Studies on the Chemical and Nutritional Quality of Protein Powders Isolated from Shrimp Waste

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Protein powders were prepared from processing waste of prawns either by mechanically squeezing the shell and freeze drying the resultant aqueous extract or by treating the shell with 0.5% sodium hydroxide, filtering it and freeze drying the filtrate. Comparative studies on the proximate composition, amino acid profile, consumer acceptability and nutritional quality of the protein powders showed that the product prepared by freeze drying of the press liquor obtained by passing the waste through a hand operated expeller is better in all aspects studied than the product prepared by mild alkali extraction.

The annual catch of penaeid prawns in India is 1.21 lakh tonnes (Anon, 1986), the processing of which results in more than 50% of the raw material as waste. Although this waste contains sufficient animal protein, it is not processed further for the preparation of edible products, but is used as manure, in poultry feed or discarded. Method of preparation and storage life of a broth prepared from shrimp waste has been reported by Revankar (1978). Thankamma *et al.* (1982) have described several potential methods developed for the utilization of shrimp waste. They have also reported the nutritional quality of the protein powder prepared by mild alkali extraction of the shrimp waste. Since the nutritional quality of the protein powder isolated by alkali extraction was not satisfactory, attempts were made to prepare a better product from shrimp waste and also to study the quality differences in protein powders isolated from the head and tail portions of the shrimp waste. Results of these studies are presented in this paper.

Materials and Methods

Fresh shrimp waste collected from the local peeling sheds and the processing division of the institute was used for extraction of the protein. Two methods were followed for the separation of protein from the shell. In the first method the cleaned and washed shrimp waste was passed through a hand operated expeller and the aqueous extrudate was collected and freeze dried. In the other method the shrimp waste was boiled with 0.5% sodium hydroxide solution for 20–30 min, shell waste was removed by filtration and the filtrate was neutralised to pH 7.0 using hydrochloric acid in the initial stages and acetic acid near neutralisation point. The neutralised extract was concentrated in a steam jacketed kettle and finally freeze dried. The head and tail waste were collected separately and subjected to the same treatments as above for separation of the protein from them.

Moisture, fat, ash and crude protein of the protein powders were determined as per the methods of AOAC (1975). Chitin nitrogen (CN) was estimated following the method reported by Garg *et al.* (1977). Mineral analysis was carried out by dissolving the ash in 1 N hydrochloric acid, making upto volume and determining the respective mineral content using a Systronic flame photometer for Na, K and Ca and Atomic Absorption Spectrophotometer Model CBC 902 for the micro-elements.

The amino acid composition of both products was determined by microbiological assay methods of Schockman (1963). Chemical score was calculated using the amino acid scoring pattern proposed by FAO/WHO (1973).

Comparative studies were carried out on the effect of feeding the protein powders at 10% protein level on 21–23 days old male weanling rats. Casein (Sisco Research Laboratory) was used as the control. PER was evaluated according to the method of Chapman (1959). Visual observations on the appearance and behaviour of the experimental rats were also recorded.

Results and Discussion

The proximate composition of a typical raw material sample used in the studies and the shell residues obtained after separation of protein from shrimp waste is presented in Table 1. The waste contains about 40% protein (DWB) most of which can be recovered. The yield and composition of the protein powders isolated by the two methods from whole waste, head waste and tail waste are shown in Table 2. Although alkali extraction results in higher yield, the mineral content of the product is high owing to the presence of sodium chloride. The colour of the product is deeper and less appealing. Mechanical separation resulted in a higher protein content of the product. Consumer acceptability studies also showed that the mechanically separated product had better appeal. The presence of small quantities of chitin nitrogen in the protein powders can be attributed to small amounts of prawn shell coming along with the protein extrudate/alkali extract as very fine particles. It is also seen from Table 2, that the head portion gives a higher yield of protein powder than the tail portion. However, the products isolated from the tail portion contain more protein and less

Table 1. *Proximate composition of shrimp waste and shell residues after separation of protein*

Characteristics	Shrimp waste whole	Shell residue separated by Mechanical Separation		Alkali Extraction	
		Head**	Tail**	Head**	Tail**
Moisture %	77.43	52.81	56.41	54.62	60.21
Ash*	23.94	34.05	35.52	38.41	39.40
Fat*	5.60	0.30	0.27	0.27	0.12
Total nitrogen*	8.41	4.47	4.84	3.65	3.57
Chitin nitrogen*	1.79	1.43	1.56	1.58	1.78
Crude protein % (TN–CN) 6.25	41.38	19.00	20.50	12.94	11.19

