية. تم تمثيل المعادن بشكل أساسي من خلال الفسفور P (87.44 و91.35) والبوتاسيوم K (6732.78 و7826.96) والكالسيوم Ca (33.8 و50.7) والمغنيسيوم Mg (13.56 و18.24) (ppm) في كل من الحشرات الكاملة والحوريات على التوالي.