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Food properties of common West African fresh water male and female crab

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ABSTRACT

Food properties (water, oil, oil emulsion and foaming capacities: WAC, OAC, OEC, FC; foaming and oil emulsion stabilities: FS, OES; least gelation concentration: LGC; protein solubility: PS) of common West African Fresh water crab (*Sudananautes africanus africanus*) were determined. Samples used were the soft flesh, exoskeleton and whole crab. In the flesh, levels of WAC, FC, OAC, OEC were better in female than in male; this type of consistency was not observed in exoskeleton and whole crab. In both sexes, LGC values were lower in the whole crab and exoskeleton than the flesh. Both FS and OES were low in all the samples. The rate of change of FS was lowest in female whole crab (0.54 min – 1) but highest in male exoskeleton (3.89 min – 1). OES was low in all samples and collapsed within four minutes. PS was female flesh > female exoskeleton > female whole crab > male flesh > male whole crab > male exoskeleton with 66.7% of samples showing two isoelectric points (pI).

Key words: Food properties, fresh water, male and female crab.

INTRODUCTION

A crab is characterized by a flattened, broad body covered by a shell or carapace. Crabs belong to the order Decapoda, class crustacean, phylum Arthropoda. The order Decapoda consists of two sub-orders (a) Natantia – the swimmers and (b) Reptantia – the crawhers. Reptantia includes the crabs, lobsters and hermit crabs. They have heavy legs that can support the body for crewing. True crabs are the most successful decapodas with about 4500 species[1]. Crabs are found throughout the world, chiefly in waters, but they also inhabit fresh water and land where they dig or inhabit burrows.

Several crabs are prized as food. They include the Alaska king crab (*Paralithodes camtschatica*); the blue crab (*Callinetes sapidus*), which is the commercially important crab occurring along the East and Gulf coasts of the United States of America[2]; the Dungenes crabs (*Cancer magister*) which are present in Europe – non-swimming crabs used as food[2]; and the giant mangrove swimming crab (*Sayllia serrata*) which is popular in pacific waters from the East coast of Africa to India and as far away as Japan[3].

The crab is usually consumed by individuals and it is often recommended for pregnant women. Literature is available on the chemical composition of the nutritionally valuable parts of male and female common West African fresh water carb, *Sudananautes africanus africanus*[4]. There is also information on the amino acids profile of *S. africanus africanus* male samples[5]. The study being reported in this article deals with an attempt to assess the food or functional properties of the whole body (edible parts), flesh and exoskeleton of the male and female common West African fresh water crab, *S. africanus africanus* caught at the same time within the same environment.

MATERIAL AND METHODS

Collection and Treatment of Sample

Sudananautes africanus africanus samples were collected from the banks of River Osun, located at Ikere Ekiti, Ekiti State, Nigeria during the onset of the rainy season (they normally hibernate in the dry season). Six pieces of matured freshly caught crabs were selected from more than 12 crabs caught in holes along the river banks. The samples were stored under freezing at-10°C.

Two whole crabs were separated fresh. While the internal organs were discarded, the other separated parts were dried in the oven at 105°C. For the purpose of analysis, the separated parts were carapace and cheliped exoskeleton (which constitute the exoskeleton sample) and the muscle from thoracic sterna and cheliped (which constitute the flesh sample). For the whole body sample, the following constituted it: cheliped (muscle and exoskeleton) carapace, thoracic sternum and the other four pairs of walking legs and then dried at 105°C. The samples: whole body, exoskeleton and the flesh were separately blended.

Determination of food properties

The protein solubility was examined from pH 1-2 by the method of Adeyeye *et al* [6]. The sample (0.2g) was thoroughly stirred with distilled water (10ml) at room temperature and the pH was adjusted either with 0.1M HCl or 0.1M NaOH. Insoluble materials were removed by centrifuging for 30min at 3500 rpm. The nitrogen content of the supernatant liquid was determined by the micro-Kjeldahl method[7] and the protein was taken as N% x 6.25. The protein solubility was taken as the % of the protein in the original sample present in the supernatant layer. The foaming capacity (FC) and foaming stability (FS) were measured by the method of Coffman and Garcia[8]: a 2% w/v solution (50nl) was homogenized for 1min in a Kenwood major blender at maximum speed and the contents were immediately poured into a graduated cylinder. FC was the foam volume immediately after mixing as a percentage of the starting volume. FS was the foam volume after standing for a given period of time as a percentage of the initial foam volume. Oil and water absorption capacities were measured by the Sosulski[9] procedures; in the former, Avop vegetable oil was used. Oil emulsion capacity was determined by the procedure of Inklaar and Fortuin[10], as modified by Adeyeye *et al.*[6], and oil emulsion stability by the method of Beuchat[11]. The least gelation concentration was determined by the method of Coffman and Garcia[8]. All the results given are the means of triplicate determinations and both standard deviations and coefficient of variation percent were calculated[12]. All chemicals used were of BDH analytical grade.

