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Effects of Drying Methods on Quality Attributes of Shrimps

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Abstract

Shrimps are fresh and saltwater animal on aquatic habitat. They are known today as one of the fastest growing food commodities in international trade, maybe as a result of their perceived health benefits, culinary attributes and importantly, being a source of protein. The effects of two major drying methods; sun-drying and oven-drying at 50°C, 60°C or 70°C were investigated on the nutritional, microbiological and sensory properties of shrimp powder. From the result of the study, it was observed that the sun-dried shrimp powder had higher moisture content than the oven-dried shrimp powder. There were slight variations in the proximate compositions of the shrimp powder. The total yeast count was higher in the sun-dried shrimp powder (38×10^{-5} cfu/g) and the lowest yeast count was observed in oven-dried shrimp powder at 70°C (19×10^{-5} cfu/g). Also, the oven-dried shrimp powder at 70°C had the lowest total viable count (TVC) of 12×10^{-5} cfu/g while higher TVC was observed in the sun-dried shrimp powder (36×10^{-5} cfu/g). Neither mold nor coliform growth was observed on both sun-dried and oven-dried shrimp powder. The result of the sensory evaluation revealed the significant effects of drying methods on the sensory parameters of shrimps. There were significant differences in consumer preferences for aroma, appearance, color, taste and overall acceptability. The oven-dried shrimp powder at 70°C was preferred in all parameters evaluated than the sun-dried powder.

Keywords: Shrimps; Saltwater; Food; Sun-dried

Practical Applications

Drying of a food material causes reduction of moisture content from its water activity to a level which impacts some technological advantages such as; prolonged shelf life, ease of transportation and handling, impartment of desirable characteristics such as odor, color, flavor, and taste. Various drying methods are used to preserve shrimp, which is aimed at preventing deterioration and spoilage before consumption. However, some of these drying methods have negative effects on the quality attributes of shrimps, which could reduce its nutritional composition, consumer acceptability and caused a human hazard. Therefore, this study investigated the best method for frying shrimp that will not affect the nutritional, microbiological and sensory characteristics of shrimps.

Introduction

Shrimps belong to the kingdom of *Animatia*, (phylum): *Arthropoda*, (class): *Crustacean*, (order); *Decapoda*, (general): *Penacus*, species: *Penaeus kerathunes* (zebra shrimp), *Penacin notails* (pink shrimps), *Oarapenaeosspsis atlantic* (brown shrimp), *Aristeus variden, Plesiopenaeus edwardslanus* and *Parapenaues longwstir* [1,2]. Shrimps are characterized by the semi-transparent body which is laterally compressed. They have two pairs of pre-oval appendages; which are anti-uniform but sensory in functions, also a rostrum on which there are teeth both on the ventral and dorsal surfaces [2].

Seafood, which includes shrimps, are dietary staple foods in many countries and there is currently an increase in demand for seafood's as they are a very good source of polyunsaturated fatty acids called omega and fatty acids [3]. Shrimps with their natural perceived health fitness and culinary attributes are increasingly the protein choice of people globally. They contain about 18%-20% protein, 75%-80% water, low fat (4.5%), amino acids and minerals such as selenium, copper, zinc, and calcium in right proportion [3,4]. Shrimps also contain polyunsaturated fatty acids necessary to improve human health and are also rich in astaxanthin and vitamin B_{12} with antioxidant properties [2].

The agents of spoilage in shrimps are bacteria and autolytic enzymes, which operate under constraining optimum conditions. Bacteria require water and are sensitive to heat, salt concentrations, and pH while enzymes activities are sensitive to temperature changes but can be inactivated by chemical irradiation [5]. Shrimps deteriorate rapidly when captured because of their high moisture and protein content unless they are preserved by cold storage condition [6].

Drying has been used to preserve food all over the world since prehistoric times when people learned that sun-dried foods remain wholesome for a longer time [7]. Drying of foods including shrimps reduces the moisture content of foods to a safe level, which impacts some technological advantages, such as increased shelf life, ease of handling and transportation, impartment of desirable characteristics such as odor, flavor, color, and taste [8]. As water is essential for the activities of all lung organisms, its removal will also slow down and stop microbial or autolytic activities. This is because microorganisms need water for growth and food enzymes cannot thrive without a watery environment, therefore drying can be effectively used as a method of preserving shrimps. Completely dried-shrimp or powdered-shrimps have been widely accepted, as they can be used as spices in soups or foods for flavor and protein source [9].

