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Occurrence and market value implication of Melanosis (black spot) in five shrimp species wild-caught in Nigerian Coastal Waters

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ABSTRACT: The study investigated the occurrence and market value implications of melanosis in five shrimp species caught in Nigerian Coastal waters by thirty-six vessels of an Industrial Shrimping Company in Lagos, Nigeria, over twelve months (January 2024 - December 2024). All Black Tiger shrimps (*Penaeus monodon*), White shrimps (*Penaeus notialis*), Brown shrimps (*Parapenaeopsis atlantica*), Flower Tiger shrimps (*Penaeus kerathurus*), and Rainbow shrimps (*Parapenaeopsis sculptilis*) were treated with a solution of 3kg Food grade Sodium metabisulphite (E-223) powder dissolved in 50litres of water to prevent melanosis. All *P. monodon* and *P. notialis, P. kerathurus and P. atlantica* weighing 25g-400g each were dipped for 10minutes. *P. notialis, P. kerathurus and P. atlantica,* weighing 5g-15g each, were dipped for 8 minutes, respectively, while all *P. sculptilis* were dipped for 15 minutes. Shrimps were deep frozen on board and weighed 2 kg each into absorbent packets. Shrimps were visually assessed for signs of melanosis upon arrival. Data were subjected to Analysis of Variance (ANOVA) using SPSS v 23 and Fisher's Least Significant Difference. A total of 596 packets (1192kg) had the occurrence of melanosis (black spots). There is no significant difference between black tiger shrimps (29±9.07) and white shrimps (30.33±8.19) in the means, but they were significantly different from brown shrimps (35.75±17.33) at $P<0.05$. 6W (9g-11g) grade of white shrimps had 4.3% as the highest occurrence of melanosis among all five shrimp species. The emergence of melanosis hits its peak level in April 2024, with over 450kg of shrimps having black spots. The mean loss recorded for black tiger shrimps sales (NGN 584561.8± NGN335.27) was significantly different from that of brown shrimps (NGN 335906± NGN155.97). A total loss of NGN 7,729,908.30 was recorded in sales of the five shrimp species. The 0.11% occurrence of melanosis led to a reduction of the market value of the shrimps.

Keywords: Black spot, melanosis, Nigerian coastal waters, shrimps, sodium metabisulphite.

INTRODUCTION

Shrimping in Nigeria dates back to about 1950. Then, foreign fishing vessels exploited Nigerian shrimp resources. By 1961, there was a large commercial stock of shrimp in the Nigerian territorial waters to sustain a shrimp trawling industry (Anyanwu *et al.*, 2011). Melanosis, often referred to as "black spot" or "blackening," is a natural enzymatic reaction that occurs in crustaceans, including shrimp, after they are harvested. It's essentially the shrimp's version of browning in apples or other fruits when exposed to air. It's primarily a cosmetic issue and generally doesn't indicate spoilage or pose a health risk (Pierce, 2025).

Melanosis in shrimp usually leads to a reduction in shelf life, which causes a significant loss in the economic value of shrimp products. Also, melanosis (or black spot) formation during postmortem storage is problematic and causes substantial loss in the nutritional value, reduction in its shelf life, quality and economic value of shrimp products (Phan *et al.*, 2021). In the formation of melanosis, phenols are oxidised to the quinones by the enzyme polyphenol oxidase. This is one of the most important problems of the shrimp industry. Researchers have conducted various studies to prevent melanosis with different inhibitors. Sulphides have been used as major inhibitors of melanosis worldwide (Toktas and Gokoglu, 2020). The deterioration of the shrimp quality is closely related to the appearance of the black colour found in the shrimp carapace. The formation of colour can be affected by enzymatic and non-enzymatic reactions. Melanosis rate in shrimp is strongly influenced by high concentrations of tyrosine substrate in shrimp chitin shells, oxygen, and tyrosinase enzyme (Sipahutar and Sitorus, 2024).

