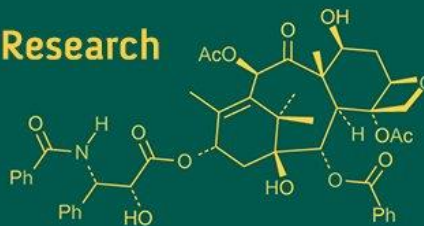


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(6): 962-970
www.biochemjournal.com
Received: 25-03-2026
Accepted: 29-04-2026

Tandel Khushiben Prakashbhai
P.G Scholar, Department of
Fish Processing Technology,
College of Fisheries Science,
Kamdhenu University,
Veraval, Gujarat, India

DV Bhola
Associate Professor,
Department of Fish Processing
Technology, College of
Fisheries Science, Kamdhenu
University, Veraval, Gujarat,
India

BG Chudasama
Professor, Department of Fish
Processing Technology, College
of Fisheries Science,
Kamdhenu University,
Himmatnagar, Gujarat, India

Binal Tandel
Ph.D. Scholar, Department of
Aquaculture, College of
Fisheries Science, Kamdhenu
University, Veraval, Gujarat,
India

Dhruti N Tandel
Department of Aquaculture,
College of Fisheries Science,
Kamdhenu University,
Himmatnagar, Rajpur, Nava,
Gujarat, India

Krupa B Tandel
P.G Scholar, Department of
Fish Processing Technology,
College of Fisheries Science,
Kamdhenu University,
Veraval, Gujarat, India

Corresponding Author:
Tandel Khushiben Prakashbhai
P.G Scholar, Department of
Fish Processing Technology,
College of Fisheries Science,
Kamdhenu University,
Veraval, Gujarat, India

Effects of partial sodium replacement on quality of salted-dried shrimp (*Metapenaeus affinis*) stored at ambient temperature

Tandel Khushiben Prakashbhai, DV Bhola, BG Chudasama, Binal Tandel, Dhruti N Tandel and Krupa B Tandel

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6l.8799>

Abstract

The current study was carried out to assess the effects of partial sodium replacement on quality of salted-dried Jinga shrimp (*Metapenaeus affinis*) stored at ambient temperature conditions. Fresh Jinga shrimp was purchased from the fish landing center and processed under hygienic conditions. After processing, shrimp were treated with different salts such as potassium chloride and calcium chloride as partial replacement of sodium chloride as per the following treatment details: T₁ (100% NaCl), T₂ (50% NaCl and 50% KCl), T₃ (50% NaCl and 50% CaCl₂) and T₄ (33.33% each NaCl, KCl and CaCl₂) followed by drying in artificial air dryer, packed into LDPE bags and stored at ambient temperature for six months. The variation in the quality of shrimp was observed during storage period. To measure those changes proximate, biochemical, microbiological, physical and sensory analysis were carried out at one month intervals. According to the results obtained from the above analysis indicated that treatment T₂ (50% NaCl and 50% KCl) achieved highest acceptance values. The proximate composition for treatment T₂ such as moisture increased and crude protein, fat and total ash decrease to the lesser extent than other treatments. The biochemical parameters such pH, TMA-N, TVB-N and PV indicated that treatment T₂ was the best alternative for the replacement. The microbiological parameters such as total plate count were increased during storage period. According to the sensory score the treated samples were accepted compared to control and the total fungal count was also increased in treatment T₁, T₃ and T₄, respectively. Treatment T₂ showed the best result for all parameters with higher sensory scores indicated that potassium chloride as a partial replacement of sodium chloride was possible without losing product quality. Treatment T₁ (100% NaCl) spoiled earlier than all treatments, followed by treatment T₃ (50% NaCl and 50% CaCl₂) due to the hygroscopic nature of calcium chloride. While, treatment T₄ (33.33% each NaCl, KCl and CaCl₂) resulted intermediate scores between treatment T₂ and T₃. As potassium chloride share similar properties with sodium chloride and act as a best alternative for partial replacement of sodium in lesser quantity. Higher replacement of sodium chloride with other salts may produced bitter taste and adverse effects.

Keywords: Jinga shrimp (*Metapenaeus affinis*), partial sodium replacement, potassium chloride, drying, ambient temperature storage

1. Introduction

Seafood, including fish and other aquatic foods, plays an important role in global food security by supplying nearly 20% of the animal protein consumed by people worldwide (FAO, 2014) [15]. Seafood is a nutritious and healthy food for people of all age groups, including children, pregnant women, active adults and older people (Reames, 2012) [48]. The demand for seafood is increasing because it is a good source of healthy polyunsaturated fatty acids, especially omega-3 fatty acids such as EPA and DHA. These nutrients are well known for their many health benefits and help maintain good overall health (Ajifolokun *et al.*, 2018) [1].

In 2024, marine fish landings along the mainland coast of India were estimated at 3.45 million tonnes, showing a slight decline of about 2% compared to 3.53 million tonnes recorded in 2023. Among shellfish resources, non-penaeid shrimps contributed the highest share with 1.06 lakh tonnes, whereas penaeid shrimp landings were estimated at 0.27 lakh tonnes (CMFRI, 2025) [10].

During the financial year 2023-24, India achieved its highest-ever marine product exports, reaching 16,98,170 metric tonnes with a total export value of US\$ 7.45 billion. The United States and China remained the major importers of Indian seafood products. Among all exported marine products, frozen shrimp continued to be the leading export commodity. Dried marine products also made a notable contribution to the export sector, with an export quantity of 2,52,948 metric tonnes. These dried products accounted for 14.90% of the total export volume and contributed 4.57% to the overall export value (MPEDA, 2025) [36].

Shrimp have semi-transparent and flattened bodies, which give them a distinct appearance compared to other aquatic animals (Entsua-Mensah *et al.*, 2002) [13]. Shrimp continue to play an important role as a source of income and economic value. *Metapenaeus affinis* is a commercially important species because it is widely distributed along the entire west coast and the southern east coast of India. This species is also comparatively larger in size (SJ & Sankar, 2023) [52]. Shrimp are becoming a popular protein choice around the world because of their health benefits and delicious taste. They are highly nutritious, containing about 18-20% protein, 75-80% water and only a small amount of fat (around 4.5%). Shrimp also provide important nutrients such as essential amino acids and minerals like selenium, copper, zinc and calcium, all of which are beneficial for maintaining good health (Yanar & Celik, 2006; Sriket *et al.*, 2007) [59] [48]. Shrimp contain high amounts of moisture and protein, which makes them highly perishable. As a result, they spoil rapidly after harvesting if they are not properly stored under cold conditions (Kortei, 2015) [27].