Different drying methods have been used to process and preserve shrimps such as; freeze-drying [10], super-heated air drying [11], heat pump drying [12], solar drying [7], jet- emitted bed drying and hot air drying [13]. Solar drier and hot air have been the most common and cheapest processing methods of preserving shrimps because they require less sophisticated efforts and inputs [14]. However, drying usually affect

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some food materials but not much evidence has been provided on its effects on the quality attributes of shrimps, acceptability and market value of the resulting dried shrimps. Therefore, this study is aimed to determine the best method for drying shrimp that will not affect its nutritional, microbiological and sensory properties.

Materials and Methods

Fresh marine shrimps (*Penaeus notialis*) were procured and transported on ice in a cold box to the laboratory from a nearby fish market. The shrimps were washed in potable water to reduce the level of microbial loads accompanying it from its muddy habitat, physical contaminants were also removed.

Parboiling and drying

Cleaned shrimps were parboiled in dilute solution brine for about 15 minutes and drained. The shrimps were then divided into four portions. A portion was spread on trays in a layer of 2-3 inches deep, placed under the sun and turned over every 20 minutes to have a uniform drying rate. The other three portions were spread in different trays in a layer of 2-3 inches deep and dried in hot air oven (Apex B35E, London) at 50˚C, 60˚C or 70˚C respectively until they were completely dried. The various dried samples were milled into a fine powder using a blender, packaged, sealed and labeled for further analyses.

Nutritional analyses

Crude protein, fat, ash, crude fiber, moisture content and carbohydrates contents of both sun and oven dried shrimps were determined according to the standard methods of the association of official analytical chemists [15].

Microbiological analyses

MacConkey agar Potato dextrose agar (PDA), Nutrient agar (NA, LAB M) and, De Man Rogossa agar (MRS), were used as described by Adeniran and Ajifolokun [16] for total viable, yeast, mold and coliform counts respectively. All counts were done in duplicates using a straight scientific colony counter with model number LEAB PPC. 0.29 [17].

Sensory evaluation

Sensory evaluation was conducted on the shrimps' powder produced using 20 trained panelists. Quality parameters evaluated were; aroma, appearance, taste, color and overall acceptability using 9 point hedonic scales viz., Dislike extremely (1), Dislike very much (2), Dislike moderately (3), Dislike slightly (4), Neither like nor dislike (5), Like slightly (6), Like moderately (7), Like very much (8), Like extremely (9).

Statistical analysis

Triplicates analyses were carried out while analysis of variance (ANOVA) was performed by one-way procedures with the application of Duncan's multiple range tests and descriptive statistics using SPSS 16. Difference between means was tested for, using the Least Significant Difference (LSD) and significance was defined at $P<0.05$. Results were reported as mean values of determinations ± Standard deviation.

Results and Discussion

Proximate composition

The results of the proximate composition for the dried shrimp powder were shown in Table 1. Proximate composition varied with drying methods used and is influenced by drying temperatures and water contents. The sun-dried shrimp powder had the highest moisture content of 13.70% ± 0.05% whereas lower moisture contents of 10.91% ± 0.04%, 9.70% ± 0.06% and 6.90% ± 0.05% were observed in oven-dried shrimps' powder at 50˚C, 60˚C and 70˚C respectively, as a result of temperature changes. This showed that the lower the moisture content, the higher the drying temperature and vice versa [18].

The decrease in moisture content of the oven-dried shrimps was as a result of rapid dehydration, which was a function of temperature [19]. Among the oven-dried samples, shrimps dried at 70˚C had the lowest moisture content. This depicted that it can stay longer during storage because low moisture content in dried shrimps protects it from enzymatic action and microbial attack [20]. Sun-dried shrimps are liable to both enzymatic and microbial decomposition during storage due to the fact that foods that contain moisture content higher than 13% have been reported to be vulnerable to putrefaction by microorganisms [18,21]. These results were in accordance with the results of Osibona [22] that the moisture content of shrimp powder could be higher at about 75% of the total weight and that moisture was usually held at the expense of fiber. The fiber content of sun-dried shrimp was 0.74% ± 0.01% while that of oven-dried at 50˚C, 60˚C and 70˚C were 1.05% ± 0.01%, 0.88% ± 0.01%, and 0.94% ± 0.01% respectively. These results were in accordance with the report of Kumaran et al. [20] that the lower the drying temperature, the higher the fiber content.

Sun-dried shrimps exhibited a higher crude protein percentage of 58.41% ± 0.51% than the oven-dried shrimps at 50˚C, 60˚C and 70˚C, which were 56.45% ± 0.50% , 55.83% ± 0.40% and 53.21% ± 0.35% respectively. From this result, it was observed that the lower the drying temperature, the higher the protein content. This supported the findings of Begum et al., [23] that the increase in drying temperature and moisture loss results in denaturation of the protein. The high percentage of protein recorded for all shrimp sampled may be attributed to their high protein dietary consumption such as crustaceans, diatoms, algae, partly digested fishes and molluscs [22]. This high protein content of shrimps provides a very good source of amino acids in diets [24]. However, sun-dried shrimps had the lowest value of 18.40% ± 0.23% carbohydrate content while the oven-dried shrimps had higher carbohydrates values of 20.64% ± 0.20%, 20.79% ± 0.25%, 25.17% ± 0.03% within the temperatures of 50˚C, 60˚C and 70˚C. This implied that the highest the protein content, the lower the carbohydrate content of shrimps powder.

