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**Mahendra Kumar**
Department of Food Science& Technology, JNKVV, Jabalpur, Madhya Pradesh, India

**Alpana Singh**
Department of Food Science& Technology, JNKVV, Jabalpur, Madhya Pradesh, India

**Ankit Bharti**
Department of Food Science& Technology, JNKVV, Jabalpur, Madhya Pradesh, India

**Madhvi Sharma**
Department of Food Science& Technology, JNKVV, Jabalpur, Madhya Pradesh, India

**Corresponding Author:**
**Mahendra Kumar**
Department of Food Science& Technology, JNKVV, Jabalpur, Madhya Pradesh, India

# Effect of storage period and packaging material on moisture and sensory properties on parched, puffed and malted quinoa products

**Mahendra Kumar, Alpana Singh, Ankit Bharti and Madhvi Sharma**

**Abstract**
All the processed products developed by optimisation of malting, puffing and parching which were organoleptically acceptable. In the present study among two packaging material, aluminium foil with paper laminates was revealed as best for sensory attributes with higher score in comparison to the PVC rigid containers at the end of storage. Processed products packed in aluminium foil with paper laminates were successfully stored for 90 days at room temperature without any major changes in moisture and organoleptic parameters. According to the scoring was done on nine point hedonic scale, overall acceptability of malted quinoa of 24 hrs soaked with 144 hrs germination indicated "like very much" while malted quinoa (12 hrs, 48 hrs) which indicated "like slightly". Highest score (8.7) was scored by taste aspect of malted quinoa (24 hrs, 144 hrs), which indicated "like very much" while lowest score was scored by colour aspect (5.9) of malted quinoa (12 hrs, 48 hrs) which indicated "like moderately". Texture profile of parched quinoa (160°C, 30 s) shows maximum score (8.9) whereas parched sample ( 190°C, 30 s) shows minimum score (6.6). In case of puffing, color & appearance aspect got highest "like very much" whereas texture aspect got lowest "like moderately". This study evaluates the acceptance level of quinoa products among consumers by determining consumption by different socio-economic strata, determining consumption of various processed products.

**Keywords:** Quinoa, aluminium foil, PVC rigid container, hedonic rating scale

## Introduction
In any food product, ultimate goal of food product development is good sensory properties along with nutritional quality and the sensory score got down as time spent during storage in comparison to freshly prepared product, so it is crucial important that estimate the duration of sensory properties of newly developed product that is acceptable to the consumers. There is a growing trend to integrate what were traditionally seen as separate sensory analysis and consumer research methods into a single array of complementary product tests focusing on sensory questions, each tailored to a particular situation and each contributing a distinctive element of information. Foods have several characteristics that require evaluation by sensory methods. Though technically a grain, quinoa is classified as a pseudo-cereal and is a good source of plant protein and fiber. Quinoa (*Chenopodium quinoa* Willd., *Amaranthaceae*) is a grain-like, stress-tolerant food crop that has provided subsistence, nutrition, and medicine for Andean indigenous cultures for thousands of years (Graf *et al*. 2015) [7]. Quinoa is also naturally gluten-free and can be eaten safely if one has gluten intolerance such as celiac disease. Sensory analysis is not new to the food industry, but its application as a basic tool in food product development and quality control has not always been given the recognition and acceptance as it deserves. Sensory analysis is the identification, scientific measurement, analysis and interpretation of the properties (attributes) of a product as they are perceived through the five senses of sight, smell, taste, touch, and hearing. Sensory analysis has become increasingly accepted as a standard component of food testing. Sensory evaluation is a science that measures, analyses, and interprets the reactions of people to products as perceived by the senses.

Storage and shelf life quality of developed product largely depend upon the packaging material in which food product is packaged for a specific period of time. In many cases it has been seen that product quality can be protected for longer period and let the food safe and palatable for consumption. So, this study has planned to evaluate the effects of packaging material and time duration on the organoleptic properties and moisture gain by the food product.

## Material and Methods

Sensory analysis of malted quinoa done by using nine point hedonic rating scale which was vary from " Extremely like" on point 9 and " Extremely dislike" on point 1 as described by Amerine *et al.* (1965) [3]. Sensory evaluation parameters in booths under white light were color & appearance, aroma, taste, texture and overall acceptability, evaluated by panel of 15 trained judges. Tasters were instructed to evaluate each sample individually.