In 2022, global exports of shrimps and prawns reached USD 32.3 billion, an increase of 8.7 per cent from 2021, which had already seen a 22 per cent growth from 2020 following three consecutive years of decline between 2018 and 2020. This forms part of the 8% of crustaceans produced in the world Fisheries and Aquaculture data for the year 2022 (FAO, 2024). According to Wamucii (2024), the export prices of shrimp and Prawns from Nigeria have seen a steady increase over the past five years. In 2019, the export price per kilogram was $2.90, which was a slight increase from the previous year. In 2020, the export price per kilogram rose to $3.10, a 6.9% increase from the previous year 2021 saw the price further increased to $3.20, a 3.2% increase from the previous year 2022, saw a slight decrease to $3.15, a 1.6% decrease from the previous year. In 2025, the approximate wholesale price range for Nigerian shrimps and prawns is between US$22.28 and US$26.33 per kilogram or between US$10.10 and US$11.94 per pound (lb), while the retail price range for Nigerian shrimps and prawns is between US$31.83 and US$37.61 per kilogram or between US$14.43 and US$17.06 per pound (lb).

The global price of Shrimp was $8.3979 as of 2024-11-01, according to the International Monetary Fund (2025). Historically, the global price of Shrimp reached a record high of $18.0779 and a record low of $6.5088; the median value is $11.6845. Typical value range is from $6.67 to $12.05. The market value of shrimp is generally based on the visual appearance of their body colour. The appearance of the product and the resulting quality implications play a significant role in maintaining a high consumer acceptance. Shrimps are very perishable with a short shelf life and are susceptible to black spot formation called melanosis during post-mortem handling and storage. It does not have an influence on odour or flavour (Montero *et al*, 2001). It is a common visual defect in shrimp that affects marketability. Polyphenol oxidase enzymes, an endogenous enzyme complex with tyrosinase as the main active enzyme that causes the darkening of the shell (Andrade *et al*, 2015).

The goal of anyone in business is to make a profit. Sustainable profit in the shrimp value chain could be subject to some exogenous factors (Achoja, 2019). It has been widely reported that melanosis affects consumers' acceptability of shrimps, which in turn affects the market prices. Since studies that actually demonstrate the economic loss in terms of market prices as a result of melanosis in shrimps are rare, there is a need for this study to bridge the gap.

The aim of this study is to assess the emergence of melanosis (black spots) and its impact on the market prices of the shrimps over a period of twelve (12) months (January 2024 - December 2024). The outcome of this research contributed to the Sustainable Development Goal of life below water by highlighting the economic impact of melanosis in shrimps on the fisheries sector. It further suggested ways of preventing economic losses due to melanosis.

MATERIALS AND METHODS

The study area

The Nigerian Coastal waters fall within the Eastern Central Atlantic FAO Area 34. Nigeria is bordered to the North by the Republic of Niger and Chad, to the West by the Republic of Benin, to the East by the Republic of Cameroon, and to the South by the Atlantic Ocean. Nigeria has a coastline of approximately 853 km facing the Atlantic Ocean (Figure 1). This Nigerian coastline lies between latitude $4°10^{1}$ to 6^{0} 20^{1} N and longitude 2°45′ to 8°35′E. The terrestrial portion of this zone is about 28,000km in area, while the surface area of the continental shelf is 46,300 km (Nwilo and Badejo, 2006). The coastline has nine states it shares borders with. They are Lagos, Ogun, Ondo, Edo, Rivers, Delta, Akwa Ibom, Bayelsa and Cross River States (Fajana and Adeboyejo, 2022).

Voyages

A trawler voyage of sixty (60) days to and fro covers the area and also the nine coastal states. A total of 191 voyages (some uncompleted voyages are inclusive) by the shrimping vessels of a commercial company in Nigeria on the high sea beyond 5 nautical miles occurred over 12 months spanning from January 2024 – December 2024.