Salt is a naturally occurring inorganic compound composed of sodium and chloride, usually seen as white crystalline cubes. It is one of the most widely used ingredients in food because it not only enhances flavour but also helps in preserving food products. In meat and processed meat products, salt plays several important roles, such as improving water retention, enhancing colour, binding proteins and fats and contributing to better texture and taste. When used in higher concentrations, salt also helps control the growth of microorganisms through osmotic action, thereby increasing the shelf life of the product (Nitipong *et al.*, 2020; Silva *et al.*, 2003; Toldra *et al.*, 2009) [39] [50] [55]. Consuming too much sodium can lead to several health issues, including an increased risk of stomach cancer, reduced bone strength caused by loss of mineral density and a possible higher risk of obesity (Faralizadeh *et al.*, 2016) [16]. In India, high blood pressure is one of the major risk factors for non-communicable diseases (NCDs) and is believed to account for nearly 10% of all deaths (Lim *et al.*, 2012) [30]. It is widely recognized that consuming more than 6 g of salt per day can increase blood pressure over time, especially as people grow older. To support healthy blood pressure and overall well-being, it is recommended to limit daily salt intake to less than 5 g (WHO, 2003) [58]. The recommendation to limit daily sodium intake to less than 1500 mg is supported by strong scientific evidence (Antman *et al.*, 2014) [4].

Due to growing health concerns about excessive sodium intake have created a greater demand for low-sodium food products (Gomes *et al.*, 2021) [21]. Partially replacing sodium chloride (NaCl) with potassium chloride (KCl) is considered an effective approach to lowering the sodium content in foods. Since both salts perform similar functions in food

processing, this substitution can be made without significantly affecting food quality. In addition, potassium intake is not associated with high blood pressure or cardiovascular diseases (Geleijnse *et al.*, 2007) [20]. The type of salt used can affect the effectiveness of the salting process. For instance, salts containing calcium and magnesium may slow the absorption of salt into fish tissues, which can reduce the overall efficiency of salting (Moody & Flick, 1990) [35]. Small amounts of calcium and magnesium salts can be beneficial, as they help improve the whiteness of fish and reduce enzyme activity that causes spoilage. Though, replacing more than 50% of sodium chloride with potassium chloride and calcium chloride may produce a metallic or bitter taste and can also negatively affect the overall flavour and texture of the salted product (Wang *et al.*, 2021) [57].

Before drying, seafood products are often treated by salting, blanching or soaking them in antioxidant or preservative solutions. These pretreatment methods help reduce drying time, improve product yield, enhance flavour and taste and increase the shelf life of the final product (Qiu *et al.*, 2019) [43]. To obtain high-quality dried products, it is important to preserve the key qualities of fresh foods throughout the drying process (Zhang *et al.*, 2017) [60].

2. Materials and Methods

2.1 Experimental procedure

The study was carried out on Jinga shrimp (*Metapenaeus affinis*) at the Fish Processing Technology Laboratory, College of Fisheries Science, Kamdhenu University, Veraval. Fresh shrimp were procured from the Veraval fish landing center and transported to the laboratory in an insulated box with ice, maintaining the temperature between 1-2 °C. Once at the laboratory, the shrimp were washed with chilled water to remove dirt, slime and other impurities. Their average length and weight were measured and they were sorted by size. After that, the shrimp were beheaded, peeled and deveined (PD) for further analysis.

The jinga shrimp were processed into four treatment groups: T₁, T₂, T₃ and T₄. In treatment T₁ (control), the shrimp were pre-treated with 12% (w/w) salt using 100% sodium chloride (NaCl), in treatment T₂, the shrimp were pre-treated with 12% (w/w) salt using a mixture of 50% sodium chloride (NaCl) and 50% potassium chloride (KCl), in T₃ treatment, the shrimp were pre-treated with 12% (w/w) salt using a mixture of 50% sodium chloride (NaCl) and 50% calcium chloride (CaCl₂) and in treatment T₄, the shrimp were pre-treated with 12% (w/w) salt using an equal mixture (33.33% each) of sodium chloride (NaCl), potassium chloride (KCl) and calcium chloride (CaCl₂), followed by drying in artificial dryer at 55 °C for 17 hours, packing in LDPE bags and storage at ambient temperature.

2.2 Proximate composition of shrimp

The proximate composition of shrimp such as moisture, crude protein, lipid and ash content of raw material as well as salted-dried shrimp were assessed by AOAC (2006) [5] method and expressed as%.

2.3 Quality evaluation of shrimp

The quality parameters of salted-dried Jinga shrimp, including physical, biochemical, microbiological and sensory characteristics, were assessed using standardized methods. pH, total plate count (TPC) and total fungal count

(TFC) were determined according to AOAC (2006) [5]. Trimethylamine nitrogen (TMA-N) and total volatile base nitrogen (TVB-N) were estimated using the method described by Beatty & Gibbons (1937) [6]. Sensory characteristics were evaluated using the method developed by Peryam & Pilgrim (1957) [41].

3. Statistical Analysis

Statistical analysis was carried out on triplicate observations for each sample at every storage interval. Significant differences among treatments were evaluated using ANOVA as described by Snedecor & Cochran (2014) [53]. Data were analyzed using IBM BASIC Windows (Release 1.13).

4. Results and Discussion

4.1 Proximate composition of salted-dried shrimp

4.1.1 Moisture content (%)

The moisture content of shrimp explained in Table 1. Treatment T₁ with (100% NaCl) shows higher moisture content than other treatments T₂, T₃ and T₄. El-sanat *et al.* (2006) [12] found that the control samples, which were salted exclusively with NaCl, generally retained more moisture compared to those treated with varying levels of NaCl replacement by KCl in grey mullet, which was similar with findings of the present study. Faralizadeh *et al.* (2016) [16] also found similar result in hot smoked Kilka during storage at ±4° C moisture content of fish treated with KCl was lower than control (with NaCl). At the beginning, the moisture content was low, but it gradually increased over time, indicating a risk of spoilage and microbial contamination.

