Microbiological, Biochemical and Organoleptic Quality of Marine Shrimp Ready-To-Eat (RTE) Value added Products Purchased from Self Help Group

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Abstract
The enzymatic, chemical, microbiological spoilage and organoleptic quality were assessed for three ready-to-eat (RTE) shrimp products. A total of three RTE products such as dry prawn pepper fry, dry prawn sambal and dry prawn masala were purchased from self help group women of Tuticorin. The quality of the product was good based on the nutritive profile (protein, lipid, carbohydrate and ash), quality (TVB-N, PV, TPC) and organoleptic factors. During sale these foods were kept at room temperature. During storage study at room temperature, the quality of RTE shrimp products in term of appearance, flavor and texture was found to be superior. Enzymatic, microbial and chemical spoilage of RTE shrimp samples were found to be decreased slower from origin value during storage. These RTE shrimps were biologically safe and sensorially acceptable after 30 days of storage at room temperature. Hygienically prepared RTE shrimp products is a novel type of important domestic products in Tuticorin with good mouth feel and long shelf life was obtained and such product is of a great economic significance by expanding the utilization of shrimps.

Keywords
Ready-to-eat shrimp product; Quality assessment; Spoilage; Storage; Shelf life

Introduction
Fresh shrimps are highly perishable, thus they predominantly appear in the form of frozen raw or cooked products in markets. Apart from fresh and cooked product a ready-to-eat (RTE) product would be more convenient for the consumer. RTE shrimp is a novel type of important domestic products prepared by self help group people of Tuticorin and sold in public markets, i.e. supermarkets and traditional market, and they provide consumer for immediate consumption or for consumption with simple processing or preparation. However, RTE products possess a managerial challenge to the food safety authority for continuous surveillance of the quality and preparation of the foods [1-3]. The shrimp product contaminated as a result of the ways of post-harvest and process by manpower, affecting the storage characteristic.

From harvest to the table, sea foods may be exposed to a range of hazards, some of which are natural to the sea food’s environment and others that are introduced by handlers [4]. There are serious safety concerns related to the consumption of raw fish and shellfish due to the presence of biological (bacteria, viruses, parasites) and chemical hazards that could pose health risks to consumers [5]. The many gaps in the literature on possible local sources of infections in foods, including shrimp, led to the undertaking of this research, to determine whether shrimp product consumption could pose such health risks to consumers as a result of bacterial, enzymatic and chemical contamination.

The appearance, odour, colour and texture of RTE products are fundamental to assess the quality. An estimate of freshness can be obtained by defining criteria related to changes in the organoleptic attributes like appearance, odour, colour and texture that can be measured or quantified by sensory methods [6]. Organoleptic evaluation is defined as the scientific discipline used to evoke, measure, analyze and interpret reactions to characteristics of food as perceived through the senses of sight, smell, taste, touch and hearing. Several quality studies have already been undertaken in countries such Turkey, Thailand, Brazil, Iceland, Greece and Mexico on the biochemical, microbiological, physical and sensory characteristic changes in shrimp by products [7-14].

Present market trends reflect a rapidly growing demand for ready to serve and ready to cook convenience products. The sophisticated consumer abroad as well the urban consumer at home demand new type of value added, hygienically prepared, nutritious and attractively packed products. Increasing number of working women and also more emphasis is put on leisure pursuits. Europeans also have a reasonable good expendable income and educations are some of the considerations which increase the demand and
marketability of value added products [15]. During development of new products, price of the raw material, physico-chemical characteristics of the raw material, shelf-life of the product, nutritional quality, consumer acceptance and advertising skills plays an important role. The investigations have been carried out to assess the ready to eat shrimp products are shelf stable and microbiologically safe using standard methods and proper packaging and storage. The objectives of this study were to: (i) determine the enzymatic, chemical, organoleptic and microbiological quality of shrimp value added products (Penaeus sp.) sold met international and local standards and (ii) compare the quality of the products at 0 storage time to 3 months stored at room temperature.

Materials and Methods

**RTE shrimp products**

The shrimp ready to eat value added products such as dry prawn pepper fry (Figure 1), dry prawn sambal (Figure 2) and dry prawn masala (Figure 3) were bought from Tuticorin self help group women own manufacturing during November 2017. They prepared and sold it in super market and they plan to export also. For this product preparation they use the small size shrimp as a raw material purchased from the fish landing center of Tuticorin at low cost. Some time they use the bycatch for economical benefits. During collection all the samples were packed with ice transported to the processing area, cleaned and dried hygienically using the solar dryer provided by SDMRI laboratory. The dried raw materials were used to prepare the ready to eat shrimp products such as prawn pepper fry, dry prawn sambal and dry prawn masala. The exact recipe of the product was not given in the label. They told except dry prawn sambal all the other products can eatable as raw like snack. Dry prawn sambal can consumed after simple preparation. The nutritive and quality indicators were not given in the package. The final product was packed in low density polyethylene pouches of 50 g capacity.

