Studies on Blue Discolouration in Canned Body Meat of Crab (*Scylla serrata*)

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Blue discolouration met with in the canned body meat of crab (*Scylla serrata*) was due to copper content exceeding 1.8 to 2.0 mg/100g on dry weight basis. Bleeding the cleaned carcasses of crab thoroughly in running water brought down the copper content below this level and blue discolouration prevented. Addition of copper ions to the thoroughly bled crab meat to raise the copper content above this level caused discolouration. The incidence of blue discolouration was independent of the freshness of the animals used. Citric acid in high concentration prevented blueing to some extent, but is not advisable as texture and flavour were adversely affected.

Blue discolouration in canned crab meat is a common phenomenon which has engaged the attention of several workers in identifying the causative factors and its prevention. Most of the literature on the subject suggest that copper ion is mainly responsible for its occurrence. Goringer & Dassow (1964) observed that the blued product in King crab *(Paralithodes camtschatica)* had some properties similar to those of copper proteins or biuret complexes. Osaka (1958) succeeded in preventing the blue discoluration in canned crab meat by a "low temperature and fractional heating" of the carcasses from which carapaces were removed. Blackwood *et al.* (1959) recommended a fractional cooking method as a means of preventing the blue discolouration in canned Queen crab *(Chinoecetes opilio)* meat. Inoue & Motihiro (1970, a, b, c, d, e; 1971, 1971a) studied in detail the cause and mechanism of the blue discolouration in canned King crab meat and established a relationship between the copper content in the meat and incidence of the blue discolouration. However, Waters (1971), based on his studies on canned crab (*Callinectes sapidus)* inferred that only ferrous and ferric ions produced blue discolouration typical of that met with in canned crab meat. In his studies neither cuprous nor ammonium ions was found to cause significant blueing.

Crab meat forms a sizeable proportion of the canned marine products exported from India. Its share in the total exports of canned products is presented in Table 1.

Table 1. *Export of canned marine products from India**

Item		1979	1978	1977
Shrimp	Q	139	204	128
	V	64.28	91.49	52.21
Crab meat	Q	56	42	50
	V	29.35	19.41	31.44
Tuna	Q	NEG	14	22
	V	0.15	2.20	3.49
Sardine	Q	—	NEG	NEG
	V	—	NEG	NEG
Fish	Q	2	1	—
	V	0.80	0.20	—
Mussel	Q	2	NEG	—
	V	0.48	0.13	—
Total	Q	199	261	211
	V	95.06	113.43	88.55

*Sources: "Indian Seafood Exports Scale New Heights, Rs. 262 Crores." Marine Products Export Development Authority, Cochin

Q: Qty. in tonnes; V: Value Rs. in lakhs

Sporadic occurrence of blue discolouration has been met with in the Indian canned crab meat when the body meat is canned separately or body and claw meats are canned together, the degree of incidence being higher in the latter case. Practically

no research work has been carried out in India on this problem. Attempts to analyse the cause and possible methods of prevention of this phenomenon in canned body meat of *Scylla serrata* is discussed in this paper.

Materials and Methods

Crabs of average length 15 cm caught from Cochin backwaters were processed after about 3 h. The carapaces and claws were removed and the resultant carcasses were halved and kept in running water for varying periods whenever required. The carcasses were cooked in 2% boiling brine until the meat became firm enough to facilitate easy removal by scissors, mixed thoroughly and packed in lacquered cans (301 x 109) with parchment lining on all sides, filled with hot brine (2% brine containing 0.1% citric acid) and heat processed at 110° C for 60 min.

Moisture was estimated by the method of A.O.A.C. (1975). The crab meat after drying was ashed, and the ash dissolved in a small volume of hydrochloric acid to give a 0.1 N solution on dilution with distilled water. The analysis for copper was done directly using a Varian Techtrom atomic absorption spectrophotometer Model 1100. (Bryan, G.W.). Visual observations were made on the colour of the canned meat and gradings given according to the intensity of colour.

Results and Discussion

Freshly caught crab was divided into three lots. One processed immediately and the second and third were processed after exposing to the atmosphere for 4 and 8 h respectively. The first group of crabs processed were activity live, the second sluggish and the third near dead when processed. The canned meat from these three lots were examined for any incidence of blue discolouration. The results are presented in Table 2.

