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Proceeding Paper

Gluten-Free Couscous Made from Quinoa Sprouts: Study of Shelf Life †

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Abstract: The aim of this work was to determine the shelf life of a gluten-free couscous made from germinated quinoa. Desaponified quinoa of the Tunkahuan variety from Ecuador was used. Quinoa kernels were germinated, dried, milled, agglomerated, and finally steamed in controlled conditions. A designed particle agglomeration equipment was used to produce the couscous. The shelf life of the product was determined by accelerated testing. Product quality changes were evaluated during storage for 90 days in different types of packaging (cardboard, polyethylene polyester, and metallized polypropylene) under different conditions (15, 25, 35, and 45 °C). The moisture content, water activity, free fatty acids, and peroxide value showed a significant increase with time and temperature, while the maximum compression force showed a significant decrease. Analysis of total aerobes, total coliforms, molds, and yeasts showed that the product complies with the microbiological parameters established in the three types of packaging during storage. An increase in Aw and free fatty acids was found, whose kinetics of deterioration presented a first-order reaction. Aw activity was selected to estimate the shelf life of germinated quinoa couscous. Hence, the results suggest that this product can extend its shelf life at 20 °C up to 85 days and 136 days in cardboard and polyester polyethylene packaging, respectively.

Keywords: couscous; quinoa; germination; shelf life; accelerated testing

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1. Introduction

Couscous is a traditional staple food from North Africa, made of agglomerated granules from steamed wheat semolina. This product has been spread worldwide even using raw materials of botanical origin other than wheat for its manufacture, e.g., quinoa. Quinoa is a pseudocereal from the Andean region with high nutritional quality in protein, vitamins, and minerals, etc., and is considered a healthy food. Quinoa germination improves fiber and protein content, mineral availability, the concentration of total phenolic compounds, and phytase activity while decreasing phytic acid content [1]. To the knowledge of the authors, only one study has explored the effect of germination in quinoa to produce couscous. This work showed, that the nutritional and functional properties of germinated quinoa couscous were maximized compared to couscous from ungerminated quinoa and traditional couscous [2]. However, its shelf life has not been studied.

The objective of this work was to determine the shelf life by accelerated shelf-life testing of a couscous made from Ecuadorian fermented quinoa stored in different packaging (cardboard, polyethylene polyester, and metallized polypropylene).

2. Materials and Methods

2.1. Raw Material

Desaponified quinoa of the Tunkahuan variety (golden quinoa) from Ecuador was used. Quinoa kernels were disinfected and stored in a chamber at room temperature, in the dark.

2.2. Germination

After soaking, quinoa was placed into a germinator for 24 h at 20 °C and 100% RH.

2.3. Couscous Preparation

Quinoa sprouted, was dried in an oven, then ground and sifted, agglomerated, and finally steamed and dried in controlled conditions. A designed particle agglomeration equipment was used to produce the couscous [2].

2.4. Shelf-Life

The shelf life of the product was determined by accelerated testing. A mixed experimental design was performed to determine the shelf life of germinated quinoa couscous stored in different packaging. Product quality changes were evaluated during storage for 3 months in different types of packaging (cardboard, polyethylene polyester, and metallized polypropylene) under different conditions (15, 25, 35, and 45 °C). The moisture content, water activity, free fatty acids, peroxide value, and maximum compressive strength were evaluated as well as microbiological analysis i.e., total aerobes, total coliforms, molds, and yeasts [3].

The results of each of the factors were evaluated by means of an analysis of variance (ANOVA) and a least significant difference test by Fisher's LSD method, with a confidence level of 95% ($p < 0.05$).

3. Results

The determination of the kinetics of deterioration was obtained in a short period of time using accelerated tests. For which, the germinated quinoa couscous was stored in cardboard packaging and at high temperatures, conditions that accelerated its deterioration process, which allowed the increase of unwanted factors. During the 90 days of storage of the germinated quinoa couscous at all the temperatures evaluated, it did not reach the maximum permissible limit (MAL) of moisture content (13.5%) [4]. In water activity, the same previous tendency was observed, the higher temperature, the decrease in water activity, and the lower time. However, it exceeded the MAL of water activity 0.6% [5] in 15 and 25 °C from 75 days of storage. This could be explained by the permeability of cardboard packaging. Storage of the product in a place with a relative humidity greater than that of equilibrium allowed the migration of water vapor toward the food. For germinated quinoa couscous stored in cardboard, the deterioration kinetics due to water activity was adjusted to a reaction order one. The increase in free fatty acids is expressed as a percentage of oleic acid as a function of time at the different studied temperatures for germinated quinoa couscous stored in cardboard. It exceeded the MAL of free fatty acids by 0.5% in all studied temperatures at 90 days of storage. The increase in fatty acids can be caused by the enzymatic hydrolysis of lipids, which is also related to the increase in humidity [6].

For germinated quinoa couscous stored in cardboard, the deterioration kinetics due to free fatty acids were adjusted to a first-order reaction. The peroxide index at the end of the storage period at 45 °C increased. The maximum value obtained is less than the maximum permitted peroxide index limit (10 meq O_2/kg oil) [7]. On the other hand, storage period and storage temperature had a significant effect on the peroxide value. The presence of the peroxide index indicates the production of peroxides and the increase of short-chain fatty acids that can cause oxidative rancidity in the food. The storage time and temperature of couscous made from germinated quinoa have significant effects on the maximum compression force (10 kg force for foods). Changes in compressive force can be caused by moisture absorption on the surface of the food, enzymatic hydrolysis, and other physical and chemical deterioration [8]. Water activity [9] and free fatty acids were the determinant factors of shelf-life analyses in this couscous type, due to the results obtained exceeded the maximum permissible limits. Regarding water activity, from the constants obtained from the deterioration kinetics, an activation energy of 4.83 kcal/mol, and a determination coefficient of 0.989 were obtained. With the data obtained and for

a maximum permissible water activity of 0.6, a useful life of 85 days was obtained. For free fatty acids, an activation energy of 1.65 kcal/mol, and a determination coefficient of 0.978 were determined for the cardboard packaging. With the results obtained and with a permissible limit of 0.5% oleic acid, a shelf life of 97 days was obtained.

Regarding microbiological analyses, total aerobes, total coliforms, molds, and yeasts were not detected during the 90-day storage period. This, despite the increased moisture content and water activity, indicates that sprouted quinoa couscous is microbiologically safe.

The results of the multiple response optimization to determine the effect of packaging material on the shelf life of germinated quinoa couscous showed that water activity was the most important quality index for determining the kinetic model of deterioration.

In this way, the shelf-life values of gluten-free couscous made from germinated quinoa were defined. The estimated shelf life for the cardboard, polyethylene polyester, metallized polypropylene packaging was 85, 136, and 86 days and for the packaging, 136 days, which means that after this storage time, the quinoa couscous would no longer meet the quality limits.

4. Conclusions

During the storage of germinated quinoa couscous, the change in water activity and fatty acids presented a reaction order of 1. Water activity was the determinant factor selected to estimate the shelf life of the germinated quinoa couscous. Germinated quinoa couscous at the end of the 90-day was considered microbiologically safe. The best packaging for storing gluten-free couscous from germinated quinoa was polyethylene polyester packaging.

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