**Sample collection**

Each shrimp value added product purchased from self help group and it was placed into a sterile bag and transported to the SDMRI laboratory. Samples were processed within 30 minutes of arrival for microbiological quality such as total plate count (TPC). The nutritive profile like protein, lipid, ash and carbohydrate were determined using standard methodology. The products were examined for enzymatic spoilage (pH, and TVB-N), chemical spoilage (PV). The rest of the samples were stored for 1, 2 and 3 months at room temperature (27°C to 30°C) to conduct the organoleptic evaluation, enzymatic, chemical and microbiological changes during storage at monthly intervals for 3 months.

**Methodology for determination of quality**

**Proximate composition:** The experimental ready to eat shrimp products were aseptically minced and homogenised for the proximate composition analysis. The protein and lipid contents of RTE shrimp products were determined according to the method of Lowry et al. [16] and Folch et al. [17]. Ash content was measured by Chicas and Ward [18] method using Muffle furnace. The moisture content was determined by drying the samples in a hot air oven at 100 -105°C for 16 hours until a constant weight was obtained [19].

**pH:** The pH analysis was done in samples homogenised with 10 volumes deionised water (w/v) by the method of Goulas & Kontominas [20] using HANNA pH 213-microprocessor pH meter.

**FFA:** Free fatty acid (FFA) was measured using titration with NaOH following the method of Morris [21] and expressed as per cent oleic acid equivalent.

**Trimethylamine nitrogen (TMA-N):** The spoilage indicators of Total volatile base nitrogen (TVB-N), was determined from trichloroacetic acid extract of the seafood sample using micro diffusion method of Conway [22].

**Peroxide value (PV):** The peroxide value (PV) was determined by titrating the iodine liberated from potassium iodide with standardized 0.01 N sodium thiosulphate solution using the method of Low & Ng [23] and it was expressed as milliequivalents of free iodine kg⁻¹ of lipid.

**Microbiological analysis:** Samples were randomly taken to estimate total plate counts (TPC) according to standard AOMC methods [24]. 10.0 g of shrimp products were blended with 90 ml of 0.85% sterile saline solution and then stomached for 3 min. Serial decimal dilutions of 10⁻¹ to 10⁻⁵ dilutions were prepared with 0.85% sterile saline solution diluent. And then 0.1 ml of each dilution was pipetted onto the surface of plate count agar plates (Hi Media). They were then incubated for 2 days at 35°C.

**Organoleptic evaluation:** The quality attributes evaluated for the raw samples were appearance, odour and texture using a score sheet. A modified version of the method outlined by Ouattara et al.
(25) was used to carry out the organoleptic evaluation of shrimp product in this research. A group of 8 trained persons were asked to grade the appearance of the, texture, odour, taste, colour, flavour and as well as the overall acceptability of the shrimp value added samples using a 10 point quality scale ranging from 10 (excellent) to 1 (unfit). All panelists were trained in advance to identify product of fresh, good, moderate, borderline and spoil quality using the quality scale and decomposed shrimp samples at various stages. The limit of acceptability was fixed at 5.0.

Storage study: The entire ready to eat shrimp sample bags were stored in room temperature (28-32°C) for three months. At the start of experiment, and thereafter at monthly intervals samples were drawn and analyzed in duplicate for all the quality indicators such as pH, TVB-N, PV, TPC and organoleptic character by the standard methods.

Results and Discussion

Ready to eat shrimp products used in the present investigation were analyzed for the proximate composition, quality characteristic and organoleptic consumer acceptance and storage. The results of this analysis are given in the following subsections (Table 1). For standardization of proper processing methods and for removing unjustified prejudice from the minds of common consumers, a clear idea about the proximate composition of common food is essential. Proximate composition of food items varies with raw material, type of species, sex, body size, environmental factors and nutritional status, and even on the type of collection [26].

Moisture plays an important role to retard the bacterial spoilage as lowering the moisture content of food [27]. Water content also found to vary considerably with the food item depending on the fat content [28]. Reddy et al. [29] reported that the moisture content of fish finger from croaker and pink perch were 70.8 and 72.0% respectively. Lazos [30] reported that the moisture content of canned fish ball (boiled at 120°C) from freshwater seabream was 69.51%. The moisture content of intermediate moisture fish patties from minced rockfish meat was 33.0% [31]. In the present study all the three shrimp value added product was less than 10%. The moisture content was less than 10% is good for the dried product to avoid the microbial spoilage [32].