RESULTS AND DISCUSSION

Table 1 shows some of the food properties of the flesh of the samples. The following parameters: water absorption capacity (WAC), oil

Table 1: Some food properties of the flesh of common West African fresh water crab

Property %	Flesh		Mean	SD[a]	CV%[b]
	Male	Female			
Water absorption capacity	190	193	193	3.54	1.84
Foaming capacity	12	14	14	2.83	20.2
Oil absorption capacity	186	205	205	26.2	12.8
Foaming stability	25(90min)	12.5(60min)	18.8	8.84	47.1
Oil emulsion stability	15(4min)	5(3min)	10	7.07	70.7
Oil emulsion capacity	55	63.2	59.1	5.80	9.81
Least gelation concentration	8	10	9	1.41	15.7

[a]SD = standard deviation

[b]CV% = coefficient of variation percent

absorption capacity (OAC) and oil emulsion capacity (OEC) were found to be of high levels; these high values also showed little variation among the flesh of the two sexes. For examples: the coefficient of variation percent (CV%) of WAC was 1.84, in OAC it was 12.8 and for OEC it was 9.81. The foaming capacity (FC) was low in both flesh samples but better in female (16.0%) than the male (12.0%) with a CV% of 20.2. The foaming stability (FS) was better in the male flesh with an FS value of 25% at 90min while the female flesh FS was 12.5% at 60min with a high value of CV% of 47.1. The oil emulsion stability (OES) was low in both samples but better in male (15% at 4min) than in the female (5% at 3min) with a high CV% of 70.7. The least gelation concentration (LGC) was also better in male flesh (8%) than in the female flesh (10%).

Table 2 contains the food properties shown in Table 1 for exoskeleton samples. The following parameters: WAC, FC, OAC, FS, OEC and OES were all generally lower in samples on pair wise basis. As observed in Table 1, WAC, OAC and OEC had CV% which were also low with respective values of 1.45, 17.9 and 7.44. The LGC in the exoskeleton was much better in the exoskeleton than in the flesh; in female LGC was 4.0%w/v and 2.0%w/v in the male. Generally in the exoskeleton, WAC, FC, OES and LGC were better in male than the female while it was vice versa for OAC, FS and OEC.

Table 3 depicts the functional properties of the whole crab. There was improvement in FC in the whole crab than both the flesh and the exoskeleton. The OAC fell within the earlier results in Tables 1

Table 2: Some food properties of the exoskeleton of common West African fresh water crab

Property %	Exoskeleton		Mean	SD	CV%
	Male	Female			
Water absorption capacity	98.6	96.6	97.6	1.41	1.45
Foaming capacity	9.0	6.0	7.5	2.12	28.3
Oil absorption capacity	128	165	147	26.2	17.9
Foaming stability	22.2(20min)	33.3(20min)	27.8	7.85	28.2
Oil emulsion stability	10(4min)	5.0(4min)	7.5	3.54	47.1
Oil emulsion capacity	45	50	47.5	3.54	7.44
Least gelation concentration	2.0	4.0	3.0	1.41	47.1

Table 3: Some food properties of the whole crab of common West African fresh water crab

Property %	Whole crab		Mean	SD	CV%
	Male	Female			
Water absorption capacity	96.4	78.0	87.2	13	14.9
Foaming capacity	14	17	15.5	2.12	13.7
Oil absorption capacity	145	147	146	1.41	0.97
Foaming stability	14.3(90min)	35.5(180min)	18.9	6.51	34.4
Oil emulsion stability	10(4min)	5(4min)	7.5	3.54	47.1
Oil emulsion capacity	50	55	52.5	3.54	6.73
Least gelation concentration	4.0	2.0	3.0	1.41	47.1

and 2. The FS in the male collapsed after 90min while the FS in female collapsed after best result in all the six samples. The LGC levels in the whole crab were the reverse of the results in the exoskeleton samples with 4.0%w/v in male and 2.0%w/v in the female but both recorded a CV% of 47.1.