Harvesting of shrimps

Black Tiger shrimps (*Penaeus monodon*), White shrimps (*Penaeus notialis*), Brown shrimps (*Parapenaeopsis atlantica*), Flower Tiger shrimps (*Penaeus kerathurus*), and Rainbow shrimps (*Parapenaeopsis sculptilis*) were caught from the Nigerian Coastal waters (Gulf of Guinea) by 35 shrimping vessels of an Industrial shrimping company located in Lagos, Nigeria by the method of bottom trawling. The shrimps were immediately sorted and washed with seawater upon hauling and landing on the deck.

Preparation of treatment solution

Fifty (50) litres of seawater were collected with the use of a low-pressure hose into a plastic trough. 3 kg of Food

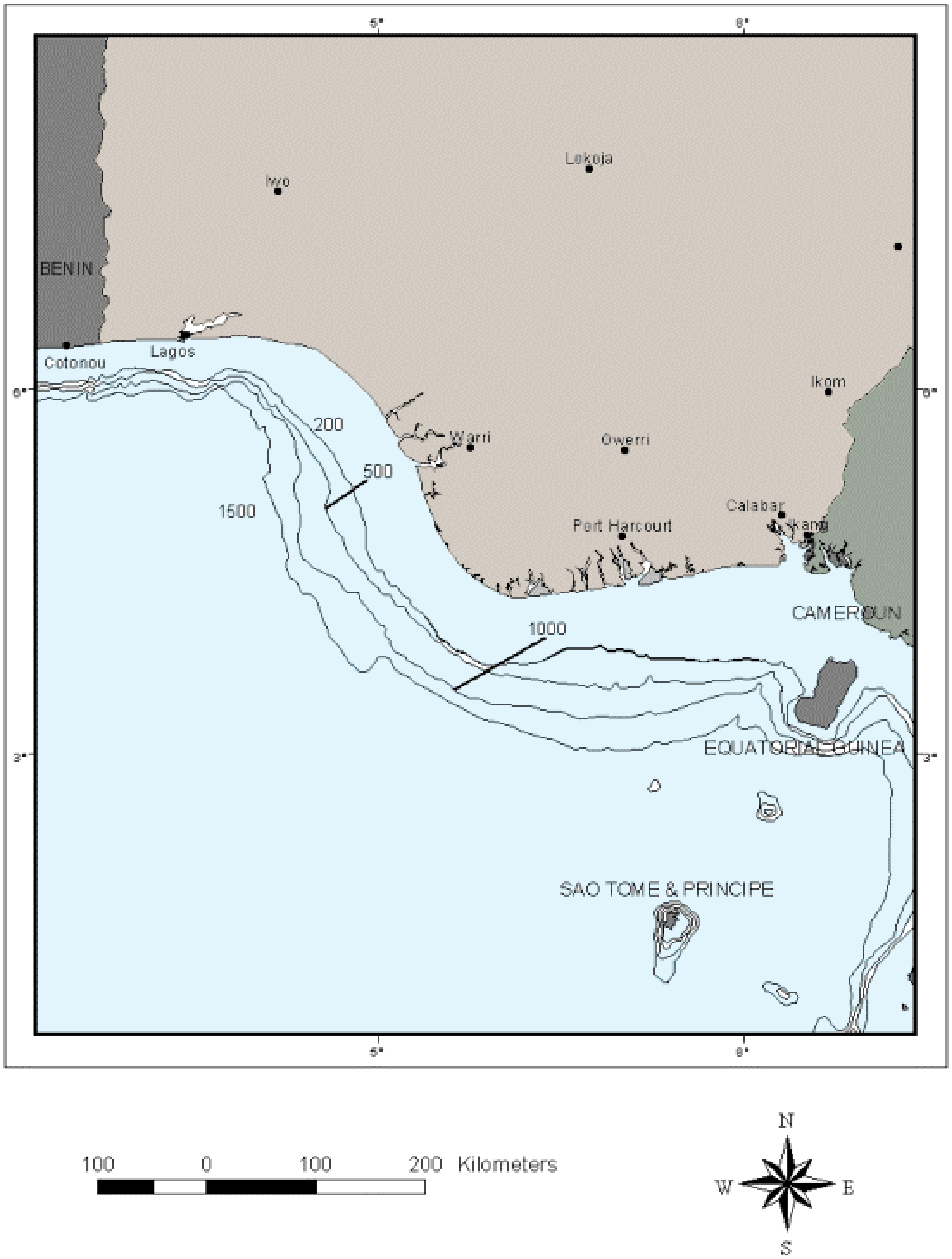

Figure 1. Map of Nigeria's Coastal waters.