Samples	Moisture (%)	Ash (%)	Crude Fibre (%)	Protein (%)	Fat (%)	Carbohydrate (%)
A	13.70 ± 0.05^{a}	6.77 ± 0.05^{d}	0.74 ± 0.00^{a}	58.4 ± 0.51^{a}	1.98 ± 0.01^{d}	18.41 ± 0.23^{a}
B	10.91 ± 0.04^{b}	8.93 ± 0.05^{c}	1.05 ± 0.51^{a}	56.5 ± 0.05^{b}	2.02 ± 0.01^{c}	67.57 ± 5.70^{e}
C	9.70 ± 0.06^{c}	10.56 ± 0.38^{b}	0.88 ± 0.22^{a}	55.8 ± 0.40^{b}	2.24 ± 0.01^{b}	80.14 ± 7.04^{b}
D	6.90 ± 0.05^{d}	11.42 ± 0.09^{a}	0.94 ± 0.14^{a}	53.2 ± 0.35^{c}	2.36 ± 0.05^{a}	79.17 ± 5.64^{c}

Sample A=Sun-dried, Sample B=Oven-dried at 50˚C, Sample C=Oven-dried at 60˚C, Sample D=Oven-dried at 70˚C.
Each value represents the mean of three replicates ± standard error
Mean on the same column followed by the same superscript are not significantly different at 5% level of significance

Table 1: Proximate composition of shrimps' powder.

The fat content of sun-dried shrimps powder was lower than the oven-dried shrimps at all drying temperatures used because of its highest moisture content. The result showed that fat content of sun-dried shrimp was 1.98% ± 0.01% whereas, the oven-dried shrimps at 50°C, 60°C and 70°C ranged from 2.02% ± 0.01%, 2.24% ± 0.01% and 2.36% ± 0.02% respectively. This depicted that fat content of shrimp is a function of its water content, as fat increases with a decrease in moisture content [25,26]. This supported the results of Chukwu and Shaba [27] that the lower the fat content, the higher the moisture content of shrimp. Bhavani and Karuppasamy [28] also reported about 2.5% fat content in all shrimps evaluated.

The sun-dried shrimps also had the lowest ash content of 6.67% ± 0.02% while higher ash content was observed in oven-dried shrimps at 50°C, 60°C and 70°C from 8.93% ± 0.02% to 10.56% ± 0.38% and 11.42% ± 0.45%. The higher ash content was due to the significant moisture loss because ash content is a function of moisture content and temperature. The higher the moisture content, the lower the ash content whereas, the higher the temperature of drying, the higher the ash content [26]. As the moisture content decreases, both fat and ash content increases. This corresponds to the findings of Fawole et al., [29] that fat and ash contents are inversely proportional to the moisture content. Ash signifies the total amount of minerals present in food and it is vital to maintaining numerous body functions, thus making shrimps a rich source of mineral in diets [30].

However, the differences in the nutritional compositions of the shrimp species evaluated in this study could be attributed to the rate at which these nutrients are available in the water habitat and how they are absorbed as well as their ability to convert the important nutrients from the diet provided in the water they live in [1,31].

Microbiological analyses of shrimps' powder

The result of the microbial counts of shrimps' powder showed that there was no mold growth on the shrimp's powder during the analysis (Table 2). This was probably due to the drying temperatures which do not support the growth and survival of pathogens [32]. Moreover, no coliform bacteria were observed in any of the samples, which implied that all samples were not pathogenic and completely free of fecal coliform.

However, the sun-dried shrimp's powder had the highest yeast counts of 38×10^{-5} cfu/g, while the total yeast counts varied with temperature from 28×10^{-5}, 25×10^{-5} and 19×10^{-5} cfu/g during drying of shrimps at 50°C, 60°C and 70°C respectively. The higher yeast count observed in sun-dried shrimp powder could be due to inconsistence drying it was subjected to and the predominantly favorable drying atmosphere for the microorganisms to thrive on the available substrate from solar air [17]. The lower counts observed in oven-dried samples was because the yeast was no resistance to heat as reported by Akingbala et al. [33]. However, the essence compounds produced by yeasts contributed to the aroma and flavor of the shrimps' powder [34].

