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Full Length Research Paper

Influence of drying method and location on amino acids and mineral elements of *Sternocera orissa* Buguet 1836 (Coleoptera: Buprestidae) in South Africa

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Influence of drying method and location on amino acid and mineral composition of African metallic wood boring beetle, *Sternocera orissa* Buquet (Coleoptera: Buprestidae), widely consumed in certain rural communities of Limpopo Province, South Africa was investigated. Randomised complete block design in a 3 × 3 factorial arrangement was used with three drying methods (oven-drying, freeze drying, locally method) and three locations (Khureng, Magatle, Ga-Masemola). The experiment was replicated three times. Relative to freeze-drying, oven-drying and cooking significantly increased essential and non-essential amino acids. Location did not have significant effect on the essential and non-essential amino acids of *S. orissa* across all the villages. Similarly, oven-drying and cooking increased potassium, phosphorus, iron, zinc and magnesium. Compared to locations, beetlesat Ga-Masemola had high amount of iron. Results of this study suggest that oven-drying and cooking improved the amino acids and mineral composition of *S. orissa*, which has the potential of enhancing nutrition nationally and internationally.

Key words: Amino acids, drying methods, location, *Sternocera orissa*, mineral elements.

INTRODUCTION

Drying as a preservation method is a very important aspect of food processing (Hassan et al., 2007) Common drying method includes sun-drying, food dryers, air-drying, and vacuum thermal-drying, oven-drying and freeze-drying. Oven-drying (Kaehler and Kennish, 1996; Robledo and Pelegrin, 1997) and freeze-drying (Norziah and Ching, 2000; Suzuki et al., 1996) are the two most widely used methods to preserve foods. The basic mechanism of oven-drying method is heating by hot-air convection (Wong and Chueng, 2001) at 65°C temperature to avoid adverse thermal reactions (Anderson, 1996). Freeze-drying was developed to overcome the problem of the loss of volatile compounds in food during conventional drying operations. Freeze drying is an effective method to extend the average lifespan of food given that it prevents the deterioration due to microbial growth or oxidation (Barbosa-Canovas and Vega-Mercado, 2000).

Drying could be an important factor affecting the nutritional value of insects either through chemical modifications or direct loss of mineral elements (Wong and Chueng, 2001). Amino acids are the building units of protein (Erasmus, 2001; Ihokoronye and Ngoddy, 1985) and serve as body builders (Bhavan et al., 2010). The biological value of food protein is dependent upon its amino acid composition (Finar, 1975; Oyenuga et al., 1974; Pant and Tulsiram, 1969; Williams, 1960).

The nature and chemical composition of essential amino acids give a particular food its protein status. Generally, high amino acid food is in high demand in South African rural communities, and sources of food

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with high amino acids are more attractive. The information on essential amino acid and nutrient element status of *S. orissa* is scanty. The objective of this study was to determine the influence of drying methods and location on amino acid and mineral elements composition of *S. orissa.*

MATERIALS AND METHODS

Study location/area

Beetles were harvested in summer November 2009 – January 2010 from randomly selected acacia trees, *Acacia campylacantha* at three locations: Khureng (24°33'53''S, 29°23'4''E), Magatle (24°27'19''S, 29°23'39''E) and Ga-Masemola (24°33'46''S, 29°38'57''E) in Limpopo Province, South Africa. The three locations have the same climatic conditions (semi-arid), with an average rainfall of 400 mm per annum and at 27°C. Soil type in Khureng and Ga-Masemola are predominately clay, Magatle is sandy.Vegetation types in Khureng and Magatle are predominantly bushveld and Ga-Masemola are mixed bushveld.

Experimental design and procedures

Harvesting was done between 5:00 and 6:30 in the morning, while beetles were still inactive on tree branches. The beating method (Holm, 1984) was used to dislodge beetles from branches. The beetles were picked from the ground and put in ventilated plastic bags and transported to the Limpopo Agro-Food Technology Station in cooler boxes and stored for three days in the refrigerator at -5ºC prior to processing (Finke et al., 1989).

Randomised complete block design arranged in a 3 × 3 factorial arrangement was used with three drying methods (freeze drying, heat drying, frying) and three locations (Khureng, Magatle, Ga-Masemola) were used as treatments with three replications. Thirty beetles from each location were defrosted at 28°C, with the elytra and wings removed and weighed the body. Oven-drying was done at 66°C temperature for 24 h, whereas freeze drying was done at pressure of 085 mtorrat -55°C for 24 h. Thirty beetles per treatment were cooked in 130-cm-diameter frying pan with 50 ml tapwater until all free water had evaporated and then fried without adding cooking oil. Beetles from all treatments were individually ground using a coffee grinder and sealed in plastic bags using the impulse sealant (KS-300 POWER 400 w, Source: 220 v 50 Hz, Hongzhan).

