UTILIZATION OF PRAWN HEAD POWDER IN ENHANCING THE NUTRITIONAL LEVELS OF SOME GHANAIAN SNACKS

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Summary

Studies on the use of prawn heads characterised as by-products of the prawn processing industry, to improve the nutrient contents of two Ghanaian snacks, namely, baked corn dough cake (*aboloo*) and fried cassava balls (*agblikaklo*) were carried out. Optimum conditions for dehydrating the prawn head wastes were determined and acceptable prawn head powder produced. The powder was incorporated into the snacks, which were assessed chemically and organoleptically. Microbiologically safe prawn head powders were produced by steaming raw prawn heads for 30 min, followed by drying at 70°C for 4 h, or by steaming for 30min, followed by drying at 50°C for 8h. Levels of 10 - 20% (w/w) prawn head powder in baked corn dough cake, with protein contents significantly increased from 7.3% dry weight to 9-14%, were most acceptable. Fried cassava dough balls with levels of 5 - 8% (w/w) of prawn head powder and significantly increased protein content from 1.5% to 6 - 8% (dry weight), produced an acceptable product.

Introduction

Prawn heads, one of the main by-products of the prawn processing industry, poses a potential disposal and environmental problems. Providing about 20% of the total marine trade (Helga, 1990), with potential for increase in world production, the world prawn industry generates, through processing, by-products that constitute between 40-80% of the initial weight of the prawn, depending on the species, processing method and location of processing (Carawan *et al.*, 1979). Hand peeling alone is estimated to produce about 30 - 40% of prawn head by-products, which are discarded as waste (Meyers, 1986).

These by-products deteriorate rapidly at ambient temperatures, especially in the tropics, as a result of both biochemical and microbiological reactions, leading to disposal and environmental problems (Green and Mattick, 1977).

Prawn heads contain high amounts of protein, estimated at about 50% dry weight basis (Meyers, 1986) as well as minerals, carotenoid pigments, amino acids and nucleotides (Chawan and Gerry, 1974). Chitin (11-27%), another major component (Meyers, 1986), from which chitosan is produced (Bough, 1977), has great potential in medicine (Knorr, 1984) and biotechnology (Stephens *et al.*, 1976).

Current research studies have shown the possibility of including prawn by-products as protein sources in foods for animals (Chawan and Gerry, 1974; Barratt and Montano, 1986), as well as for humans (Knorr, 1986; Lekshmy Nair and Prabhu, 1989; Narkviroj and Buckle, 1987).

Ghana and other West African countries produce substantial quantities of prawns for export and a large domestic market. Future developments in the prawn industry in Ghana, could lead to the generation of a large amount of by-products, especially prawn heads. These prawn heads could, however, be used to enhance some local Ghanaian snacks, which by nutritional standards, are lacking in basic nutrients.

Two such snacks are fried cassava dough balls, known as *Agblikaklo* locally, and baked corn dough cake or *Aboloo*. The aims of this study, therefore were to:

(a) Prepare from prawn head waste a dried powder that is shelf stable.
(b) Develop nutritionally enhanced *Agblikaklo* and *Aboloo*, using prawn head powder.

Materials and Methods

Sample Preparation

Frozen brown tiger prawn (*P. Esculentus*) heads (5-7 cm long) from commercial operations at Markwell Pacific pty Ltd, Tweed heads, NSW, Australia, were held at -20°C in the laboratory until analysed or processed.

Prawn heads were thawed at ambient temperature for 20 min and washed in running tap water for 10min and the following treatments were applied to the prawn heads to obtain 3 different powders.

1. Thawed prawn heads were steamed at 100°C for 30 min and dried for 4h at 70°C (dry bulb temperature) and a final relative humidity of 28%. The dried prawn heads were ground to a fine powder, using mesh gauge number NOOO.
2. Prawn heads were initially treated as in 1, then dried for 8 h at 50°C and a final relative humidity of 48%. These were comminuted as in 1.
3. Thawed Prawn heads were dried for 10 h at 50°C with a final relative humidity of 38% and comminuted as in 1 and 2.

All the preparations were stored in glass bottles at an ambient temperature of 20 - 25°C for further studies or used in the formulation of the snacks.

Chemical Analysis

Water activity (Aw) for the Prawn head powders were determined with a Vaisala Humidity and Temperature Indicator in a sealed glass jar (Anon. 1989).

For Proximate analysis, moisture was determined by method number 934.01 of AOAC (1990). Crude protein content was by a Kjeldahl method using Kjeltec Auto-system (Anon. 1983). Fat by AOAC (1990) and Ash by a slightly modified method 942.05 of AOAC (1990) in which samples were charred overnight on a hot plate before placing in a preheated muffle furnace for 2 days at 550°C.