grade Sodium metabisulphite (E-223) powder purchased from BASF SE Company in Germany was added and allowed to dissolve completely. The treatment solution was changed after 24 hours or after 80kg of shrimp had been dipped. A new solution was prepared the next shrimping day. This was done by all 35 shrimping vessels for 60 sea days.

Dipping of shrimps

All shrimp caught were treated with Sodium metabisulphite solution by the dip method. Eight (8) baskets containing 1kg of shrimps each were dipped in the treatment solution. All *P. monodon, P. notialis, P. kerathurus and P. atlantica* weighing 25 – 400 g each were dipped for 10 minutes. *P.*

Table 1. Number of packets with melanosis occurrence.

Weights (g)	Black Tiger Shrimps	White Shrimps	Brown Shrimps	Rainbow Shrimps	Flower Tiger Shrimps
261-400	2	—	—	—	—
211-260	49	—	—	—	—
151-210	47	—	—	—	—
106-150	31	—	—	—	—
75-105	44	7	—	—	—
55-74	1	32	—	—	1
36-72	—	21	—	1	—
25-35	—	18	—	2	—
12-24	—	40	31	6	—
9-11	—	64	40	5	—
7-8	—	—	45	2	—
5-6	—	—	107	—	—
Mean±SE	29±9.07^{a}	30.33±8.19^{a}	35.75±17.33^{bc}	3.2±0.97^{cd}	1^{d}
F Stat			3.62		
Remark			Significant		

^{abcd} Means along same row with different superscript are significantly different at ($p<0.05$). **Key:** SE = Standard Error.

notialis, P. kerathurus and P. atlantica, weighing 5 – 15 g each, were dipped for 8 minutes, respectively, while all *P. sculptilis* were dipped for 15 minutes to prevent melanosis.

Freezing of shrimps

Shrimps were weighed at 2 kg using Indian scales; finger laid, wrapped in a transparent poly sheet (LDPE) with a dimension of 60 cm by 60 cm, 22.5 g weight, and packed in absorbent packets with a weight of 70 g. Each packet was arranged in trays and loaded into pre-cooled plate freezers for continuous freezing for 4 hours. Frozen shrimps were offloaded from the plate freezers at a core temperature of <-18°C and stored in the fish hold at the temperature of -20°C.

Visual assessment for melanosis

Each frozen shrimp packet was visually assessed for black spots upon arrival immediately after completing a shrimping voyage of sixty days. The shrimp packet with black spots was separated and converted to peeled headless shrimps. This was done for a year (January 2024 - December 2024).

Sales of shrimps

Shrimps packed in 2 kg packets and 18 kg cartons without traces of melanosis were exported and sold to customers as head-on shrimps, while shrimps with traces of melanosis were peeled and deveined and then sold to customers at downgraded prices.

Statistical analysis

Data were subjected to Analysis of Variance (ANOVA) using SPSS v 23 and Fisher's Least Significant Difference for the means due to the heterogeneous observations in variances.

RESULTS

Table 1 presents the number of packets of shrimps with melanosis occurrence. Each packet weighed 2kg. Black tiger shrimps whose individual weights range between 211 and 260 g had the highest incidence of melanosis to be 98kg, among the Tiger shrimps, while 55 and 74 g had the lowest incidence of melanosis to be 2kg among the Tiger shrimps. 9g-11g grade of white shrimps recorded the highest weight among the White shrimps caught, to be 64 packets (128kg), while individual weights range 75g-105g had an incidence of melanosis to be 7 packets (14 kg). Individual weight of 12g-24g had the lowest weight among Brown shrimps caught, to be 31 packets (64kg), while 5g-6g had 107 packets (214 kg) occurrence of melanosis was the highest among Brown shrimps. Individual weight range of 12g-24g recorded 6 packets (12kg) as the highest incidence of melanosis among Rainbow shrimps, while 32g-72g had 1 packet (2kg) occurrence of melanosis to be the lowest among Rainbow shrimps. The individual weight range of 55 – 74 g only recorded 1 packet (2 kg) among

Table 2. Percentage occurrence of shrimps with melanosis.