Data collection

The analysis of amino acids after acid hydrolysis extraction, pre-column derivatisation, separation by HPLC and detection by fluorescence was employed to determine the composition of proteins (De Vries et al., 1980; Einarsson et al., 1983). 0.5 g of beetles was digested with 7 ml concentrated HNO_3 and 3 ml $HClO_4$ at 200°C (Zasoski and Barau, 1977). For Ca, Mg, P, K, Na and Fe, an aliquot of the digested solution was subjected to Inductively Coupled Plasma-Optical Emission Spectrometric (ICP-OES), whereas selenium was determined by an inductively coupled plasma-mass spectrometry (Chao-Yong and Schulte, 1985).

Data analysis

Analysis of variance was performed using Statistix 8.1 software (Statistix, Analytic Software, Statistix; Tallahassee, FL, USA, 1985 -2003). Tukey Honestly Significant Differences (HSD) all – pairwise comparison test at 0.05 probability level was used to determine treatment differences among the means. When treatments were significant, the degrees of freedom and their associated sum of squares were partitioned to determine the percentage contribution of sources of variation to the total treatment variation (TTV) among the treatment means (Little and Hills, 1981).

RESULTS

Relative to freeze-drying, oven-drying method increased isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, tyrosine and valine by 227, 235, 227, 148, 218, 229, 235, 228 and 325%, respectively. Similarly, relative to freeze-drying, cooking method increased isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, tyrosine and valine by 47, 51, 66, 12, 31, 64, 82, 72 and 36%, respectively. However, location had no effect on essential amino acids. Relative to freeze-drying method, the cooking and oven-drying method increased the essential amino acids of *S. orissa* (Table 1).

Relative to freeze-drying, oven-drying method increased alanine, arginine, aspartic acid, glycine, glutamic acid, histidine, proline and serine by 208, 222, 185, 239, 198, 135, 236 and 216%, respectively. Similarly, relative to freeze-drying, cooking method increased alanine, arginine, aspartic acid, glycine, glutamic acid, histidine, proline and serine by 43, 32, 78, 49, 74, 37, 33 and 38%, respectively. However, location had no effect on non-essential amino acids. Relatively to freeze-drying method, the cooking and oven-drying methods increased the non-essential amino acids of *S. orissa* (Table 2).

Relative to freeze-drying, oven-drying method increased calcium, chlorine, cobalt, copper, iron, magnesium, manganese, phosphorus, potassium, selenium, sodium and zinc by 158, 132, 195, 182, 147, 165, 171, 156, 101, 143, 180 and 88%, respectively. Similarly, relative to freeze-drying, cooking method increased calcium, chlorine, cobalt, copper, iron, magnesium, manganese, phosphorus, selenium, sodium and zinc by 71, 46, 496, 50, 74, 32, 22, 36, 37, 85 and 81%, respectively. However, in most instances, location had no effect on essential nutrient elements except for iron (Table 4). Relative to freeze-drying method, the cooking and oven-drying method increased the essential nutrient elements of *S. orissa*, except for potassium that was reduced by cooking (Table 3).

DISCUSSION

Relative to freeze-drying, oven-drying and cooking methods increased aspartic and glutamic acid, which is in agreement with finding of seaweed by Mabeau et al. (1992) and Wong and Chueng (2001). Wilson and Walker (2000) reported that the hydrolysis procedure destroys or

Table 1. Composition (g/100 g) of essential amino acids in *Sternocera orissa* as affected by freeze, cooking and oven drying methods.

Essential amino acid	Drying method[y]			Relative to freeze method (%)[z]	
	Freeze	Cooking	Oven	Cooking	Oven
Isoleucine	0.73[b]	1.07[b]	2.39[a]	47	227
Leucine	1.14[b]	1.72[b]	3.82[a]	51	235
Lysine	0.94[b]	1.56[b]	3.08[a]	66	227
Methionine	0.25[b]	0.28[b]	0.62[a]	12	148
Phenylalanine	0.51[b]	0.67[b]	1.62[a]	31	218
Threonine	0.59[b]	0.97[b]	1.94[a]	64	229
Tryptophan	0.17[b]	0.31[ab]	0.57[a]	82	235
Tyrosine	0.46[a]	0.79[a]	1.51[a]	72	228
Valine	0.61[b]	0.83[b]	2.59[a]	36	325

[y] = Row means followed by the same letter were not different according to Tukey honest significant difference test at the probability level of 5 %. Impact[z] = Relative to freeze method = [(treatment/Freeze – 1) × 100].