Carbohydrate was computed as difference from the total of the levels of moisture, fat, crude protein and ash. The chitin content was determined using the method of Spinell *et al.* (1974). Calcium was determined using AOAC (1990) method number 965.09 C(b). Phosphorus was determined by the photometric method number 965.12 of AOAC (1990).

Microbiological Analysis

The bacteriological quality of prawn head powder was evaluated by the total plate method of Australian Standard 1766 (Anon, 1989).

Sensory Analysis

Eleven untrained Ghanaian panelists, but familiar with prawns and the snacks, were presented with 3 coded prawn head powder samples and asked to rate the samples on the basis of the following attributes on an unstructured continuous 100 mm rating scale. The attributes were appearance (very acceptable and very unacceptable), odour (high prawn colour and low prawn odour) and colour (very light to very dark). The ratings were subjected to analysis of variance (ANOVA) and Duncan's New Multiple Range test (Larmond, 1970; Steel and Torrie, 1980). Sensory evaluation was also carried out on the products developed with the prawn head powders. Attributes assessed on the products were appearance, taste, flavour and overall acceptability.

Storage Stability

The storage stability of the powders were assessed by measuring the thiobarbituric acid - reactive substances (TBARS) by the method of Ke *et al.* (1984). Nonenzymic browning (NEB) was measured by the method of Buckle and Purnomo (1986).

Product Formulation

Baked corn dough cake (*Aboloo*) was prepared from ground corn flour containing prawn head powder at levels 0, 10, 20, 30, 40 and 50% (w/w). The final mixture contained the following ingredients: 100 g of corn flour and prawn head powder, 10 g sugar and 75 - 85 ml of water. Dough formed from the formulations were baked in a preheated oven at 177°C for 25 min.

Cassava dough balls (*Agblikaklo*) were prepared from grated cassava with varying levels of prawn head powder (0, 5, 8, 10, 15% w/w). The final unfried balls contained 100 g of grated cassava and prawn head powder, salt and ground onions as spice. The balls were deep fried at 170°C for 12 min.

Results and Discussion

Table 1 shows the chemical and microbiological characteristics of the fresh pawn heads and the powders produced from the dried heads.

Table 1

*Chemical and Microbiological evaluation of Prawn Head Powder**

Parameter	Prawn Head	Prawn	Head Powder	Preparation
		Steamed -70°C/4h	Steamed -50°C/8h	Unsteamed
Yield (%)		92.7±1.0	94.3±2.0	97.1±1.8
Moisture (5%)	330.8±5.6	7.1±0.8	8.9±0.3	9.2±0.4
Water Activity	1.0±0.0	0.4±0.2	0.5±0.4	0.4±0.2
Fat (%)	6.3±0.0	4.5±0.6	4.5±0.4	0.4±0.2
Crude Protein (Nx6.25) %	48.8±0.1	47.9±0.1	47.3±0.5	49.2±0.1
Ash (%)	25.1±0.4	23.0±0.3	23.3±0.4	22.6±0.3
Carbohydrate (%)	19.8±0.3	8.4±0.7	15.2±0.8	11.8±0.4
Chitin (%)	10.3±1.2	9.7±0.9	9.9±1.1	9.8±1.1
Calcium (%)	9.7±0.5	9.3±1.3	9.8±0.3	9.6±1.4
Phosphorus (%)	2.1±0.6	1.9±0.3	1.8±0.2	1.7±0.5
Total plate Count (cfu/g)	$3.9x10^6$	NVC[1]	NVC	$7.2x10^5$

* - Determinants are means of duplicates ±SD and are based on dry weight basis.

1 - NVC - No viable count.

As one of the important nutrient components of the prawn heads, the protein contents of 47-49% (Table 1), determined for the three preparations were within the reported levels of 37-58% reported by Meyers *et al.* (1973), and Myers (1986), but slightly higher than the 34-39% obtained by Watkins *et al.* (1982) and of the 43-44% by Mendes and Noranha Soares (1976). The value of 49.5% reported by Afolabi *et al.* (1980), was not significantly different from those determined for the prawn head powder preparations in this study. However, there was a significant difference from the reported value of 57-64% by Narkviroj and Buckle (1987).

Calcium and phosphorus were the major minerals analysed and were not significantly affected by the pretreatment methods. The calcium content of 9.0 - 9.8% (Table 1), was within the range of 9.6% reported by Meyers *et al.* (1973) and the 7-9% by Narkviroj and Buckle (1987). However, a significantly higher range was reported by Watkins *et al.* (1982).