4.1.2 Crude Protein content (%)

The crude protein content of shrimp recorded in Table 1. From this finding suggested that treatment T₂ retained highest protein content after storage. Salting itself caused protein denaturation to some extent which led water to released from the fish muscle (Izdiharrudin, 2019) [24]. Lauritzsen *et al.* (2004) [28] observed that during dry salting

process protein may denatured and decrease in protein content over time in the salted cured cod. Faralizadeh *et al.* (2016) [16] observed a significant difference in protein content in hot-smoked kilka when sodium was partially replaced with potassium.

4.1.3 Changes in Fat content (%)

The fat content of shrimp noted in Table 1. The present study indicated that moisture content was inversely proportional to fat content with treatment T₂ shows best result. Akonor *et al.* (2016) [2] reported a fat content of 5.74±0.11% in solar-dried shrimp meat, which was nearly similar with fat content observed in the present study in treatment T₂. Ajifolokun *et al.* (2018) [1] reported that fat content has an inverse relationship with water content in dried shrimps (*Penaeus notialis*). Similar result also found by Chukwu (2009) [9] on their study observed that fish with lower fat content tend to have higher moisture content in dried catfish. Zhang *et al.* (2015) [61] examined that different salt combinations influenced lipid breakdown and fat quality, they found that after 6 months, treatment with (100% KCl) showed the lowest FFA value (7.80%). El-Sanat *et al.* (2006) [12] stated that the fat content showed a gradual and moderate decline, reaching 6.26% in grey mullet treated with NaCl alone and 7.53% in samples salted with a 50% NaCl + KCl mixture by the end of the four-week salting and curing period. Similar decreasing trend observed in the present study with previous reports.

4.1.4 Total ash content (%)

The values for the ash content of the shrimp described in Table 1. Due to salting inorganic substances increased at the initial stage. The values were decreased for the ash with treatment T₁ shows highest decreasing value. Martínez-Alvarez & Gómez-Guillén (2005) [31] stated that the increase in ash content may be attributed to the reduction in moisture content and the rise in salt levels in dry salted cod fillets, which is similar with current study results.

Table 1: Proximate composition of salted dried Jinga shrimp (Mean ± SD)

	Storage days/Treatment	T ₁	T ₂	T ₃	T ₄
Moisture	0	13.80±0.14	12.21±0.1	13.37±0.08	12.74±0.11
	180	19.81±0.17	16.12±0.08	18.72±0.22	17.78±0.11
Crude protein	0	73.12±0.1	73.77±0.13	73.21±0.11	73.73±0.18
	180	64.88±0.2	67.25±0.13	65.16±0.17	66.19±0.23
Fat	0	3.22±0.11	5.82±0.12	3.75±1.14	4.47±0.1
	180	1.34±0.09	1.87±0.08	1.39±0.05	1.6±0.08
Ash	0	7.46±0.1	8.07±0.05	7.77±0.19	7.91±0.09
	180	3.36±0.12	5.8±0.16	4.16±0.05	4.67±0.08

4.2 Biochemical Characteristics

4.2.1 pH

The pH serves as an indicator of microbial spoilage in fish (Eyo, 1993) [14]. During the post-mortem period, the breakdown of nitrogenous compounds results in a rise in the pH of fish flesh (Shenderyuk & Bykowski, 2020) [49]. pH of shrimps for the different treatments at day 0 was T₁ (6.15±0.12), T₂ (6.04±0.06), T₃ (6.10±0.07) and T₄ (6.04±0.06). In general, the pH of the samples gradually increased during storage, primarily due to the formation of basic compounds such as ammonia, trimethylamine and other biogenic amines generated by spoilage bacteria in fish (Fuentes *et al.*, 2012) [19]. Fish products are generally

considered acceptable up to a pH of 6.8, while values exceeding 7.0 indicate spoilage (Farid *et al.*, 2014) [17]. Leroi & Joffraud (2000) [29] reported that the addition of salt reduces the pH of fish muscle in salmon, which was similar with the present study.

4.2.2 Trimethylamine Nitrogen (TMA-N)

Trimethylamine (TMA) is a widely recognized indicator used to assess the freshness and level of spoilage in seafood. It is responsible for the characteristic fishy odor and is mainly formed by the reduction of trimethylamine oxide (TMAO) (Mer *et al.*, 2024) [34]. According to Connell (1975) [11] acceptability limit for TMA-N is 50 mg/100g for good

quality seafood. The present study TMA-N values for four treatments are T_1 (5.17 ± 0.08), T_2 (4.15 ± 0.12), T_3 (5.15 ± 0.09) and T_4 (4.64 ± 0.14) at day 0. Results indicated that treatment T_1 was spoiled at 180 days of storage and treatment T_3 value was very closed to the spoilage. Khodanazary (2019) [26] observed a significant relationship between TMA-N levels and storage time, as TMA values increased progressively during storage in *M. affinis*.

4.2.3 Total Volatile Basic Nitrogen (TVB-N)

At initial stage TVB-N value of shrimp were T_1 (38.50 ± 0.18), T_2 (35.09 ± 0.1), T_3 (37.55 ± 0.13) and T_4 (36.41 ± 0.5). Among all treatments, T_2 recorded the lowest value, suggesting that it is the safest for consumption. The TVB-N index comprises compounds such as trimethylamine and ammonia, which are generated as a result of bacterial spoilage (Masniyom *et al.*, 2002) [32]. According to Srinivasan & Joseph (1966) [54] a TVB-N value of 200 mg per 100 g is regarded as the limit indicating spoilage in cured fish. Goulas & Kontominas (2007) [22] investigated the storage stability of Mackerel (*Scomber japonicus*) and reported that TVB-N levels showed a progressive increase over time, similar trend also followed in the present study with increasing TVB-N value.