Shrimps	Grade	Percentage of Melanosis
Black Tiger shrimps	T-2/4 (261g-400g)	0.01
	T-4/6 (211g-260g)	0.09
	T-6/8 (151g-210g)	0.05
	T-8/10 (106g-150g)	0.06
	T-10/15 (75g-105g)	0.05
	T-16/20 (55g-74g)	0.01
White shrimps	1W (75g-105g)	0.1
	2W (55g-74g)	0.17
	3W (36g-72g)	0.28
	4W (25g-35g)	0.12
	5W (12g-24g)	0.81
	6W (9g-11g)	4.3
Brown shrimps	5BR (12g-24g)	0.63
	6BR (9g-11g)	0.11
	7BR (7g-8g)	0.14
	8BR (5g-6g)	0.37
Rainbow shrimps	C/T-3 (36g-72g)	0.08
	C/T-4 (25g-35g)	0.08
	C/T-5 (12g-24g)	0.49
	C/T-6 (9g-11g)	0.76
	C/T-7 (7g-8g)	0.32
Flower tiger shrimps	F/T-2 (55g-74g)	0.02
	F/T-3 (36g-72g)	0
	F/T-4 (25g-35g)	0
	F/T-5 (12g-24g)	0

Flower Tiger shrimps. There is no significant difference between black tiger shrimps (29±9.07) and white shrimps (30.33±8.19) in the means, but they were significantly different from brown shrimps (35.75±17.33) and Rainbow shrimps (3.2±0.97) at $p<0.05$.

Table 2 presents the percentage occurrence of melanosis in the five species of shrimps. T-4/6 (211 - 260 g) had 0.09%, the highest percentage occurrence of melanosis among the black tiger shrimps, while 1W (75 – 105 g) had 0.1%, the lowest percentage occurrence of melanosis among the white shrimps. 5BR (12 – 24 g) had 0.63%, the highest percentage occurrence of melanosis among the brown shrimps. C/T-6 (9 - 11 g) had 0.67%, the highest percentage occurrence of melanosis among the black tiger shrimps, while F/T-2 (55 – 74 g) had 0.02% as the only occurrence of melanosis among flower tiger shrimps.

Figure 2 presents a monthly occurrence of melanosis for the year 2024. Melanosis recorded its peak in April 2024, with over 450 kg of shrimps that had black spots, while the lowest incidence of melanosis occurred in July 2024, with 50kg of shrimps having black spots.

Table 3 analysed the losses recorded from sales of shrimps that had melanosis. The mean loss recorded for black tiger shrimps sales (NGN584561.8±NGN335.27) was significantly different from that of brown shrimps (NGN335906±NGN155.97) but not significantly different from white shrimps (NGN93282.4±NGN75.57) at $P<0.05$. A total loss of NGN 7,729,908.30 was recorded for a period of 12 months after sales of all five shrimp species, while NGN 1,729,579.46 was observed in the 211 – 260 g grade of black tiger shrimps, being the highest loss in sales among the five shrimp species. NGN 151,815.04 loss was made following sales of 55 – 74 g grade, as the highest loss among the white shrimps. NGN 479,588.98 loss was made following sales of 5-6 g grade, as the highest loss among the brown shrimps. NGN 1,562,643.60 loss was made after sales of 12 - 24 g grade, as the highest loss among the rainbow shrimps. NGN 6156.22 loss was made after sales of 55 – 74 g grade, as the only loss among the flower tiger shrimps.