As shown in Table 1, there were no viable micro-organisms on either of the steamed prawn head powder preparations, whilst a very high count of 7.2×10^5 cfu/g was recorded for the unsteamed prawn head powder.

Water activities (A_w) of the three powders, which were low (Table 1), may not promote microbial activity, but the presence of the bacteria in the unsteamed product, renders the powder a microbiological hazard at higher relative humidities.

Table 2 shows the mean sensory score evaluation of the prawn head powders.

Table 2

*Mean scores of sensory evaluation of prawn head powder preparations**

Preparation	Appearance	Colour	Odour
Steamed -70°C/4h	1.51a	1.31	1.54x
Steamed -50°C/8h	1.42a	2.54	1.64x
Unsteamed -50°C/10-11h	4.22	6.24	5.14

* Mean of scores by 11 panelists. Means in a column with the same letter are not significantly different ($P > 0.05$).

Significant variations were noted in the appearance, colour and odour of the prawn head powders (Table 2).

The powder from the unsteamed prawn heads was clearly identified as significantly different from either of the products from the steamed

heads in terms of appearance, colour and odour (Table 2). The colour of the unsteamed product was more of a light brown with the powder possessing an uncooked odour typical of fresh crustaceans. The pink colour development and cooked preferred odour of the steamed preparations might be due to the steaming. Kabota *et al.* (1986) investigated the components of the strong and favourable aroma of prawns subjected to some form of heat as roasting and boiling. Various kinds of nitrogen-containing compounds consisting of alkyl pyridines, alkyl pyrazines, amides, pyrrole, pyridone, and pyrrohdinone, as well as eight aliphatic acids (C4-C9) were identified in cooked prawn aroma concentrate. These nitrogen-containing compounds are well known for playing an important role in the roasted flavour of foodstuffs (Manly *et al.* 1974), and may have been formed by condensation of amine and carboxylic acids under the relatively high temperature conditions (Kabota *et al.* 1986). The process is thought to take part in fixing volatile amines, especially isovaleramide, which has a characteristic nutto-like flavour (fishy odour) of uncooked prawns.

In showing their preference for either of the powders from the steamed heads, panelists commented that both preparations had a pleasant aroma and were more appealing than that of the powder from the unsteamed heads, which received unfavourable comments as having an unacceptable colour and that it "might tend to darken food". Panelists also indicated their objection to the odour of the powder from unsteamed preparation.

Table 3 shows the storage stability of the prawn head powders as determined by measuring the thiobarbituric acid - reactive substances (TBARS) and the non-enzymic browning components (NEB).

There was no significant difference between the TBARS values of the three powders. Though these values suggest that lipid oxidation is very low and that these products may have a long shelf life, Meyers (1986) noted that highly unsaturated long chain fatty acids are susceptible to auto-oxidation and the reaction could be increased at very low water activities (Labuza 1971). Non-enzymic browning (NEB) values (Table 3) were very low, and no significant differences were noted between the powders. However, with such low water activities of the powders, the activation energy of Maillard reaction leading to non-enzymic browning (NEB) may also be increased (Eichner and Wolf 1983), particularly if it has been initiated during drying by the formation of Amadori compounds (Eichner and Ciner-Doruk 1981). Hence the low water activities may affect the stability of the powders during storage.

Table 3

*Thiobarbituric acid-reactive substances (TBARS) and Non-enzymic browning (NEB) values of prawn head powders**

Preparation	TBARS(μmol/kg)	NEB**
Steamed - 70°C/4h	0.05±0.01	0.014
Steamed - 50°C/8h	0.04±0.02	0.013
Unsteamed - 50°C/ 10-11h	0.06±0/01	0.015

* Mean of two determinations ± SD

** Corrected absorbance at 420nm

Though the powders from the steamed prawn heads were evaluated as better in quality than those from the unsteamed heads only the powder produced from steamed heads and dried at 70°C for 4h was chosen for inclusion in the food preparations because of its relatively ease of production.

Table 4 shows the proximate composition of *aboloo* obtained from the formulations.

Protein was significantly increased from 7.3% of the control to 25.4% (Table 4) as determined in the prawn powder added products.

Results of the sensory evaluation for corn dough cakes containing prawn head powder at varying levels compared to a corn dough cake with no added prawn head powder are shown in Table 5.

Panelists preferred products containing 10% and 20% powder as shown in table 5. Based on the attributes evaluated, corn dough cakes containing up to 20% prawn powder were more acceptable than cakes produced only with corn dough.