The storage stability of processed products (malted quinoa, puffed quinoa and parched quinoa) was carried out using PVC rigid containers and Aluminum foil with paper laminates pouches for a period of 3 months at ambient conditions. All samples were drawn periodically after 0, 30, 60 and 90 days which were analyzed for sensory qualities and moisture.

## Results and Discussion

### Malted quinoa

In general, all malted quinoa results clearly showed increase score of color & appearance on soaking and germination where maximum score (8.2) found in 24 hrs soaking with 144 hrs germination period while minimum score (5.9) was observed in malted quinoa of 12 hrs soaking time with 48 hrs germination. Aroma of all malted samples increased with increasing germination time from 48 hrs to 144 hrs.

It was revealed that maximum score of taste (8.7) found in malted samples of 24 hrs soaking with 144 hrs germination period whereas minimum score (6.9) was reported in a soaking period of 12 hrs with 48 hrs germination time.

Soaking time of 12 hrs with increased in germination time from 48 to 144 hrs showed the score from 6.3 to 7.1 whereas soaking time of 24 hrs with increasing germination period showed score from 6.5 to 7.3. The obtained results showed the increase in score of aroma & taste was observed in malted quinoa which may be due to kilning of grains during malting process.

Data suggested that quinoa soaked for 24 hrs with 144 hrs germination period had maximum texture score (7.3) while minimum score (6.3) was found in a malted quinoa which was soaked for a period of 12 hrs with 48 hrs germination time.

The overall acceptability of all malted samples was maximum (8.1) found on 24 hrs soaking with 144 hrs germination time whereas minimum score (6.5) was observed in 12 hrs soaking with 48 hrs germination period.

### Puffed Quinoa

The score of color & Appearance of puffed quinoa showed maximum score (8.6) which was found at 230°C temperature with 30 s time whereas minimum score (7.5) was found at 240°C temperature for 30 s puffing time. Aroma score of quinoa which was puffed at 230°C temperature with 30 s puffing time has maximum aroma score (8.2) whereas lowest score (7.2) was found at 210°C temperature for 15 s puffing time. Sensory characteristics of both parched and puffed products were same which may be due to similar processing methods used for preparation of product.

The results clearly indicates the increasing score of taste on increasing temperature with time and the maximum score (8.7) was found at 230°C puffing temperature with 30 Sec time while minimum score (7.1) found at 210°C temperature with 15 s puffing time and the increased texture score on increasing temperature with time and the maximum score (8.5) was found at 230°C temperature with 30 Sec time while minimum texture score (7.0) was found at 210°C temperature with 15 s puffing time. Quinoa starch is lower in amylose content (11% of starch) as reported by Ahamed (1996) [2], which may also yield the hard texture.

It was observed from the table that the maximum overall acceptability (8.3) was found at 230°C temperature with 30 s time whereas minimum score (7.2) was found in 210°C temperature with 15 s puffing time. Significant difference was observed between the treatments.

### Parched Quinoa

The results obtained from table indicates the maximum score of color & appearance (8.6) was found at 160°C temperature for 30 s time while the minimum score (6.9) was found at 190°C temperature for 30 s parching time and aroma from the table indicates that the maximum score (8.5) was found at 160°C parching temperature for 30 s time whereas minimum score (7.0) was observed at 190°C temperature for 30 s time. The maximum taste score (8.7) was found at 160°C temperature for 30 s time while minimum taste score (6.7) was at 190°C temperature for 30 s time. The data reported in the table suggested that quinoa parched at 160°C temperature for 30 s time has highest texture score (8.9) while lowest texture score (6.6) was found at 190°C temperature for 30 s parching time. Due to less temperature and without conditioning in parching, quinoa may not fully expand and shows difference in texture of the parched product.

The overall acceptability of parched quinoa was maximum (8.8) at 160°C temperature with 30 s time whereas minimum score (6.7) was found at 190°C temperature for 30 s time.

### Sensory analysis of processed products (*i.e.* malted quinoa, puffed quinoa and parched quinoa) during storage period

The initial values of colour & appearance were recorded by 8.70 for malted quinoa, 8.60 for puffed quinoa and 8.73 for parched quinoa which were gradually decreased up to 8.65, 8.55 and 8.65 respectively on 90$^{th}$ day of storage in aluminum foil with paper laminates. Similarly decreasing trend was observed in rigid container (PVC) by 8.60, 8.50 and 8.60 respectively at the end of storage.