4.2.4 Peroxide value (PV)

Fish contains lipids rich in highly unstable polyunsaturated fatty acids, which readily react with atmospheric oxygen. This reaction results in the formation of hydroperoxides and free radicals, leading to the development of off-flavours and unpleasant odours in dried fish, a process known as oxidative rancidity (Oguzhan, 2015) [40]. The peroxide index typically reflects the primary stage of lipid oxidation, especially the formation of hydroperoxides (Vafakhah *et al.*, 2014) [56]. In the present study the PV scale used described by Rashidi *et al.*, (2014) [44], as a basis for determining the freshness, the value shows that peroxide value of shrimp follows increasing trend. At initial stage peroxide value of shrimps from different treatments observed T_1 (2.13 ± 0.08), T_2 (1.44 ± 0.12), T_3 (1.95 ± 0.16) and T_4 (1.66 ± 0.1). Faralizadeh *et al.* (2016) [16] reported that, when comparing the control (with NaCl) groups with treatment 1 (combine NaCl and KCl) control fish (Kilka) samples generally exhibited significantly higher peroxide values than the other groups ($p < 0.05$) which is similar with current study.

4.3 Microbiological Characteristics

4.3.1 Total Plate Count (TPC)

Initially, the total plate count (TPC) in salted-dried shrimp samples ranged T_1 (2.49 ± 0.11), T_2 (2.12 ± 0.09), T_3 (2.36 ± 0.08) and T_4 (2.24 ± 0.11). The maximum acceptable limit of 6 log CFU/g for Total Plate Count (TPC) as specified by FSSAI (2011) [18]. The initial level of microorganisms in ready-to-eat foods is significant; However, processing, storage and display conditions can further affect the microbial load by the time the food reaches the point of sale (Angelidis *et al.*, 2006; Beuchat, 1997) [3]. Though drying lowers water activity and eliminate bacteria through heat, contamination can still occur after processing (Mepba, 2002) [33].

4.3.2 Total Fungal Count (TFC)

Water activity represents the portion of water available for reactions and microbial growth, making it a key indicator of

spoilage under low-moisture conditions. Lower a_w improves storage stability, so dried products generally have a longer shelf life than moist ones (Christian *et al.*, 2000) [8]. The changes observed during the present study in Total Fungal Count (TFC) from day 0 to 120 salted-dried shrimps were good in condition, there were no sign of fungus growth observed. After day 120 shrimps with treatment T_1 and T_3 recorded fungal count with value (0.97 ± 0.09) and T_3 (0.40 ± 0.17) respectively. After day 150, T_4 also recorded fungal count with value (0.29 ± 0.07). From findings of the current study suggested that treatments T_2 had no fungal growth at day 180 and achieved highest acceptance value. Nagwekar *et al.* (2017) [37] noted Total Fungal Count (TFC) value (1.9 ± 0.9) CFU/g in dried bombay duck which is slightly higher than the present study value.

4.4 Physical Characteristics

4.4.1 Rehydration ratio

Rehydration is the process of restoring moisture to a dried product and serves as an important quality indicator in dried foods, reflecting the extent of cellular and structural damage caused during drying (Rastogi *et al.*, 2000) [45]. At initial stage rehydration ratio of salted-dried Jinga shrimp for different treatments were T_1 (4.1 ± 0.08), T_2 (5.37 ± 0.13), T_3 (4.44 ± 0.11) and T_4 (5.13 ± 0.10). The degree and speed of water absorption during rehydration are mainly governed by the cellular and structural organization of the food matrix, as these structures create pathways for water to reach the muscle fibers. This effect has been clearly demonstrated in earlier studies (Akonor *et al.*, 2016) [2]. As reported by Niamnuy *et al.* (2007) [38] increased protein contraction may have lowered the rehydration capacity of mechanically dried shrimp meat.

4.5 Sensory Characteristics

4.5.1 Appearance

At the beginning of the study appearance score were T_1 (8.6 ± 0.52), T_2 (8.8 ± 0.42), T_3 (8.7 ± 0.48) and T_4 (8.7 ± 0.48), which shows that shrimps were of very good quality. Hafez *et al.* (2019) [23] observed that appearance scores for all salted mullet declined significantly over the storage period from 0 to 105 days at room temperature, similar results achieved in the present study as appearance score declined with storage time.

4.5.2 Color score

At initial stage color score of shrimps were T_1 (8.5 ± 0.53), T_2 (8.9 ± 0.32), T_3 (8.5 ± 0.53) and T_4 (8.6 ± 0.52). Dried shrimp typically exhibits an orange-red coloration and a characteristic smoky flavor, both of which are considered desirable attributes of a high-quality product (Siripatrawan *et al.*, 2022) [51]. Martínez-Alvarez & Gómez-Guillén (2005) [31] observed that the use of sodium chloride may cause slight yellow discoloration, which is similar with the findings of the present study. Pilkington & Allen (1994) [42] suggested that potassium chloride can be used to partially replace sodium chloride in salting processes in dry-cured hams may potentially improve its color.

4.5.3 Odor

Odor score for shrimp was decreased in the present study with highest score in treatment (T_2) with KCl, which is the similar with the study of Sanceda *et al.* (2003) [47] Who observed that replacing salts with KCl at a ratio of up to 75:25 is acceptable in sardines (*Sardinops melanostictus*). At day 0 the scores were T_1 (8.6 ± 0.52), T_2 (8.7 ± 0.48), T_3

(8.6 ± 0.52) and T_4 (8.6 ± 0.52).

4.5.4 Texture

The texture score salted-dried shrimps were T_1 (8.2 ± 0.79), T_2 (8.6 ± 0.52), T_3 (8.3 ± 0.67) and T_4 (8.4 ± 0.52) at day 0. Scores were decreased at the rates of T_1 (6.0 ± 0.82), T_2 (6.4 ± 0.84), T_3 (6.1 ± 0.74) and T_4 (6.7 ± 0.67) for the respective treatments at day 180. According to Martínez-Alvarez & Gómez-Guillén (2005) [31] observed that the use of sodium chloride leads to a softer texture.