The WAC levels in all the samples were lower than the levels reported for the edible parts of crickets with levels of 260% male and 240% female[13]; while the OAC levels in our current report were generally lower than the observed results in crickets, the levels of OAC in both female sexes were similar at a level of 223%. The FC in these results were better than in crickets (6.0 – 8.0%); the OEC levels were favourably comparable to those of crickets; both FS and OES in the current report were also favourably comparable to those in crickets but the current LGC results were all generally better than those in the crickets although its female LGC was 10%w/v[13], just like our result in the flesh. The WAC in *Zonocerus variegates* was 128%[14], sunflower flour (107%) and soya flour (130%)[15], so *S. africanus africanus* could be useful replacement in viscous food formulations such as soups or baked goods. The OAC in *Z. variegates* was 33.3%[14] which is much lower than our current report; 89.7% (pigeon pea), wheat and soya flours (84.2 and 84.4%

Table 4: Rate change in foaming stability of common West African fresh water crab flesh

Time (min)	Flesh		Mean	SD	CV%
	Male	Female			
0	100	100	100	0.0	0.0
5	83.3	97.5	90.4	10.0	11.1
10	66.7	75	70.9	5.87	8.28
20	66.7	62.5	64.6	2.97	4.60
30	50	31.3	40.7	13.2	32.5
60	33.3	12.5	22.9	14.7	64.2
90	25	-	-	-	-
120	-	-	-	-	-
Rate[a]	0.83	1.46	1.15	44.5	39.9

[a]Rate = Change min^{-1}

Table 5: Rate change in foaming stability of common West African fresh water crab exoskeleton

Time (min)	Exoskeleton		Mean	SD	CV%
	Male	Female			
0	100	100	100	0.0	0.0
5	66.7	97.5	90.4	10.0	11.1
10	33.3	75	70.9	5.87	8.28
20	33.3	62.5	64.6	2.97	4.60
30	-	-	-	-	-
60	-	-	-	-	-
90	-	-	-	-	-
120	-	-	-	-	-
Rate[a]	3.34	3.89	3.62	0.39	10.8

[a]Rate = Change min^{-1}

respectively)[15] which were both lower than our results but the levels of OAC in cowpeas (281- 310%)[16] were higher than our results. OAC is important as oil acts as a flavour retainer and improves the mouth feel of foods[17], so crabs products would be good samples for this property better than most of the materials cited. Among our samples, only the female whole crab had FS remaining uncollapsed after 120min with a value of 35.5%; most commercial products are stable for more than 2h. Consequently crabs would not be attractive for products like cakes or whipping toppings where foaming is important[18], this is with the exception of female whole crab. The OEC in wheat flour ranged from 7.0 – 11.0% and 18.0% in soya flour[15], so crabs might be useful in the production of sausages, soups and cakes[18]. However, since the OES were all generally low, this meant that the samples would be of little use in products that depend on the formation of stable emulsions. Also, since the LGC levels were generally better than in cowpea 10%[19] and pigeon pea 10%[18], crickets 10-12%[13], it means that crabs might provide better consistency to food body and be useful in cheese and curd makings[18].

The rate of change for foaming stability (FS) are shown in table 4 (flesh), table 5 (exoskeleton) and table 6 (whole crab). Male flesh was stable up to 90min with a rate change of 0.83%min^{-1} and in female flesh; FS collapsed after 60min and had a rate change of 1.46%min^{-1}.

Table 6: Rate change in foaming stability of common West African fresh water crab whole organism

Time (min)	Whole crab		Mean	SD	CV%
	Male	Female			
0	100	100	100	0.0	0.0
5	85.7	94.1	89.9	5.94	6.61
10	71.4	82.4	76.9	7.78	10.1
20	64.3	82.4	73.4	12.8	17.4
30	42.9	70.6	56.8	19.6	34.5
60	28.6	58.8	43.7	21.4	48.9
90	14.3	47.1	30.7	23.2	75.5
120	–	35.3	–	–	–
Rate[a]	0.95	0.54	0.75	0.29	38.9

[a]Rate = Change min^{-1}

Table 7: Rate change in oil emulsion stability of common West African fresh water crab flesh

Time (min)	Flesh		Mean	SD	CV%
	Male	Female			
0.0	100	100	100	0.0	0.0
0.5	100	40	70	42.4	60.6
1.0	45	25	35	14.1	40.4
2.0	35	15	25	14.1	56.6
3.0	25	5	15	14.1	94.3
4.0	15	–	–	–	–
Rate[a]	21.3	31.7	26.5	7.35	27.8