Table 2. Composition (g/100 g) of non-essential amino acids in *S. orissa* as affected by freeze, cooking and oven drying methods.

Amino acid	Drying method[y]			Relative to freeze method (%)[z]	
	Freeze	Cooking	Oven	Cooking	Oven
Alanine	1.09[b]	1.56[b]	3.36[a]	43	208
Arginine	0.93[b]	1.23[b]	3.00[a]	32	222
Aspartic acid	0.95[a]	1.69[a]	2.71[a]	78	185
Glycine	0.94[b]	1.40[b]	3.19[a]	49	239
Glutamic acid	1.49[a]	2.60[a]	4.45[a]	74	198
Histidine	0.46[b]	0.63[b]	1.48	37	135
Proline	1.03[b]	1.38[b]	3.46[a]	33	236
Serine	0.62[b]	0.86[b]	1.96[a]	38	216

[y] = Row means followed by the same letter were not different according to Tukey honest significant difference test at the probability level of 5 %. Impact[z] = Relative to freeze method = [(treatment/Freeze – 1) × 100].

chemically modifies the asparagines, glutamine and tryptophan residues in protein. While asparagine and glutamine are converted to the corresponding acids (aspartic and glutamic acids) and are quantified with them and tryptophan is destroyed. That could have informed the lowest amounts of tryptophan in all drying methods and locations. Relative to freeze-drying, oven drying method increased lysine and leucine, which agreed with findings of (Ekpe et al., 2007) on bush mango seeds (*Irvingia gabonensis*). The increase in amino acid content after cooking and oven-drying observed might be due to the effect of anti enzyme on trypsin inhibition as explained by Ekpo (2006). Findings by Hackler et al. (1965) and Stilings and Hackler (1965) reported that heat-processing temperature and time may alter the nutritional quality of protein and its amino acids composition.

Relative to freeze-drying, oven drying increased proline content. This is in agreement with observations on blue-green algae (*Spirulina platensis*) by Divakaran and Duerr (1987). Histidine content was the lowest in all drying methods. Histidine is a very oxidation sensitive amino acid and that may be the reason for its reduction. Histidine is involved in many metabolic functions including production of histamines, which takes part in allergic and inflammatory reactions. It also plays role in osmoregulation process (Abe and Ohmama, 1987).

Drying methods significantly influenced the mineral concentrations (Tables 3 and 4). Relative to freeze-drying, oven-drying increased majority of minerals concentration (Table 3). The concentrations of minerals ranged from 0.20 mg/100 g (Cobalt) to 912 mg/100 g (Potassium). The high concentration of potassium confirms the findings of Hassan et al. (2007) on *Leptadenia hastata* (Asclipiadaceae).

Furthermore, Na/K ratios across the drying methods were very low (Figure 1), which is from nutrition point of view, since the intake of sodium chloride and diets with high Na/K ratio have been related to the incidence of hypertension (Zhou and Han, 2006). Oven-drying

Table 3. Mineral elements (mg/100 g) of *S. orissa* as affected by three drying methods, including, freeze-drying, cooking and oven-drying methods.

Nutrient element	Drying method^{y}			Relative to freeze method (%)^{z}	
	Freeze	Cooking	Oven	Cooking	Oven
Calcium	24.76^{b}	42.43^{ab}	64.00^{a}	71	158
Chlorine	42.08^{b}	61.44^{ab}	97.50^{a}	46	132
Cobalt	0.20^{c}	99.47^{a}	0.59^{b}	496	195
Copper	28.03^{b}	42.10^{ab}	79.13^{a}	50	182
Iron	48.72^{c}	84.81^{b}	120.40^{a}	74	147
Magnesium	39.01^{b}	51.42^{b}	103.33^{a}	32	165
Manganese	22.56^{b}	27.67^{b}	61.16^{a}	22	171
Phosphorus	249.37^{b}	339.55^{b}	639.00^{b}	36	156
Potassium	453.63^{b}	367.68^{b}	912.67^{a}	-18	101
Selenium	0.46^{b}	0.63^{b}	1.12^{a}	37	143
Sodium	34.58^{b}	64.03^{ab}	96.80^{a}	85	180
Zinc	60.87^{b}	110.40^{ab}	114.73^{a}	81	88

^{y} = Row means followed by the same letter were not different according to Tukey Honest significant difference test at the probability level of 5 %. Impact^{z} = Relative to freeze method = [(treatment/Freeze – 1) × 100].