4.5.5 Overall acceptability

Initially overall acceptability score of shrimps for the different treatments T_1 (8.5 ± 0.53), T_2 (8.9 ± 0.32), T_3 (8.7 ± 0.48) and T_4 (8.8 ± 0.42) respectively. Treatment with KCl had highest acceptance score than other treatments. Nitipong *et al.* (2020) [39] examined that substituting 25% and 50% KCl resulted in the highest sensory acceptance scores in kapi. Previous reports got similar result with present work stated that treatment T_2 had highest overall acceptability.

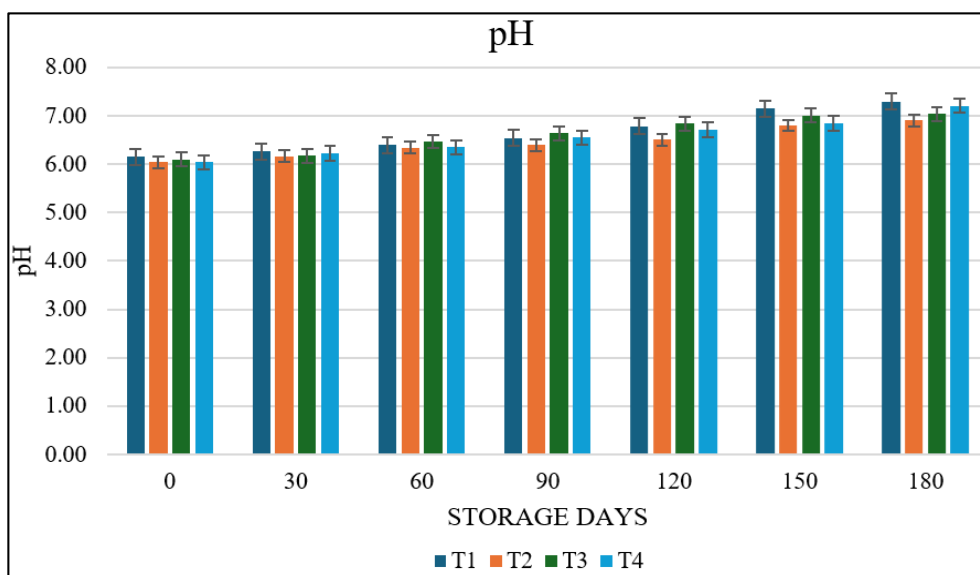


Fig 1: Changes in pH of salted-dried Jinga shrimp stored at ambient temperature

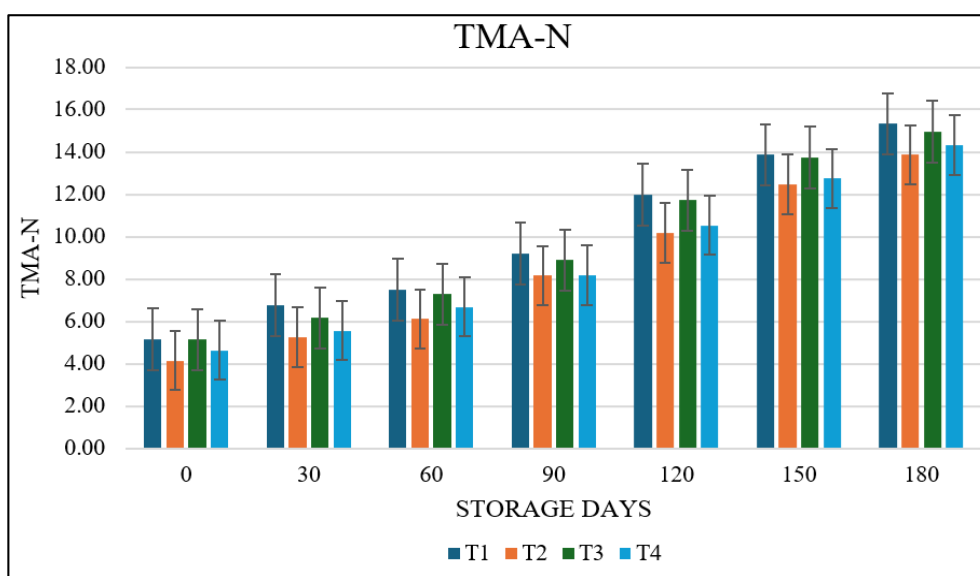


Fig 2: Changes in TMA-N of salted-dried Jinga shrimp stored at ambient temperature

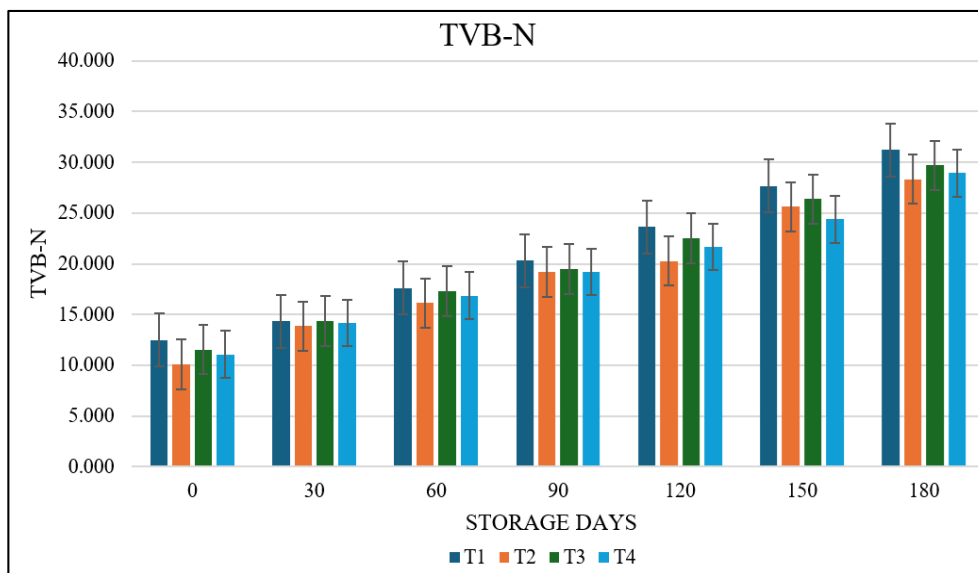


Fig 3: Changes in TVB-N of salted-dried Jinga shrimp stored at ambient temperature