Protein is the most important constituent of food from the nutritional point of view. Protein content in most seafood averages between 18-20%, though the general variation is in the range of 15-24% [28]. Variations in protein content in seafood occur in relation to age, fat content, spawning, and starvation of the raw material. Shrimp are more prone to denature under storage condition and changes in protein fraction of seafood during storage were studied by several workers [33-39]. However, the seafood muscle proteins are less stable than those of mammalian proteins [40,41]. In the present study protein content of prawn masala (9.6%), prawn sambal (11.4%) and pepper fry (9.3%) and the variation in the protein content in the products due to the processing method. Reddy et al. [29] reported that the protein content of fish finger from croaker and pink perch were found to be less (13.0 and 11.9% respectively) than the picked meat of croaker and pink perch due to the addition of additives. Lazos [30] reported that the protein content of canned fish ball (boiled at 120°C) from freshwater seabream was 19.03%. Destura and Haard [31] reported that the protein content of intermediate moisture fish patties from minced rockfish meat was 34.0%. Balachandran [28] reported the product having >8% protein content that product is good for consumption and this study shows RTE shrimp product have high protein and it is good nutritive supply to the consumers.

In a raw seafood meat, lipid oxidation occurs over days or weeks whereas in cooked meat, the reaction proceeds rapidly [42]. Reddy et al. [29] reported that the fat content of fish finger from perch and croaker were found to be more (5.5 and 5.6% respectively) than the picked meat of croaker and perch due to the incorporation of ground nut oil mainly. Lazos [30] reported that the fat content of canned fish ball from freshwater seabream was 5.18%. While Destura and Haard [31] observed that the fat content of intermediate moisture fish patties from minced rockfish meat was only 1.0%. In the present study the lipid content of prawn masala (4.1%), prawn sambal (3.5%), pepper fry (3.9%). Adeyeye et al. [43] reported Penaeus species having lipid content of 1-3% and the higher content of lipid were observed in the shrimp product may due to the incorporation of oil for frying process.

Ash is the portion left after complete combustion of the product. Ash is constituted by the minerals present in seafood and the content varies between 0.4 and 2% in seafoods [28]. Reddy et al. [29] reported that the ash content of fish finger from croaker and pink perch were found to be more (3.3 and 3.4% respectively) than the picked meat of croaker and pink perch (1.4 and 1.6 respectively) due to incorporation of ingredient mixture. Lazos [30] reported that the ash content of canned fish ball (boiled at 120°C) from freshwater seabream was 3.05%. The ash content of all the products of mackerel showed marginal increase throughout the storage period [44]. Destura and Haard [31] reported that the ash content of intermediate moisture fish patties from minced rockfish meat was 9.0%. In the present study all the RTE shrimp product have >3% ash content. The high ash content of the product due to the inclusion of whole animal with shell and addition of other ingredients [45].

The pH of the RTE products was 6.1 for dry prawn masala, 5.7 for prawn sambal and 6.23 for prawn pepper fry. Though mild acidity would be favorable to seafood products for extending their shelf-life and also to prevent the growth of spoilage bacteria. Hegde et al. [46] showed that the initial pH value of fish sausage incorporated with potato starch from croaker was 6.8. Lazos [30] reported that the pH value of canned fish ball (boiled at 120°C) from freshwater seabream was 5.21. Destura and Haard [31] reported that the pH value of fish patties (dehydrated at 40°C) from minced rockfish meat was 6.5. Smittle [47] reported that acidity pH have a significant effect on the reduction of some pathogenic organisms. The above study indicated that this mild acidity of the RTE product can retain the product with good shelf life.

The free fatty acid content is the most popular measure of lipolysis in seafood. It depends on time, temperature, processing, storage and fish species. The rate of lipolysis depends on the time of harvest, sex, gonad maturity and also on numerous factors related to processing techniques, such as mincing, blending and pre-freezing storage in frozen fish [48]. Reddy et al. [29] reported that the FFA (as % of oleic acid) content of fish finger from croaker and pink perch were 0.43 and 0.41% of oleic acid, respectively. Hegde et al. [46] reported that the FFA content of fish sausage, incorporated with potato starch dried powder increased from 3.45% of oleic acid. Most fat acidity begins to be noticeable to the palate when the FFA value calculated as Oleic acid is about 0.5 -1.5% [49]. In the present study FFA value of RTE product was high in dry prawn masala (0.32% oleic acid) followed by 0.269% oleic acid in prawn pepper fry and 0.11 % oleic acid in dry prawn sambal and these values are within the acceptable limit of lipolysis of the product.