Moreover, sun-dried shrimp powder had the maximum total viable count (TVC) of 36×10^{-5} cfu/g whereas, during the oven-drying of shrimps, TVC decreased with increase in the drying temperature from 50°C to 70°C with TVC ranging from 19×10^{-5} to 12×10^{5} cfu/g. Their growth was favored by drying temperatures used because some bacteria are heat resistance and are also stable at temperatures up to 100°C [34]. Increased TVC observed in sun-dried samples could be due to dirt and dust falling on the product during the drying process as well as the uncontrolled air it was exposed to. An increase in the Total Viable Count (TVC) during sun drying of shrimps was also observed [35]. The microbial counts observed in this study could be attributed to the contaminants in the shrimp before processing. Truly, drying method is a heat treatment process but cannot remove completely the microbes in the dried shrimps' [36].

Sensory evaluation

All the sensory parameters evaluated such as appearance, color, aroma, taste, and overall acceptability were lower for oven-dried at 50°C followed by the sun-dried shrimp powder (Table 3). Highest overall acceptability of 8.50 was observed for oven-dried shrimps at 70°C but a lower overall sensory score of 6.10 was observed for oven dried at 50°C. Oven-dried at 70°C and 60°C ranked highest for appearance; whereas, the sun-dried shrimp was preferred than the oven-dried at 50°C. Moreover, for taste; oven-dried at 60°C and 70°C were desired than oven-dried at 50°C and sun-dried. Oven-dried at 70°C ranked highest in terms of aroma whereas oven-dried at 60°C, 50°C and sun-dried were significantly different from each other. For overall, oven dried at 70°C had the highest rating in terms of color, taste, aroma, and appearance. Among the different dried samples, shrimps' powder.

The color of all the dried shrimp powder varied between 5.1-8.6

Samples	Total Viable Count (× 10^{-5})	Total yeast Count (× 10^{-5})	Total Mould Count (× 10^{-5})	Total coliform Count (× 10^{-5})
A	36	38	Nil	Nil
B	19	28	Nil	Nil
C	15	25	Nil	Nil
D	12	19	Nil	Nil

Sample A=Sun-dried, Sample B=Oven-dried at 50°C, Sample C=Oven-dried at 60°C, Sample D=Oven-dried at 70°C.
Each value represents the mean of three replicates ± standard error
Mean on the same column followed by the same superscript are not significantly different at 5% level of significance

Table 2: Microbiological analysis of shrimp powder (cfu/g).

Samples	Total Viable Count (× 10^{-5})	Total yeast Count (× 10^{-5})	Total Mould Count (× 10^{-5})	Total coliform Count (× 10^{-5})
A	36	38	Nil	Nil
B	19	28	Nil	Nil
C	15	25	Nil	Nil
D	12	19	Nil	Nil

Sample A=Sun-dried, Sample B=Oven-dried at 50°C, Sample C=Oven-dried at 60°C, Sample D=Oven-dried at 70°C.
Each value represents the mean of three replicates ± standard error
Mean on the same column followed by the same superscript are not significantly different at 5% level of significance

Table 3: Mean sensory scores for dried shrimps' powder.

in both sun-dried and oven-dried shrimps' powder. The oven dried shrimps at 50˚C exhibited the lowest while the oven-dried shrimps at 70˚C had the highest color sensory score. Visual appearance as reported by Zhang et al., [12] is a vital quality parameter, which influences sales and acceptability of a product, hence oven-dried shrimps' powder both at 60˚C and 70˚C exhibited an acceptable color to the consumer.

Conclusion

The study revealed the effects of two drying methods on the nutritional profile, sensory and microbiological properties of shrimps' powder. Although, there were slight variations in the proximate compositions of the shrimp powder, the oven-dried shrimps at 70˚C had the lowest moisture content than the other oven-dried shrimps whereas; sun-dried shrimps had the highest moisture content. The oven-dried shrimps at 50˚C had the highest protein content due to the lowest temperature it was subjected to while the sun-dried shrimps had the lowest percentage of protein. The oven-dried at 70˚C had the highest carbohydrate content while the sun-dried had the lowest carbohydrate content. The results of the microbial analysis showed that all the shrimp powder were free of mold and coliform growth. However, there was yeast and bacteria growth on the shrimp's powder in which sun-dried shrimps had the highest count. Based on the sensory scores, oven dried at 70˚C had the highest rating in terms of overall acceptability and was acceptable among the different drying conditions.

Recommendation

Further research should be carried out on the chemical composition and shelf life of the shrimp powder. Shrimps' should be processed in an oven drier at 70˚C so as to reduce the microbial load and conserve the quality attributes. Also, consumption of shrimp's powder should be encouraged in the diet as spice or flavor enhancer and in the production of infant formulations because of its high nutritional value.

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