It was revealed that decreasing trend of aroma and taste was observed among all malted samples, puffed and parched samples of quinoa during storage. Aluminium foil is also an absolute barrier to aroma, meaning that it neither absorbs aroma nor allows its loss by permeation. The taste score of malted quinoa (8.63) was decreased up to 8.51in aluminium foil with paper laminates on 90$^{th}$ day of storage whereas the score in puffed quinoa (8.85) was decreased up to 8.78 in aluminium foil with paper laminates at the end of storage and score of parched quinoa samples (8.50) was decreased upto 8.38 in the same packaging material at the end of the 90 day storage period. Slight decrease in score of taste was observed in rigid container (PVC) as 8.43, 8.60 and 8.32 respectively on 90$^{th}$ day of storage.

It was reported that the value of the malted, puffed and parched quinoa were 8.57, 8.70 and 8.59 respectively at initial stage and decreased during the period of storage upto 8.49, 8.60 and 8.55 respectively in aluminium foil with paper laminates. It was revealed from the results that a decreasing trend was also observed in rigid container (PVC) as 8.42, 8.49 and 8.40, respectively at the end of storage. Aluminium foil with paper laminates had two layered packaging system that restrict the flavour and aroma of the food to go outside

whereas in the rigid containers color, taste and aroma of the food may be lost with time as observed from result. Similarly, Lindner-Steinert and Zou (1996) [8] suggested the aluminium foil laminate was found to be the most suitable packaging material.

The score of overall acceptability scores of malted quinoa (8.50), puffed quinoa (8.75) and parched quinoa (8.60) were decreased gradually upto 8.43, 8.69 and 8.50 respectively at the end of storage period in aluminium foil with paper laminates. Similarly, decreasing trend was observed in rigid container (PVC) as 8.40, 8.55 and 8.46 respectively on 90$^{th}$ day of storage.

**Moisture analysis during storage period**

The slight increasing trend was observed in moisture content of different processed products during storage in all the packaging materials. From both type of the packaging material, aluminum foil with paper laminates was found as the best packaging material in term of moisture barrier during storage period. This may be due to because aluminum foil with paper laminates has two layers for the packaging 1$^{st}$ layer was aluminum foil that from outside creates restriction for the moisture and second layer was butter paper which had food material.

Results depicts increase in moisture content of processed products upon storage. However, moisture content at the end of 30 days was highest as compared to the initial moisture content of processed products. Increased moisture content of processed quinoa over the period may be due to the changes in water holding capacity of quinoa during the storage as already reported by Abugoch (2009) [1]. Increase in moisture content might also be due to water vapour transmission through the PVC container material used to store the processed products (Bertrandt. 2013) [4]. As, the moisture content of food is inversely related to its shelf life (Genkawa *et al.*, 2008) [6]. The results depict degradation in shelf life of formulated processed products with time.

The data revealed that moisture content of malted, puffed and parched quinoa had an initial value of 7.40%, 6.70% and 8.51% which was increased gradually up to 7.57%, 6.83% and 8.65% respectively in aluminum foil with paper laminates at the end of storage period. Similarly increase trend observed in rigid container (PVC) as 7.71, 6.97 and 8.75 respectively on 90$^{th}$ day of storage. The results infer better consumer acceptability of processed quinoa products rather than raw quinoa (Bhaduri and Navder, 2014) [5].

**Table 1:** Sensory analysis of malted quinoa

| Samples | Soaking Time (hrs) | Germination Time (hrs) | Color & Appearance | Aroma | Taste | Texture | Overall Acceptability |
|---|---|---|---|---|---|---|---|
| Malted Quinoa | 12 | 48 | 5.9 | 6.7 | 6.9 | 6.3 | 6.5 |
| | | 72 | 6.2 | 6.9 | 7.1 | 6.5 | 7.1 |
| | | 96 | 6.5 | 7.0 | 7.5 | 6.7 | 7.2 |
| | | 120 | 7.4 | 7.2 | 7.9 | 6.9 | 7.7 |
| | | 144 | 7.8 | 7.3 | 8.0 | 7.1 | 7.9 |
| | 24 | 48 | 6.1 | 6.9 | 7.0 | 6.5 | 7.0 |
| | | 72 | 6.4 | 7.1 | 7.2 | 6.7 | 7.3 |
| | | 96 | 6.7 | 7.2 | 7.7 | 6.9 | 7.6 |
| | | 120 | 7.6 | 7.4 | 8.1 | 7.1 | 7.9 |
| | | 144 | 8.2 | 7.5 | 8.7 | 7.3 | 8.1 |
| | 36 | 48 | 6.0 | 6.8 | 6.9 | 6.4 | 6.9 |
| | | 72 | 6.7 | 6.8 | 7.1 | 6.6 | 7.2 |
| | | 96 | 6.6 | 7.1 | 7.2 | 6.8 | 7.4 |
| | | 120 | 7.5 | 7.3 | 7.8 | 6.9 | 7.7 |
| | | 144 | 8.0 | 7.3 | 8.2 | 7.1 | 7.8 |
| S.Em | | | 0.179 | 0.211 | 0.203 | 0.191 | 0.178 |
| CD@5% | | | 0.554 | 0.671 | 0.651 | 0.579 | 0.569 |