Table 1: The quality of shrimp RTE products

<table>
<thead>
<tr>
<th>Nutritive parameters</th>
<th>Dry prawn masala</th>
<th>Dry prawn sambal</th>
<th>Prawn pepper fry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (%)</td>
<td>9.6</td>
<td>11.4</td>
<td>9.3</td>
</tr>
<tr>
<td>Lipid (%)</td>
<td>4.1</td>
<td>3.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>3.7</td>
<td>4.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>5.1</td>
<td>5.08</td>
<td>3.5</td>
</tr>
<tr>
<td>Quality indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.1</td>
<td>5.7</td>
<td>6.23</td>
</tr>
<tr>
<td>TVB-N (mg N/100 g)</td>
<td>5.6</td>
<td>2.4</td>
<td>7.12</td>
</tr>
<tr>
<td>PV (meq O2/kg fat)</td>
<td>1.18</td>
<td>0.12</td>
<td>1.2</td>
</tr>
<tr>
<td>FFA (% of oleic acid)</td>
<td>0.29</td>
<td>0.11</td>
<td>0.32</td>
</tr>
<tr>
<td>Microbial quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBC (CFU/g)</td>
<td>0.2 x 10³</td>
<td>0.7 x 10³</td>
<td>TLTC</td>
</tr>
</tbody>
</table>

https://boffinaccess.com/journals/food-and-nutrition-open-access/index.php
Total volatile base nitrogen (TVB-N) is one of the most common indices of quality used universally for deciding the state of freshness of the food. Spoilage of seafood is accompanied by the release of several volatile compounds like dimethylamine, trimethylamine oxide, trimethylamine and ammonia etc. In this study the concentration of these compounds in the products may indicate the degree of spoilage, particularly in the later stage of spoilage. Kimura and Kiamakura [50] suggested that volatile base nitrogen level of 10-20 mg N/100 g or less for fresh food, 20-30 mg N/100 g at the beginning of spoilage and over 30 mg N/100 g for spoiled food. Babbbiti et al. [51] suggested that drying and frying process accelerates the reduction of TVMAO. Suzuki [52] reported that higher values of TVB-N of the similar products prepared by mixing the minced meat of different varieties of fish and found them acceptable. Reddy et al. [29] reported that the TVB-N value of fish finger from croaker and pink perch were 8.4 and 9.8 mg N/100 g respectively. Lazos [30] reported that the TVB-N value of canned fish ball (boiled at 120°C) from freshwater bream was 42.19 mg N/100 g. The TVB-N content of fish sausage, incorporated with potato starch dried powder from croaker, was 6.78 mg N/100 g. In the present study high TVB-N content was observed in prawn pepper fry (7.12 mg N/100 g) followed by dry prawn masala (5.6 mg N/100 g) and dry prawn sambal (2.4 mg N/100 g). The high TVB-N was observed in fried RTE products compared to non-fried one (sambal) but, both the values are within the acceptable limit of spoilage. Frying was more effective in reduction of TVB-N due to the heating effect of cooking process may be related to the volatilization of the volatile nitrogen during frying [53]. The wide variations in the levels of TVB-N are due to differences in the composition and handling methods etc. [28].

Oxidative rancidity is one of the most important factors that determine the acceptability of the seafood products during processing and storage. The peroxide value is a measure of the first stage of oxidative rancidity, the very complex nature of the reactions involved during auto-oxidation. The correlation between peroxide value and organoleptically detectable rancidity is often slightly variable [28]. If the PV is above 10-20 milliequivalent 02/kg of fat, the seafood will smell and taste rancid [54]. Anand [55] observed that peroxides were absent in very fresh pink perch. Deng et al. [56] reported a PV of 2 milliequivalent 02/kg of fat of fresh fish muller. The PV content of fish finger from croaker and pink perch were 2.43 milliequivalent 02/kg of fat and 2.97 milliequivalent 02/kg of fat respectively [29]. In the present study shrimp ready to eat products have very less PV such as 1.18, 0.12, 1.2 meq 02/kg of fat for dry prawn masala, dry prawn sambal and prawn pepper fry respectively and the results indicates the product was fresh without rancid.