It was observed in several cases that meat picked from fresh crabs had the colour superior to those from sluggish or dead crabs. It is evident from the results that the blue colour is independent of the freshness of the crab used for processing. Waters (1971) has reported that dead or decayed crabs do not cause any blue discolouration in canned meat. It has been observed in the present study that blueing whenever occurred, was irrespective of the freshness of the meat.

In another set of experiments, meat picked from fresh boiled crabs was packed in 2% brine containing varying concentrations of citric acid to study the effect, if any, of citric acid on prevention of blueing. The results are summarised in Table 3.

In one set of experiments the colour of samples turned blue when citric acid in brine was 0.3% or less and at 0.4% this phenomenon was apparently controlled.

Varga *et al.* (1969) carried out studies on the use of citric acid in preventing blueing in Queen crab (*Chinoecetes opilio)* meat. They observed that 0.1% citric acid considerably prevented the colour change and completely prevented the phenomena at higher concentration of the acid. Dipping the meat in acetic or citric acid solutions has been recommended for preventing blueing in European edible crab (*Cancer pagurus)* (Edwards & Early). However, this does not appear to be a recommendable process as the flavour and texture of the resultant product was very much adversely affected.

Copper has been reported to be a major factor responsible for the blue discolouration in canned crab meat. The copper content in a number of samples of raw crab meat was estimated and reported in Table 4, which shows that the copper content in crab meat varied between 0.09 and 5.696 mg/100g. In order to discern the relationship between the copper content in the meat and its influence on the blue colouration of canned meat, meat showing blue discolouration in cans was separated out and the copper content estimated and compared with the copper content in normal meat. Table 5 shows a definite relationship between copper content and the occurrence of blue discolouration. Canned meat with very light blueing had a copper content of 1.81mg/100g and the intensity of the colour increased with increase in copper.

Inoue & Motihiro (1970) have established a relationship between the copper content

Table 2. *Effect of time lapse between catching and processing on the incidence of blue discolouration in canned body meat*

Experiment No.	State of crab used	Colour of meat	Visual rating of blueing
1	L	White	0
	S	White/ dull white	0
	D	Dull white	0
2	L	White	0
	S	White	0
	D	Dull white	0
3	L	White	0
	S	White/ dull white	0
	D	Dull white	0
4	L	White with slight blueing in parts	+
	S	White with slight blueing in parts	+
	D	Dull white with slight blueing in parts	+
5	L	White with moderate blueing in parts	+ +
	S	White with moderate blueing in parts	+
	D	Dull white with moderate blueing in parts	+ +

L = actively live, processed without delay
S = sluggish, processed after 4 h
D = dead/near dead, processed after 8 h

0 = no blueing
+ = slight blueing
+ + = moderate blueing

Table 3. *Effect of citric acid in the prevention of blue discolouration*

Experiment No.	Concentration of citric acid in brine %	Visual rating of blueing
1	0 – Control	0
	0.1	0
	0.2	0
	0.3	0
	0.4	0
	0.5	0
2	0 – Control	+
	0.1	+
	0.2	+
	0.3	+
	0.4	0
	0.5	0

0 = normal; — no blueing; + = slight blueing; + + = moderate blueing

Table 4. *Copper content in raw crab body meat*

Sample	Copper content (DWB) mg/100g
1	2.190
2	2.890
3	5.696
4	5.589
5	5.023
6	3.724
7	3.524
8	5.213
9	0.090
10	0.160

Table 5. *Correlation between copper content and blue colour in canned crab meat*

Sample	Copper content (DWB) mg/100g	Visual rating of blueing
1	0.06	0
2	0.095	0
3	1.62	0
4	1.82	—+
5	2.043	+
6	2.89	++
7	3.34	+++
8	4.33	+++

0 = no blueing; — + = very slight blueing; + = slight blueing; ++ = moderate blueing; +++ = heavy blueing

and the incidence of blue discolouration in the meat of King crab. They found 0.49mg/100g copper in normal King crab meat and 2.8mg/100g in the blue crab meat and stated that the blue colour appears when copper exceeds 22mg/100g. Their studies on the cause and mechanism of blue discolouration in canned crab (Inoue & Motihiro, 1970a, 1971, 1971a) showed 1970b, that it is due to the haemocyanin contained in crab haemolymph, which can react with hydrogen sulphide to produce blue colour. They observed that the reflectance spectra of haemocyanin-sulphide complex closely resembled that of the blue meat and concluded that the causative factor for blue discolouration in canned crab is a haemocyanin-sulphide complex.