**Table 2:** Sensory analysis of puffed quinoa

| Samples | Puffing Temp. (°C) | Puffing Time (s) | Color & Appearance | Aroma | Taste | Texture | Overall Acceptability |
|---|---|---|---|---|---|---|---|
| Puffed Quinoa | 210 | 15 | 7.5 | 7.2 | 7.1 | 7.0 | 7.2 |
| | | 20 | 7.7 | 7.5 | 7.3 | 7.2 | 7.5 |
| | | 25 | 8.0 | 7.6 | 7.4 | 7.2 | 7.9 |
| | | 30 | 8.1 | 7.6 | 7.4 | 7.5 | 8.0 |
| | 220 | 15 | 7.6 | 7.3 | 7.6 | 7.5 | 7.5 |
| | | 20 | 7.8 | 7.7 | 7.7 | 7.7 | 7.7 |
| | | 25 | 7.9 | 8.0 | 8.1 | 7.9 | 8.0 |
| | | 30 | 8.5 | 8.1 | 8.5 | 8.4 | 8.2 |
| | 230 | 15 | 8.1 | 8.0 | 8.4 | 8.1 | 8.0 |
| | | 20 | 8.3 | 8.1 | 8.6 | 8.3 | 8.2 |
| | | 25 | 8.5 | 8.2 | 8.6 | 8.4 | 8.2 |
| | | 30 | 8.6 | 8.2 | 8.7 | 8.5 | 8.3 |
| | 240 | 15 | 8.1 | 7.9 | 8.3 | 8.0 | 8.1 |
| | | 20 | 8.0 | 8.1 | 8.5 | 8.2 | 8.2 |
| | | 25 | 7.7 | 8.0 | 8.4 | 8.1 | 8.1 |
| | | 30 | 7.5 | 7.8 | 8.5 | 7.9 | 7.7 |
| SEM | | | 0.177 | 0.208 | 0.191 | 0.208 | 0.072 |
| CD@ 5% | | | 0.519 | 0.667 | 0.612 | 0.671 | 0.241 |

**Table 3:** Sensory analysis of parched quinoa

| Samples | Parching Temp. (°C) | Parching Time (s) | Color & Appearance | Aroma | Taste | Texture | Overall Acceptability |
|---|---|---|---|---|---|---|---|
| Parched Quinoa | 160 | 15 | 8.2 | 8.0 | 8.1 | 8.2 | 8.1 |
| | | 20 | 8.4 | 8.2 | 8.3 | 8.5 | 8.3 |
| | | 25 | 8.5 | 8.3 | 8.5 | 8.7 | 8.5 |
| | | 30 | 8.6 | 8.5 | 8.7 | 8.9 | 8.8 |
| | 170 | 15 | 8.3 | 8.5 | 8.6 | 8.7 | 8.4 |
| | | 20 | 8.0 | 8.3 | 8.5 | 8.5 | 8.3 |
| | | 25 | 7.5 | 8.1 | 8.3 | 8.2 | 8.1 |
| | | 30 | 8.0 | 8.0 | 8.1 | 8.1 | 8.0 |
| | 180 | 15 | 7.7 | 7.9 | 7.8 | 7.8 | 7.8 |
| | | 20 | 7.5 | 7.8 | 7.7 | 7.6 | 7.7 |
| | | 25 | 7.3 | 7.6 | 7.5 | 7.3 | 7.4 |
| | | 30 | 7.2 | 7.5 | 7.4 | 7.2 | 7.3 |
| | 190 | 15 | 7.1 | 7.3 | 7.2 | 7.2 | 7.2 |
| | | 20 | 7.0 | 7.2 | 7.1 | 7.0 | 7.0 |
| | | 25 | 7.0 | 7.2 | 6.9 | 6.8 | 6.9 |
| | | 30 | 6.9 | 7.0 | 6.7 | 6.6 | 6.7 |
| SEM | | | 0.195 | 0.312 | 0.254 | 0.231 | 0.168 |
| CD@ 5% | | | 0.622 | 0.923 | 0.782 | 0.743 | 0.533 |