Microbiological changes affect the composition of food product. To produce a finished product with high quality, it is important to protect and monitor the integrity of the product. Tarr [57] suggested that the best single test for the bacteriological quality of seafoods would be the determination of total bacterial populations. Liston [58] stated that spoilage of food products is a bacteriological phenomenon and the chemical changes which take place are mostly due to bacterial enzymes. Josephson et al. [59] reported that putrid aromas and flavours resulting from microbial degradation of food products. The microbial counts were in excess of 1.00 × 107 cfu/g which were considered unacceptable quality [60]. Total plate count should not exceed 5.0 × 107 cfu/g in raw fish and fishery product whereas, in cooked/boiled fishery product it should not exceed 1.0 × 105 cfu/g [61]. Raccagh and Baker [62] reported that total plate count of mechanically deboned cod, pollock and whiting ranged from 4.7 × 107 cfu/g to 7.0 × 105 cfu/g. Reddy et al. [29] found a total plate count of 3.0 × 105 cfu/g and 2.16 × 105 cfu/g in fish finger from croaker and pink perch respectively. Hegde et al. [46] observed that a total plate count of value added fish sausage was 1.4 × 105 cfu/g and Yu and Lee [63] observed total plate count of 2.2 × 105 cfu/g in fish balls. In the present study total bacterial load was high in dry prawn masala followed by 0.2 × 105 cfu/g followed by 0.7 cfu/g in dry prawn sambal and too low to count in pepper prawn fry (<30 colonies) and all the three products were microbiologically pure and free from heavy bacterial load. Spices like chilli powder and pepper were added in shrimp RTE products may be the reason for very less microbial count [64]. Monk et al. [65] reported spices have antimicrobial properties. But in the case of sambal fresh raw material without any preservative and it may be the reason for presence of microbial load when compared to other two products [66]. Ayres [67] reported freshness of raw material was responsible for the microbial load of the food products. In the present study very fresh raw material was collected for processing and drying were done using hygienic solar dryer might be the reason for very less microbial load in ready to eat shrimp products.

The organoleptic qualities of shrimp RTE products are presented in Table 2. Organoleptic evaluation is a tool for assessing the quality of food products if such tests are designed properly and trained personnel were selected [68]. Farber [69] developed a numerical scoring system for the organoleptic assessment of freshness. Govindan [70] stated that organoleptic evaluation is a very important method in determining the acceptability of all food products. These are being used to assess flavour, texture, taste, colour and overall acceptability [71]. Keeton [72] developed 10 point hedonic scale panel sheet for the sensory assessment of food products. Hegde et al. [46] reported that the organoleptic attributes in fish sausage incorporated with potato starch, dried powder from croaker, showed higher mean values as the beginning of the experiment. In the present study 10 hedonic scale panel sheet were developed for shrimp RTE products resulted all the products are having excellent characters and showed higher values and all are accepted favorably by the consumers. The panel scores for all the organoleptic characteristics remained within the acceptable limit for all the shrimp products. An appearance is very good for all types of shrimp ready to eat products, and according to the opinion of the taste panel, the dry prawn pepper had good taste followed by prawn sambal and dry prawn masala.

Apart from the quality study the storage stability of the above product were examined for the period of 3 months (Table 3) because seafood meat has shorter storage life compared to other foods. During storage period, the processing action product itself, which break down, allowing greater opportunity for enzymatic and chemical changes in the seafoods [73]. Mills [74] stated that the quality changes that are occurring during room temperature storage are of great economic importance. The quality deterioration seafoods products during storage has been documented for a long time [75].

<table>
<thead>
<tr>
<th>Organoleptic parameters</th>
<th>Dry prawn masala</th>
<th>Dry prawn sambal</th>
<th>Prawn pepper fry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Colour</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Odour</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Taste</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Texture</td>
<td>8</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Falvour</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2: Organoleptic characteristics of the shrimp ready to eat products
Acknowledgement

Samples of all the products were subjected to sensory analysis by a trained panel of consumers. The panelists rated the products on a scale from 1 to 5 for each parameter: texture, color, appearance, and odor. The overall acceptability of each product was also determined.

Conclusions

1. The sensory acceptability of RTE shrimp products such as dry prawn masala, dry prawn sambal, and prawn pepper fry was influenced by the length of storage. The products stored for a longer period showed a decrease in sensory acceptability.

2. The pH values of the products remained within the acceptable range throughout the storage period, indicating that the products were stable.

3. The TVBN values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

4. The FFA content increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

5. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

6. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

7. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

8. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

9. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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11. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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13. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

14. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

15. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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17. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

18. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

19. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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21. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

22. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

23. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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25. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

26. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

27. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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29. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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38. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

39. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

40. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

41. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

42. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

43. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

44. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

45. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

46. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

47. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

48. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

49. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

50. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

51. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

52. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

53. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.

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82. The PV values increased with the storage period, indicating the onset of lipid oxidation. However, the values remained within the acceptable limits for food products.

83. The TPC values remained within the acceptable range throughout the storage period, indicating that the products were stable.
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