Plates 1 and 2 show the emergence of black spots in the

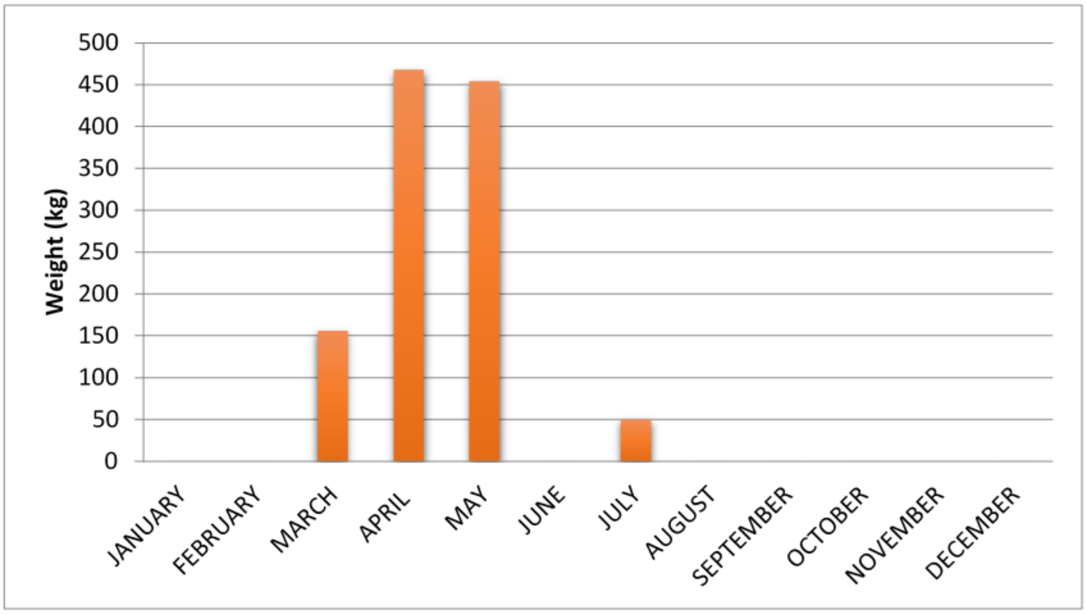

Figure 2. Monthly occurrence of melanosis for the year 2024.

Table 3. Annual loss due to melanosis in Naira

Weights (g)	Black Tiger Shrimps	White Shrimps	Brown Shrimps	Rainbow Shrimps	Flower Tiger Shrimps
261-400	114073.88	—	—	—	—
211-260	1729579.46	—	—	—	—
151-210	1064714.50	—	—	—	—
106-150	372314.34	—	—	—	—
75-105	218817.78	55026.44	—	—	—
55-74	7871.5	151815.04	—	—	6156.22
36-72	—	84946.26	—	12500.90	—
25-35	—	67245.84	—	25482.60	—
12-24	—	108521.60	297831.26	1562643.60	—
9-11	—	92139.26	302312.80	1185868.00	—
7-8	—	—	263890.80	6156.22	—
5-6	—	—	479588.98	—	—
Mean±SE	584561.8 ± 335.27^{a}	93282.4 ± 75.57^{a}	335906 ± 155.97^{b}	558530.3 ± 338.32^{bc}	6156.2^{c}
F Stat			5.43		
Remark			Significant		

^{abcd} Means along same row with different superscript are significantly different at ($p<0.05$). **Key:** SE = Standard Error.

frozen state of brown shrimps (*P. atlantica*) with extremely severe and severe cases, respectively. Plate 3 shows a single black tiger shrimp (*P. monodon*) with melanosis on the carapace and pleopods after a thawing process.