**Table 4:** Sensory attributes of processed quinoa ( *i.e.* Malted, Puffed and Parched ) during storage period in different packaging materials

| Attributes | Aluminum foil with paper laminates | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 Days | | | 30 Days | | | 60 Days | | | 90 Days | | |
| | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa |
| Color & Appearance | 8.70 | 8.60 | 8.73 | 8.70 | 8.59 | 8.70 | 8.68 | 8.56 | 8.69 | 8.65 | 8.55 | 8.65 |
| Aroma | 8.56 | 8.77 | 8.66 | 8.55 | 8.76 | 8.65 | 8.53 | 8.73 | 8.63 | 8.50 | 8.70 | 8.60 |
| Taste | 8.63 | 8.85 | 8.50 | 8.60 | 8.83 | 8.46 | 8.55 | 8.80 | 8.40 | 8.51 | 8.78 | 8.38 |
| Texture | 8.57 | 8.70 | 8.59 | 8.56 | 8.67 | 8.58 | 8.52 | 8.62 | 8.56 | 8.49 | 8.60 | 8.55 |
| Overall Acceptability | 8.50 | 8.75 | 8.60 | 8.48 | 8.73 | 8.59 | 8.45 | 8.70 | 8.56 | 8.43 | 8.69 | 8.50 |
| **Rigid container (PVC)** | | | | | | | | | | | | |
| | 0 Days | | | 30 Days | | | 60 Days | | | 90 Days | | |
| | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa | Malted Quinoa | Puffed Quinoa | Parched Quinoa |
| Color & Appearance | 8.70 | 8.60 | 8.73 | 8.68 | 8.60 | 8.70 | 8.64 | 8..56 | 8.63 | 8.60 | 8.50 | 8.60 |
| Aroma | 8.56 | 8.77 | 8.66 | 8.52 | 8.70 | 8.60 | 8.48 | 8.65 | 8.50 | 8.40 | 8.59 | 8.45 |
| Taste | 8.63 | 8.85 | 8.50 | 8.60 | 8.75 | 8.45 | 8.52 | 8.68 | 8.40 | 8.43 | 8.60 | 8.32 |
| Texture | 8.57 | 8.70 | 8.59 | 8.50 | 8.65 | 8.55 | 8.50 | 8.60 | 8.48 | 8.42 | 8.49 | 8.40 |
| Overall Acceptability | 8.50 | 8.75 | 8.60 | 8.45 | 8.70 | 8.56 | 8.40 | 8.66 | 8.55 | 8.40 | 8.55 | 8.46 |

**Table 5:** Moisture content of processed products (*i.e.* malted quinoa, puffed quinoa and parched quinoa) during storage period

| Storage period (Days) | Aluminum foil with paper laminates | | |
|---|---|---|---|
| | Malted Quinoa | Puffed Quinoa | Parched Quinoa |
| 0 | 7.40 | 6.70 | 8.51 |
| 30 | 7.46 | 6.78 | 8.59 |
| 60 | 7.53 | 6.81 | 8.63 |
| 90 | 7.57 | 6.83 | 8.65 |
| **Rigid container (PVC)** | | | |
| 0 | 7.40 | 6.70 | 8.51 |
| 30 | 7.52 | 6.80 | 8.63 |
| 60 | 7.65 | 6.89 | 8.67 |
| 90 | 7.71 | 6.97 | 8.75 |

## Conclusion

Rural agro industries are dependent on low-cost, easy-to-manage technologies such as parching, puffing and malting. Based on the above discussion, this dissertation focused on the study of sensory characteristics such as color & appearance, aroma, taste and texture of processed quinoa, and overall acceptability characteristics among various quinoa products. The developed products were tested for their organoleptic scores by the semi-trained panel of 15 judges using 9 point hedonic rating scale. From the obtained data, the drivers of consumer liking were determined. Data shows difference ($P<0.05$) in colour & appearance, aroma, texture, taste and overall acceptability of processed product of quinoa. The best processing treatments with respect to desirable quality characteristics found during acceptability studies were selected from developed processed product to conduct the storage stability studies. It could be seen from the results that at the end of storage period, processed products which was packed in aluminum foil with paper laminates contained less moisture content than packed in rigid container (PVC).

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