Table 4

Proximate composition (% dry weight) of baked corn dough cake (Aboloo)

Proportion of Powder (%)	Moisture (%)	Fat (%)	Protein (Nx6.25) %	Ash (%)
0 (Control)	27.0±0.4	2.0±0.2	7.3±0.2	0.9±1.1
10	28.8±0.2	2.2±0.1	9.1±0.3	4.1±0.5
20	31.4±0.5	2.5±0.3	13.6±0.1	5.0±0.3
30	28.0±0.2	2.8±0.4	16.6±0.4	5.8±0.2
40	22.6±0.4	2.7±0.2	19.5±0.3	7.7±0.4
50	33.6±1.0	3.0±0.5	25.4±0.2	8.2±0.2
Corn Flour	11.9±0.6	1.9±0.2	8.7±0.2	1.2±0.3

* Means of duplicate determination ± SD.

Table 5

*Mean scores of sensory evaluation of corn dough cake with varying levels of prawn head powder inclusion**

Proportion of Prawn Head Powder (%)	Sensory Attribute			
	Appearance	Taste	Flavour	Overall Acceptance
0 (Control)	1.79a	2.30d	3.90	2.74y
10	1.73a	2.15c	2.85g	2.62y
20	1.82a	1.99c	2.56g	2.15y
30	1.89a	2.40d	2.52g	3.63
40	2.50b	3.07	2.25h	4.90n
50	2.59b	3.26	2.21h	5.06n

* Means of scores by 11 panelists followed by the same letter are not significantly different ($P > 0.01$).

Table 6

Proximate composition (% dry weight) of fried cassava dough balls (Agblikaklo)

Proportion of Powder (%)	Moisture (%)	Fat (%)	Protein (Nx6.25) %	Ash %
0 (Control)	85.1±0.1*	5.9±0.3	1.5±0.3	6.1±0.9
5	81.2±1.2	5.5±0.1	6.0±0.1	7.8±1.1
8	73.0±0.6	5.6±0.2	8.0±0.2	8.5±0.6
10	65.0±0.5	7.2±0.1	9.4±0.3	8.9±0.7
15	53.5±1.5	12.0±0.6	11.6±0.2	10.8±0.4
Raw Cassava Dough	132.9±0.1	0.9±0.1	1.9±0.3	2.8±1.4

* Means of duplicate determinations ± SD

The results of the proximate analysis of fried cassava dough balls with and without prawn head powder are presented in Table 6.

There is no doubt that the significant increases in protein content of the products containing varying levels of prawn head powder was due to the prawn head powder. The increases are consistent with the proportion of prawn head powder added to the cassava dough (Table 6).

The sensory evaluation of the results for the fried cassava dough balls with varying levels of prawn head powder are presented in Table 7.

Table 7

*Mean scores of sensory evaluation of fried cassava dough balls (Agblikaklo) with varying levels of prawn head powder**

Proportion of Prawn Head Powder (%)	Sensory Attribute			
	Appearance	Taste	Flavour	Overall Acceptance
0 (Control)	1.6a	2.98	5.13	2.25e
5	1.6a	2.08b	2.52c	2.26e
8	1.7a	2.13b	2.42c	2.26e
10	3.7	4.70	2.11d	2.43e
15	4.3	5.34	1.96d	3.90

* *Means of scores by 11 panelists followed by the same letter are not significantly different ((P>0.01).*

The products with the highest inclusions of prawn head powder of 10 to 15% (Table 7) have a significantly lower flavour rating compared to those containing 5 to 8% prawn head powder.

Fried cassava balls containing prawn head powder at levels of less than 15% were acceptable but the highest preference after the control was for products containing 5 to 8% prawn head powder.

Conclusion

Though prawn heads are regarded as by-products, these are potentially rich in protein, chitin and minerals such as calcium and phosphurus. Steaming the raw prawn heads for 30 min. followed by drying at 70°C for 4 h, or drying at 50°C for 8 h, and comminuting in to powder could yield microbiologically-safe prawn head powders.

Prawn head powder incorporated at levels of 10-20% (w/w) in baked corn dough cakes (Aboloo) produced the most acceptable products with their protein contents increased significantly from 7.3% to 9-14% on dry weight basis.

Fried cassava balls (*Agblikaklo*) containing prawn head powder at levels of 5-8% (w/w) were the most acceptable products. The balls were well flavoured significantly with increased protein content from 1.5% to 6 - 8% (dry weight).

The results showed an improvement of the nutrient content of both snacks. The powder, which is simple to prepare, could be used in other products to offset a low protein intake.

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