DISCUSSION

In this present study, the slightest visual observation for black spots as stated by Andrade *et al.* (2015) was adopted, but was not categorised based on the score for melanosis according to Montero *et al.* (2001). The shrimp species considered for this study was different from the shrimp species considered by Toktas and Gokoglu (2020), who worked on *Aristaeomorpha foliacea, Plesionika edwardsi* and *Melicertus hathor in a study of the e*ffects of ascorbic acid and erythorbic acid on melanosis and quality in different shrimp species caught from the Gulf of Antalya,

Plate 1. Frozen brown shrimps (*P. atlantica*) with extremely severe occurrence of Melanosis,

Plate 2. Frozen brown shrimps (*P. atlantica*) with severe occurrence of Melanosis.

Plate 3. Black tiger shrimp (*P. monodon*) with melanosis on the carapace and pleopods after thawing.

Turkey. While Sipahutar and Sitorus (2024) considered melanosis outbreaks from traditional and intensive ponds, this study examined the melanosis occurrence from five shrimp species caught in the wild (Nigerian Coastal Waters).

A total of 984.75 tonnes was caught over the period of twelve months (January 2024 - December 2024), out of which 1192 kg (596 packets) had the occurrence of melanosis (black spots), which is 0.11%. This indicated 99.89% effectiveness of sodium metabisulphite treatment, which was supported by Gokoglu *et al.* (2022) who used commercial sodium metabisulphite as an antimelanotic agent in giant red shrimps (*Aristaeomorpha foliacea*). However, Badee *et al.* (2020) suggested that 2% Mango Seed Kernel Extract could be used as an effective natural alternative to synthetic antimelanosic agents to inhibit post-mortem melanosis and improve the quality of shrimp during storage.

A total of 1192 kg of all shrimp species considered in this study were found to have black spots. Despite the treatment, other factors such as temperature abuse or fluctuation due to mechanical breakdown of the freezer or fish hold also play a significant role in the emergence and development of black spots, especially when the temperature during storage is not at an optimum level, such as -18°C or lower. This may likely be the cause of the 0.11% melanosis recorded in this study. While this study applied the use of sodium metabisulphite to prevent melanosis, Kimbuathong *et al.* (2020) increased CO_2 from 20 to 80% and decreased O_2 from 15 to 5% to inhibit melanosis.

A striking observation in this study revealed that melanosis hit its peak in April 2024, with over 450kg of shrimps that had black spots, closely followed by approximately 450 kg in May 2024. There seems to be an activity amounting to a deviation from the process that led to the occurrence of melanosis within both months. Ren *et al.* (2021) reported in a review of literature that physiological parameters of crustaceans are influenced significantly by temperature changes. This may have induced melanosis during this period. The lowest incidence of melanosis occurred in July 2024, with 50 kg of shrimps having black spots. The deviation appeared to have been rectified in the cooling system or through a favourable weather condition in July 2024; hence, no incidence of black spots was recorded from August to December 2024.

In Spain, the market price of fresh deep-water rose shrimp has increased by 25 – 50% in the past five years, reaching an average range of 15–50 euros/kilo in 2018, depending on the size (Martínez-Álvarez *et al*, 2020), while this study revealed different prices for export and downgraded prices for local sales. The downgraded prices were a result of melanosis. In a study on the profitability of the shrimp value chain in Delta State, Nigeria, carried out by Achoja (2019), the mean profit realised was NGN70,092, NGN36,255, and NGN26,097.30 by harvesters, processors, and marketers, respectively. In contrast to this study, sales of the products recorded the highest losses of NGN 1,729,579.46, NGN 151,815.04, NGN 479,588.98, NGN 1,562,643.6, NGN 6156.22 in black tiger (211 – 260 g), white (55 – 74 g), brown (9 – 11 g), rainbow (25 – 35 g) and flower tiger (55 – 74 g) grades, respectively among other grades of shrimps. The losses were made because of the emergence of black spots throughout the period under consideration.

Conclusion

The study concludes that the 0.11% occurrence of melanosis resulted in a significant reduction in the market value of shrimps. To prevent economic loss due to melanosis, shrimp marketers and businessmen should ensure adequate treatment of shrimps, optimum storage temperature and proper handling of shrimps. Further studies on the impact of melanosis on market prices for an increased number of years should be conducted for a better understanding of the trend over the years.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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