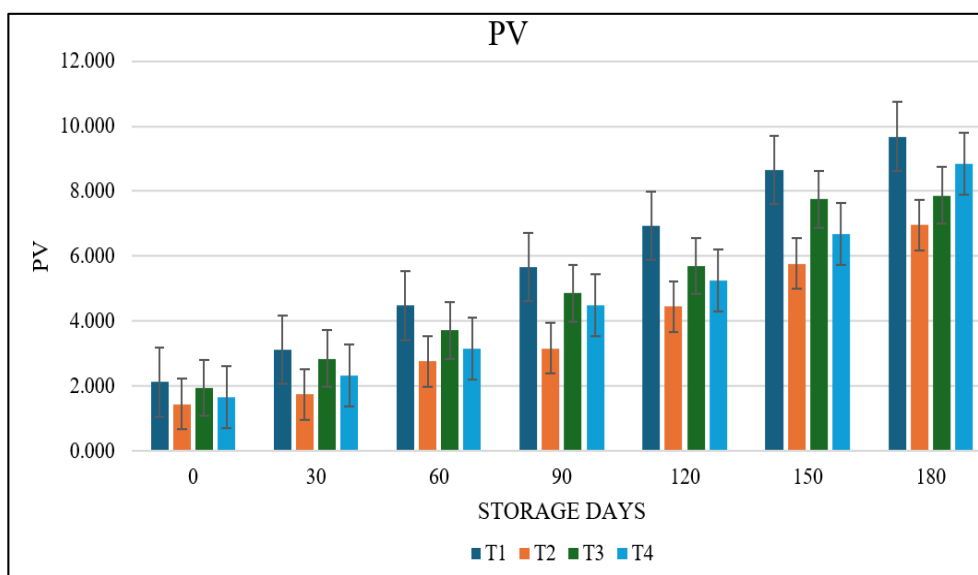


Fig 4: Changes in PV of salted-dried Jinga shrimp stored at ambient temperature

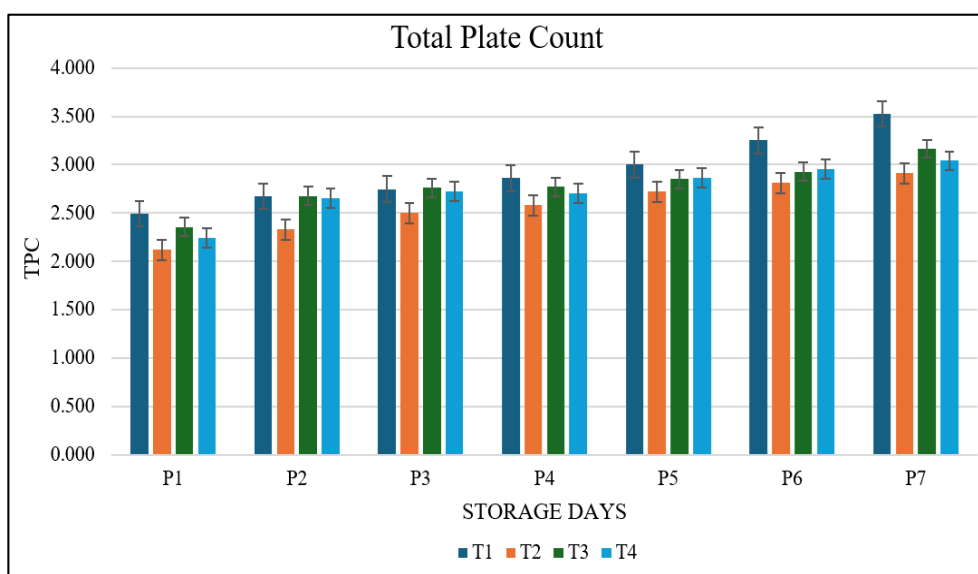


Fig 5: Changes in TPC of salted-dried Jinga shrimp stored at ambient temperature

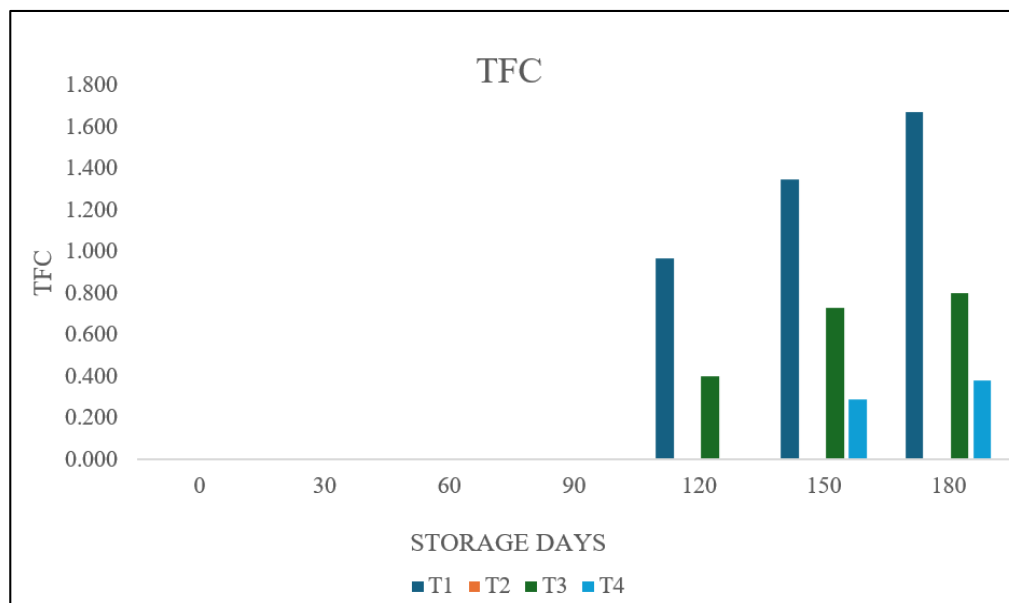


Fig 6: Changes in TFC of salted-dried Jinga shrimp stored at ambient temperature

5. Conclusion

The present study demonstrates that partial replacement of sodium chloride (NaCl) with potassium chloride (KCl) and calcium chloride (CaCl_2) in salted-dried Jinga shrimp is a promising approach to reduce sodium content without compromising product quality. Among the treatments, KCl showed better overall performance in terms of physicochemical, microbiological and sensory attributes indicating its suitability as an effective NaCl substitute. Calcium chloride also contributed positively but is recommended at lower levels due to its stronger impact on taste and texture. By reducing sodium levels in a widely consumed seafood product, this research contributes to the development of healthier alternatives.