Table 4. Mineral elements (mg/100 g) of *S orissa* as affected by three drying methods, including Khureng, Magatle and Ga-Masemola locations.

Nutrient element	Location^{y}			P ≤
	Khureng	Magatle	Ga-Masemola	
Calcium	34.76^{a}	56.24^{a}	40.18^{a}	ns
Chlorine	78.67^{a}	62.01^{a}	60.34^{a}	ns
Cobalt	99.42^{a}	0.57^{a}	0.27^{a}	ns
Copper	58.13^{a}	51.56^{a}	39.56^{a}	ns
Iron	80.36^{a}	78.02^{ab}	94.95^{b}	**
Magnesium	62.23^{a}	75.86^{a}	55.65^{a}	ns
Manganese	32.30^{a}	37.85^{a}	41.24^{a}	ns
Phosphorus	401.55^{a}	444.02^{a}	382.35^{a}	ns
Potassium	556.91^{a}	626.16^{a}	550.91^{a}	ns
Selenium	0.70^{a}	0.73^{a}	0.78^{a}	ns
Sodium	65.45^{a}	67.20^{a}	62.77^{a}	ns
Zinc	108.86^{a}	102.36^{a}	104.78^{a}	ns

^{y} = Row means followed by the same letter were not different according to Tukey Honest significant difference test at the probability level of 5 %; ns = significant at 10% level of probability.

the potassium and lowered sodium. However, higher potassium with low sodium is a protective effect against excessive sodium intake (Hassan et al., 2007). The high potassium level in the heat treated samples may be an added advantage over the freeze-dried samples for use as therapy and are vital for bone development (Dzomeku et al., 1993). Most of the trace elements (Fe, Cu, Zn and Se) present in adult *S. orissa* are for physiological functions (Liu, 1996). Relative to freeze-drying, oven-drying increased trace elements (Zn, Cu, Fe, Mn). Copper was found to be lower while Zn was found to be highest. This results tallies with the work of Teeny et al. (1984) and Akinneye et al. (2010) on different fish species. Zinc was relatively high upon oven-drying, which might be attributed to contamination from water as previously reported in other studies during drying process. Zinc is nutritionally important for its roles in immune system (Bhaskaram, 2002), for insulin secretion (Chausmer, 1998), in the release of vitamin from the liver (Hwang et al., 2002).

Conclusion

Conclusively, the results of this study suggest that oven-drying and cooking method improves the availability of

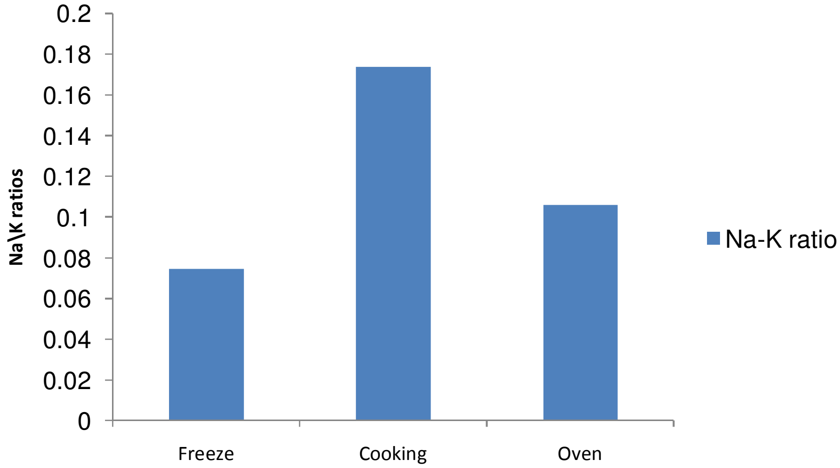

Figure 1. Na\ K ratio of adult *S. Orissa*.

amino acids and minerals of *S. orissa*. Oven-drying and cooking method has the potential of preserving amino acids and minerals of *S. orissa,* thus can contribute towards the reduction of malnutrition experienced in the rural communities of Limpopo Province.

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