[a]Rate = Change min^{-1}

Table 8: Rate change in oil emulsion stability of common West African fresh water crab exoskeleton

Time (min)	Exoskeleton		Mean	SD	CV%
	Male	Female			
0.0	100	100	100	0.0	0.0
0.5	50	50	50	0.0	0.0
1.0	45	35	40	7.07	17.7
2.0	35	25	30	7.07	23.6
3.0	25	15	20	7.07	35.4
4.0	10	5	7.5	3.54	47.1
Rate[a]	22.5	23.8	23.2	0.92	3.97

[a]Rate = Change min^{-1}

Table 9: Rate change in oil emulsion stability of common West African fresh water crab whole organism

Time (min)	Whole crab		Mean	SD	CV%
	Male	Female			
0.0	100	100	100	0.0	0.0
0.5	45	44	44.5	0.71	1.59
1.0	35	32	33.5	2.12	6.33
2.0	25	25	25	0.0	0.0
3.0	15	15	15	0.0	0.0
4.0	10	5	7.5	3.54	47.1
Rate[a]	22.5	23.8	23.2	0.92	3.97

[a]Rate = Change min^{-1}

In Table 5, the FS collapsed after 20min for both male and female exoskeleton; this gave them a higher level of unstability with rate change of 3.34%min^{-1} (female) and 3.8%min^{-1} (male). Table 6 shows that foam collapsed after 90min for male whole crab while female foam collapsed after 120min; the rate change being 0.95%min^{-1} (male) and 0.54%min^{-1} (female). From results in Tables 4, 5 and 6, the trends in rate change could be arranged as follows: female (whole crab) < male (flesh) < male (whole crab) < female (flesh) < female (exoskeleton) < male (exoskeleton). The rates here were generally lower than the values reported for the African yam bean flour (hulled and dehulled seeds)[20].

The rate of change in the oil emulsion stability (OES) are shown in Table 7 (flesh), Table 8 (exoskeleton) and Table 9 (whole crab). Among the OES values, 83.3% collapsed after 4min while 16.7% (female flesh) collapsed after 3min. Despite the low level of stability, the rate of change was also much higher than in the foaming stability. Values of rate change ranged foam 21.3% min^{-1} to 31.7% min^{-1}. Here the trend of rate change was male (flesh) < male (whole crab) = male (exoskeleton) < female (exoskeleton) = female (whole crab) < female (flesh).

The effects of pH on the protein solubility (PS) of the samples are depicted in Figure 1 (male

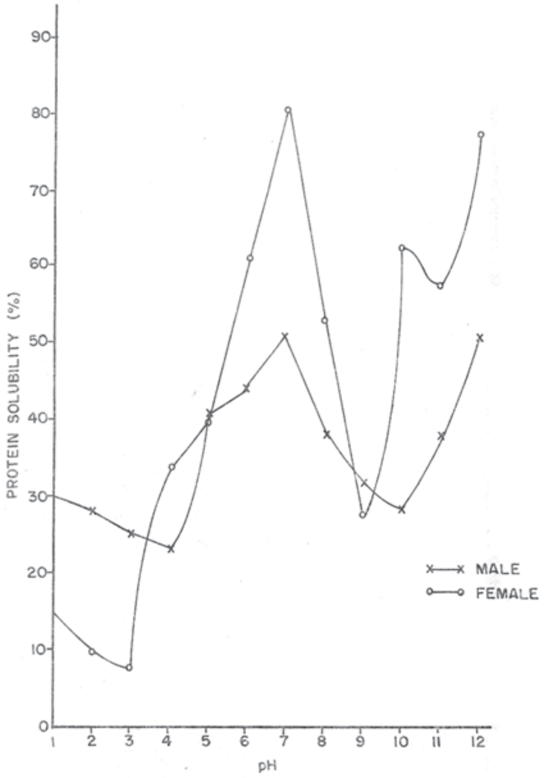

Fig. 1: Protein solubility of the flesh of common west African fresh water crab as a function of pH