Since the blood haemocyanin of crab is the source of copper in the meat, different methods were tried to bleed the animals to get rid of copper. In order to increase the exposed area to facilitate bleeding the cleaned carcasses were halved and then subjected to treatments as detailed in Table 6.

The data indicates that it is advantageous to bleed the carcasses in running water for 30 min. To find out the optimum time required for bleeding and to bring down the copper content to a satisfactory level, the cleaned carcasses were bled in running water for varying periods and the copper contents estimated after bleeding and the meat canned and observed for the incidence of blueing. The results are presented in Table 7.

When the initial copper content was low, bleeding for 15 min in running water was sufficient to bring down the copper content to a satisfactory level when no blue colour developed in the canned meat. When the initial copper content was very high, bleeding upto 45 min did not yield satisfactory results. Longer bleeding in such cases, not only failed to prevent the appearance of blue colour but also affected the texture and flavour of the meat. However, cases wherein such abnormally high copper content is met with are very rare and for practical purposes bleeding for 30 min in water was quite sufficient to prevent the incidence of blue colour in the product.

The "low temperature and fractional heating" method described by Osakabe employs the principle of bleeding of the crab carcasses to get rid of the copper making use of the difference in the coagulating temperatures of blood and muscle proteins. Similar method has been recommended by Blackwood *et al.* (1969) for prevention of blueing. However bleeding the cleaned carcasses of crab in water was found to be simple and sufficient from this study.

Tables 5 and 7 indicate that the blue discolouration becomes apparent when the copper in the meat is around 2 mg/100g Known amounts of copper in the form of.

Table 6. *Copper content in the body meat of raw crab after various treatments*

Treatment	Copper content mg/100g (DWB) Experiment 1	Experiment 2
Raw body meat (control)	2.89	3.524
Bled in running water for 30 min	1.80	1.910
Dipped in 2% brine for 30 min	2.31	2.620
Dipped in 2% brine containing 0.1% citric acid for 30 min	2.29	2.710

Table 7. *Effect of duration of bleeding on the copper content and the incidence of blueing*

Copper content mg/100g (DWB) and visual rating of blueing

Time of bleeding min	I Copper	I Visual rating	II Copper	II Visual rating	III Copper	III Visual rating
10	2.19	0	2.89	+	5.199	+ + +
15	1.829	0	2.17	0	3.720	+ +
30	1.62	0	1.81	0	2.920	+
45	1.50	0	1.72	0	2.160	0

0 = no blueing; + = slight blueing; + + = moderate blueing; + + + = heavy blueing

Table 8. *Effect of added copper ions on blueing*

Copper (as $CuCl_2$) added mg	Copper in canned meat mg/100g (DWB)	Visual rating of blueing
Control	1.628	0
0.5	1.916	— +
1	2.54	+ +
1.5	4.36	+ + +

0 = no blueing; — + = very slight blueing; + + = moderate blueing; + + + = heavy blueing

cupric chloride solution were added to the meat picked from thoroughly bled and cooked crab carcasses to find out the effect of added copper ions in the occurrence of blue discolouration and also to determine the critical level of copper needed for the appearance of blue colour. It is observed from Table 8 that by introducing copper ions blue colour occurred in the sample with a copper content of 1.916mg/100g.. This is almost in agreement with the observations recorded in Tables 5 and 8.

From the experiments and observations made above it can be reasonably concluded that the blue discoluration in canned crabs is due to copper content around 2 mg/100g and by bringing down the copper content below this level by bleeding the meat in water, the phenomenon of blue discolouration can be prevented in canned crab meat.

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