6. References

- Ajifolokun OM, Basson AK, Osunsanmi FO, Zharare GE. Effects of drying methods on quality attributes of shrimps. *J Food Process Technol.* 2018;10(772):2.
- Akonor PT, Ofori H, Dziedzoave NT, Kortei NK. Drying and physical and nutritional properties of shrimp meat as affected by different traditional drying techniques. *Int J Food Sci.* 2016;2016(1):7879097.
- Angelidis AS, Chronis EN, Papageorgiou DK, Kazakis II, Arsenoglou KC, Stathopoulos GA. Non-lactic acid contaminating microbial flora in ready-to-eat foods: a potential food-quality index. *Food Microbiol.* 2006;23(1):95-100.
- Antman EM, Appel LJ, Balentine D, Johnson RK, Steffen LM, Miller EA, *et al.* Stakeholder discussion to reduce population-wide sodium intake and decrease sodium in the food supply: a conference report from the American Heart Association Sodium Conference 2013 Planning Group. *Circulation.* 2014;129(25):e660-e679.
- AOAC. Official methods of analysis of the Association of Official Analytical Chemists. 18th ed. AOAC International; 2005.
- Beatty SA, Gibbons NE. The measurement of spoilage in fish. *J Biol Board Can.* 1937;3(1):77-91.
- Beuchat LR, Ryu JH. Produce handling and processing practices. *Emerg Infect Dis.* 1997;3(4):459.
- Christian JHB. Drying and reduction of water activity. In: *The microbiological safety and quality of food.* 2000. P. 146-174.
- Chukwu O. Effects of drying methods on proximate compositions of catfish (*Clarias gariepinus*). *World J Agric Sci.* 2009.
- CMFRI. Annual report 2024. Kochi: Central Marine Fisheries Research Institute; 2025. 306 p.
- Connell JJ. Control of fish quality. 1975.
- El-sanat SY, Khalifa EMI, Baz GB. Effect of partially substitution of potassium chloride to sodium chloride on chemical, physiochemical and organoleptic properties of salted fermented grey mullet fish (*Mugil cephalus*).
- Entsua-Mensah M, deGraft-Johnson KAA, Atikpo MO, Abbey LD. The lobster, shrimp and prawn industry in Ghana: species, ecology, fishing and landing sites, handling and export. 2002.
- Eyo AA. Traditional and improved fish handling, preservation and processing techniques. In: *National workshop on fish processing storage, marketing and utilization.* 1993. P. 207.
- FAOSTAT. Available from: <https://faostat3.fao.org/download/Q/QC/E>
- Faralizadeh S, Rahimabadi EZ, Khanipour AA. The influence of sodium chloride replacement with potassium chloride on quality changes of hot smoked Kilka (*Clupeonella cultriventris caspia*) during storage at $\pm 4^\circ\text{C}$. 2016.
- Farid FB, Latifa GA, Nahid MN, Begum M. Effect of sun-drying on proximate composition and pH of shoal fish (*C. striatus*; Bloch, 1801) treated with salt and salt-turmeric storage at room temperature (27°C - 30°C). *J Agric Vet Sci.* 2014;7(9):01-08.
- FSSAI. Food safety and standards (food products standards and food additives) regulations. New Delhi: Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, Government of India; 2011. P. 877.
- Fuentes A, Fernandez-Segovia I, Serra JA, Barat JM. Effect of partial sodium replacement on