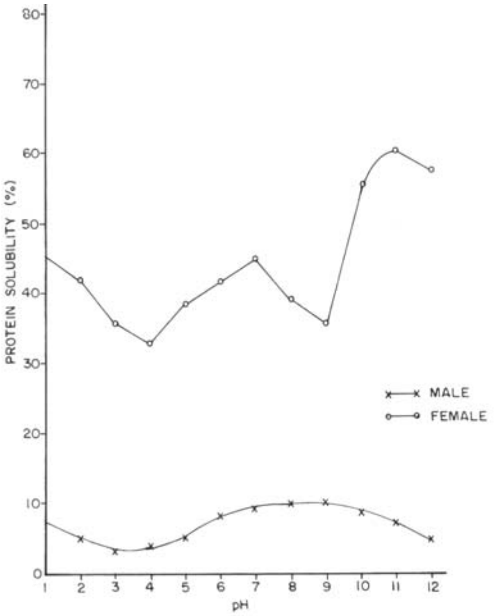

Fig. 2: Protein solubility of the exoskeleton of common west African fresh water crab as a function of pH

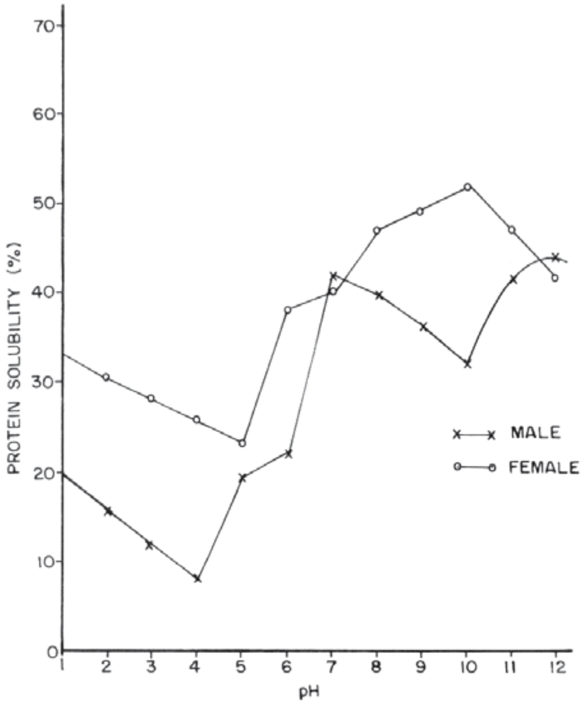

Fig. 3: Protein solubility of the whole crab common west African fresh water crab as a function of pH

and female flesh), Figure 2 (male and female exoskeleton) and Figure 3 (male and female whole crab). From Figure 1, the PS of female flesh was better than in the male flesh; while the highest PS in flesh of female was 81% it was 51% in the male flesh. Both have two isoelectric points: pH of 3.0 and 9.0 in female flesh and 4.0 and 10.0 in the male flesh showing a pI shift of one unit in both zones by the male flesh. The possession of two pI values in both samples could mean that both samples have two major protein units. These results resemble very perfectly the profile of PS in the reddish brown variety flour of African yam bean seeds[20] and male PS profile of cricket[13]. The PS values were generally lower in the acid region than the alkali region for both sexes; this was also observed in crickets[13]and *Z. variegates* (variegated grasshopper)[14]. The PS was still rising at pH 12 for both samples. The PS values in the current report were better than in the crickets (*Brachytrypes membranaceus*) and the variegated grasshopper. The high PS of crab flesh in both acid and alkali indicates that it may be useful in formulating carbonated beverages[21,22] and very low – acid foods such as meat products[16].

Figure 2 shows the PS profile of the exoskeleton of male and female crabs. The PS of male exoskeleton was much lower than those of the female exoskeleton. While highest PS value was 61% in the female exoskeleton, it was 11% in the male. The female exoskeleton showed two pI levels at pH 4.0 and 9.0. Unlike the flesh PS profile, the solubility started decreasing at pH 12. The profile of the PS of the male exoskeleton resembled the observation in the light brown with black patches dehulled seeds of African yam bean[20]. The female exoskeleton would be useful in carbonated drinks formulation.

Figure 3 shows the PS profile of the female and male whole crab samples. While the male showed two distinct pI at pH 4 and 10, the female only showed one pI at pH 5.0. The maximum PS for male was at pH 12 with a value of 44% while it was pH 10 with a value of 52% in the female. While PS started decreasing at pH 10 down to 12 in the female whole crab, it was increasing from pH 10 up to 12 in the male whole crab. Solubilities in the acid pH were lower than in the alkali pH for both samples. However both will be useful in formulating carbonated beverages as well as very low-acid foods.

CONCLUSION

The food properties of WAC, OAC, OEC, LGC and PS in common West African fresh water male and female crab (*Sudananautes africanus africanus*) were much better than most literature samples thereby making crabs useful in many food formulations.

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