* Percent on dry weight basis

** Mixture of two species *M. dobsoni* and *P. stylifera*

Table 2. *Percentage yield and composition of shrimp extract powder from prawn shells*

Characteristics	Mechanical separation			Alkali extraction		
	Whole	Head**	Tail**	Whole	Head**	Tail**
Yield	7.41	5.12	2.35	8.00	6.08	3.65
Moisture	3.56	5.39	5.08	4.44	5.64	7.25
Ash*	12.05	11.00	12.13	22.29	18.48	15.02
Fat*	10.62	10.90	6.00	6.10	7.40	3.90
Total nitrogen	11.14	10.81	11.23	9.97	10.36	10.86
Chitin nitrogen	0.37	0.53	0.35	0.18	0.22	0.10
Protein	67.31	64.25	68.00	61.19	63.38	67.25

* On dry weight basis (DWB)

** Mixture of two species *M. dobsoni* and *P. stylifera*

fat. It is found from Table 2 that the whole waste recorded a higher yield than that from tail or head shell. The difference in yields of protein powder may be attributed to the difference in the species, quality of the raw material and handling and peeling methods followed in different peeling sheds. The residual protein content of shell is much less after the alkali treatment (Table 1).

The mineral content of mechanically separated shrimp extract powder is shown in Table 3. Sodium content is considerably higher than the calcium and potassium content. Similar high sodium values have been recorded for slipper lobster *(Thenus orientalis)* and *Porogadus* sp. by Mukundan&Devadasan (1988). The iron content is also very high and the powder is a good source of other micronutrients.

The essential amino acid composition of the two products is presented in Table 4, in comparison with the 1973 FAO/WHO reference protein. Lysine content of both products was high compared to the FAO pattern, phenylalanine plus tyrosine and valine are present in more than required amounts and the sulphur amino acids, threonine and tryptophan are present in adequate amounts. Leucine is the limiting amino acid in the mechanically separated shrimp extract powder, the chemical score being 86. Both isoleucine and leucine are not present in required amounts in the alkali separated protein powder, leucine being the first limiting amino acid in this case also. The chemical score is 77.

The effect of the method of separation on protein quality was assessed by determination of PER. The results of this study are shown in Table 5. Rats fed on mechanically separated protein powder and casein ate well, grew rapidly and exhibited significantly greater final weights than those fed on the alkali extracted protein powder. The PER values for mechanically separated shrimp extract powder was higher and for the alkali extracted powder was lower than the PER value for the casein. The essential amino acid pattern of the two products also confirms this result. The heat treatment given to the protein during the extraction and

Table 3. *Mineral content of mechanically separated shrimp extract powder (mg/100g)*

Ca	Na	K	Mn	Cd	Cu	Zn	Fe
490	810	450	2.4	Nil	2.8	7.6	16.4

Table 4. *Essential amino acid profile of shrimp extract powders (g amino acid/16 g nitrogen)*

Amino acid	FAO/WHO scoring pattern (1973)	Shrimp extract powder separated By mechanical means	Using alkali
Isoleucine	4.0	4.0	3.8
Leucine	7.0	6.0	5.4
Lysine	5.5	10.0	7.2
Methionine + Cystine	3.5	3.6	3.5
Phenylalanine + Tyrosine	6.0	9.2	7.9
Threonine	4.0	4.2	4.3
Tryptophan	1.0	1.0	1.0
Valine	5.0	6.7	6.1
Total	36.9	44.7	39.2

Table 5. *Bioassay of shrimp extract powders*

	Shrimp extract powder separated		
	Mechanically	Using alkali	Casein
Initial wt g	41.20 ± 2.66	40.88 ± 1.58	40.94 ± 2.10
Final wt g	117.00 ± 10.92	83.62 ± 7.02	91.40 ± 4.16
Gain in wt g	75.80 ± 9.59	42.74 ± 7.23	51.46 ± 4.11
Protein intake g	27.68 ± 1.72	21.34 ± 2.68	20.56 ± 2.00
True PER	2.73 ± 0.23	2.00 ± 0.12	2.51 ± 0.25
Adjusted PER	2.71	1.99	2.50

concentration stages must have reduced the availability of some of the essential amino acids resulting in a lower PER. Neither untoward symptoms nor mortality were observed during the feeding trials.

Out of the two methods studied for the utilization of shrimp waste, mechanical separation gives a product with better chemical characteristics, growth promoting properties and organoleptic acceptability.

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