- physicochemical parameters of smoked sea bass during storage. *Food Sci Technol Int.* 2012;18(3):207-217.
20. Geleijnse JM, Witteman JC, Stijnen T, Kloos MW, Hofman A, Grobbee DE. Sodium and potassium intake and risk of cardiovascular events and all-cause mortality: the Rotterdam Study. *Eur J Epidemiol.* 2007;22:763-770.
 21. Gomes MDSA, Kato LS, de Carvalho APA, de Almeida AECC, Conte-Junior CA. Sodium replacement on fish meat products-a systematic review of microbiological, physicochemical and sensory effects. *Trends Food Sci Technol.* 2021;118:639-657.
 22. Goulas AE, Kontominas MG. Effect of modified atmosphere packaging and vacuum packaging on the shelf-life of refrigerated chub mackerel (*Scomber japonicus*): biochemical and sensory attributes. *Eur Food Res Technol.* 2007;224(5):545-553.
 23. Izdiharudin MF. Heat transfer analysis of solar fish drying machine on the effects of fish mass and blower speed variations. *Am J Mod Energy.* 2019.
 24. Jacob MB. The chemical analysis of foods and food products. 3rd ed. New York: D. Van Nostrand Co Inc; 1958.
 25. Khodanazary A. Freshness assessment of shrimp *Metapenaeus affinis* by quality index method and estimation of its shelf life. *Int J Food Prop.* 2019;22(1):309-319.
 26. Kortei JNK. Comparative effect of steam and gamma irradiation sterilization of sawdust compost on the yield, nutrient and shelf-life of *Pleurotus ostreatus* stored in two different packaging materials. 2015.
 27. Lauritzsen K, Akse L, Gundersen B, Olsen RL. Effects of calcium, magnesium and pH during salt curing of cod (*Gadus morhua* L). *J Sci Food Agric.* 2004;84(7):683-692.
 28. Leroi F, Joffraud JJ. Salt and smoke simultaneously affect chemical and sensory quality of cold-smoked salmon during 5 °C storage predicted using factorial design. *J Food Prot.* 2000;63(9):1222-1227.
 29. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, *et al.* A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012;380(9859):2224-2260.
 30. Martínez-Alvarez O, Gómez-Guillén MC. The effect of brine composition and pH on the yield and nature of water-soluble proteins extractable from brined muscle of cod (*Gadus morhua*). *Food Chem.* 2005;92(1):71-77.
 31. Masniyom P, Benjakul S, Visessanguan W. Shelf-life extension of refrigerated seabass slices under modified atmosphere packaging. *J Sci Food Agric.* 2002;82(8):873-880.
 32. Mepba HD. Effects of processing methods and storage on the qualities of coconut milk. *Discov Innov.* 2002;14(3):179-185.
 33. Mer JR, Solanki JB, Rathore V. Effect of prior plasma-activated water soaking and carboxymethyl cellulose incorporated with clove essential oil on the shelf life of peeled shrimp (*Metapenaeus affinis*) during refrigerated storage.
 34. Moody MW, Flick GJ. Smoked, cured, and dried fish. In: *The Seafood Industry.* Boston: Springer US; 1990. P. 381-406.
 35. MPEDA. Annual report 2024. Kochi: Marine Products Export Development Authority; 2025. P. 19-22.
 36. Nagwekar N, Tidke V, Thorat BN. Microbial and biochemical analysis of dried fish and comparative study using different drying methods. *Dry Technol.* 2017;35(12):1481-1491.
 37. Niamnuy C, Devahastin S, Soponronnarit S. Effects of process parameters on quality changes of shrimp during drying in a jet-spouted bed dryer. *J Food Sci.* 2007;72(9):E553-E563.
 38. Nitipong J, Kamonwan R, Teeraporn K. Effects of low sodium chloride substitutes on physico-chemical and sensory properties of Kapi, a fermented shrimp paste, during fermentation. *J Microbiol Biotechnol Food Sci.* 2020;9(4):695-699.
 39. Oguzhan Yildiz P. Effect of essential oils and packaging on hot smoked rainbow trout during storage. *J Food Process Preserv.* 2015;39(6):806-815.
 40. Peryam DR, Pilgrim FJ. Hedonic scale method of measuring food preferences. *Food Technol.* 1957.
 41. Pilkington DH, Allen JC. Substitution of potassium chloride for sodium chloride in commercially-produced dry-cured hams. *J Food Prot.* 1994;57(9):792-795.
 42. Qiu X, Chen S, Lin H. Oxidative stability of dried seafood products during processing and storage: a review. *J Aquat Food Prod Technol.* 2019;28(3):329-340.
 43. Rashidi Y, Baboli MJ, Sary AA. Effect of vacuum packaging on quality changes of refrigerated Jinga shrimp *Metapenaeus affinis* muscle. *Aquac Aquar Conserv Legis.* 2014;7(4):311-319.
 44. Rastogi NK, Angersbach A, Niranjan K, Knorr D. Rehydration kinetics of high-pressure pretreated and osmotically dehydrated pineapple. *J Food Sci.* 2000;65(5):838-841.
 45. Reames E. Nutritional benefits of seafood. 2012.
 46. Sanceda N, Suzuki E, Kurata T. Quality and sensory acceptance of fish sauce partially substituting sodium chloride or natural salt with potassium chloride during the fermentation process. *Int J Food Sci Technol.* 2003;38(4):435-443.
 47. Sriket P, Benjakul S, Visessanguan W, Kijroongrojana K. Comparative studies on chemical composition and thermal properties of black tiger shrimp (*Penaeus monodon*) and white shrimp (*Penaeus vannamei*) meats. *Food Chem.* 2007;103(4):1199-1207.
 48. Shenderyuk VI, Bykowski PJ. Salting and marinating of fish. In: *Seafood.* CRC Press; 2020. P. 147-162.
 49. Silva JG, Morais HA, Silvestre MP. Comparative study of the functional properties of bovine globin isolates and sodium caseinate. *Food Res Int.* 2003;36(1):73-80.
 50. Siripatrawan U, Hwansena V, Ornrootee K, Chuesiang P, Ruengdech A, Keratimanoch S, *et al.* Effect of packaging systems on dried shrimp quality and storage stability as visualized using pattern recognition. *Agric Nat Resour.* 2022;56(5):987-996.
 51. SJ L, Sankar TV. Comparative study of biochemical composition and nutrient profile of four species of penaeid shrimps. *Fish Technol.* 2023;60:254-261.
 52. Snedecor GW, Cochran WG. Statistical methods. 8th ed. Wiley Blackwell; 2014.

53. Srinivasan R, Joseph KC. A survey of the quality of salt-cured fish produced in the Kanyakumari district, Madras State. *J Fish Technol.* 1966;3(2):103-112.
54. Toldra F, Aristoy MC, Flores M. Relevance of nitrate and nitrite in dry-cured ham and their effects on aroma development. *Grasas Aceites.* 2009;60(3):291-296.
55. Vafakhah F, Ouraji H, Baboli MJ. Lipid quality in Benni (*Barbus sharpeyi*) fillets during ice storage.
56. Wang J, Wang H, Lu W, Zhang M, Xue J, Yu X, *et al.* Low-salted salmon: effects of salt reduction on physicochemical, lipidomic, and sensory characteristics. *LWT.* 2021;152:112311.
57. World Health Organization. Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. Vol. 916. Geneva: World Health Organization; 2003.
58. Yanar Y, Celik M. Seasonal amino acid profiles and mineral contents of green tiger shrimp (*Penaeus semisulcat* De Haan, 1844) and speckled shrimp (*Metapenaeus monoceros* Fabricus, 1789) from the Eastern Mediterranean. *Food Chem.* 2006;94(1):33-36.
59. Zhang M, Chen H, Mujumdar AS, Tang J, Miao S, Wang Y. Recent developments in high-quality drying of vegetables, fruits, and aquatic products. *Crit Rev Food Sci Nutr.* 2017;57(6):1239-1255.
60. Zhang YW, Zhang L, Hui T, Guo XY, Peng ZQ. Influence of partial replacement of NaCl by KCl, L-histidine and L-lysine on the lipase activity and lipid oxidation in dry-cured loin process. *LWT Food Sci Technol.* 2015;64(2):966-973.