International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 17-04-2020; Accepted: 18-04-2020; Published: 03-06-2020
www.foodsciencejournal.com
Volume 5; Issue 3; 2020; Page No. 30-33

Development of snack bars from puffed quinoa and its sensory evaluation

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Abstract
Quinoa is a pseudocereal extremely rich in highly bioavailable protein, micronutrients and health promoting bioactive compounds. The objective of the study is to formulate crispy, convenient and healthy ready-to-eat snack bar from puffed quinoa and statistically analyse its sensory attributes. The moisture and salt treated quinoa seeds were puffed in hot air oven and three different ready-to-eat snack bars such as sweet bar, spicy bar and chocolate enrobed bar were prepared from puffed quinoa. Sensory evaluation was done by 30 semi-trained panel members based on 9 point hedonic scale. It was found that spicy quinoa bar received significantly (p<0.05) higher rating for texture profile. The other attributes such as appearance, taste, odour and flavour of chocolate enrobed bar were higher than the rest two bar samples with average overall acceptability of 7.83. The high consumer acceptance of Chocolate enrobed puffed bar offers commercial potential.

Keywords: Quinoa, puffing, nutrient bar, sensory evaluation

1. Introduction
An ancient grain of South America named Quinoa (*Chenopodium quinoa*) is a super food having great demand these days for its outstanding nutritional and health value [1, 2]. The qualitatively and quantitatively superior protein in quinoa makes it a suitable food for addressing globally prevailing protein energy malnutrition. It has greater protein content compared to commonly consumed cereals such as wheat, maize and rice [3]. As the cereals are deficient in essential amino acid lysine, the entire protein becomes unavailable to body if not complemented with other lysine sources. Unlike cereals, quinoa is rich in lysine as well as all other essential amino acids [4]. Being gluten free, it can be consumed by people having celiac disease [5]. Quinoa protein would assist in better muscle development as its protein efficiency ratio is higher than milk protein [6, 7]. Low glycemic index and high fiber in quinoa prefers its inclusion in diet of diabetic people [8]. Carbohydrate from quinoa was found to reduce triglycerides and free fatty acid level in blood [2]. Soluble fibre in quinoa can act as a food for intestinal microbes thereby enhancing gastrointestinal health [9]. It is one of the good plant based source for unsaturated fatty acids like linoleic acid, oleic acid and linolenic acid with polyunsaturation index of 3.9-4.7 [10, 2]. The presence of vitamin E makes quinoa to exhibit antioxidant activity against free radical damage of blood cells and protects cardiovascular system [11]. Folic acid and pyridoxine in 100 g quinoa are sufficient to fulfill the daily requirement, whereas 80% of requirement is satisfied by riboflavin. The ascorbic acid content in 100 g of quinoa ranges from 4 to16.4 mg depending on variety [12]. Minerals such as calcium, iron, magnesium and phosphorous are abundant in quinoa [13]. It is considered as a functional food for its health promoting properties such as antioxidant, antihypertensive, anti-inflammatory, anticarcinogenic and immune-modulatory effects [8-10]. Puffing is the process of heating the grains at high temperature for short residence time to make the grain crispy, porous, aerated and highly appealing ready-to-eat snack [14, 15]. Being exposed for only short residence time, puffing was found to cause no significant loss to nutrients [16]. As the puffing reduces grain moisture and kills the inherent microbes, the puffed product will have more shelf life [17, 18]. Moreover, it was found in previous studies that puffing improves digestibility of protein and suppress anti-nutrients [19, 20]. Quinoa is not much explored for its bitter after taste which is provided by saponin residues in it. However, heat involved in puffing would suppress the bitterness by oxidizing saponin [21, 12]. Nutrient rich snack bars are greatly demanded by consumers for its convenience and superior sensory quality. It is expected from nutrient bars to confirm to emerging trends of functional foods providing additional health benefits [22, 23]. Considering the nutritional and bioactive potential of quinoa, the present study aimed to formulate healthy puffed quinoa based snack bars such as sweet bar, chocolate enrobed bar and spicy bar, and comparatively evaluate their sensory quality.

2. Materials and methods
2.1 Raw Materials
The cleaned, sorted and dried white variety of quinoa seeds of Indian origin was procured from Organic India Private Limited, Bangalore. Salt, cocoa powder, hydrogenated vegetable fat, milk powder, powdered sugar, liquid glucose, spice powders (turmeric, red chilli, coriander, cumin, curry leaf) and raw mango powder were purchased from locality bakery ingredients shops.

2.2 Methodology
2.2.1 Puffing Experiment
Quinoa seeds were moisture-conditioned by adding 0.2 ml water/10g sample and tempered for 30 minutes to attain equilibrium. Puffing was done in hot air oven by exposing the tempered seeds to high temperature of 254 ºC for 60 seconds puffing time. After cooling to 27 ºC, the puffed quinoa seeds were taken for bar preparation.

2.2.2 Sweet Bar
Sugar syrup was prepared by dissolving 100 g of granular sugar in 50 ml of water and heated in saucepan to 70˚Brix. It was then homogenously mixed with puffed quinoa and pressed into aluminium foil overlaid rectangular mould. After cooling for 2 hours at 27 ºC, the sweet puffed quinoa bar was gently taken out of the mould and packed in low density polyethylene packet.

Fig 1: Sweet Puffed Quinoa Bar

2.2.3 Chocolate Enrobed Bar
About 12.5 g of Cocoa powder, 35 g of hydrogenated vegetable fat, 6 g of milk powder and 12.5 g of powdered sugar were mixed together, heated under steam to melt and enrobed for 3 mm thickness on previously prepared puffed quinoa bar. After cooling for 3 hours at 5˚C, the chocolate enrobed puffed quinoa bar was packed in aluminium foil pack.

Fig 2: Chocolate Enrobed Puffed Quinoa Bar

2.2.4 Spicy Bar
Seasoning mix was prepared by mixing 1 g of turmeric powder, 1 g of red chilli powder, 1 g of coriander powder, 0.5 g of cumin powder, 0.5 g of curry leaf powder, 1 g of raw mango powder and 0.5 g of salt. It was then mixed with puffed quinoa homogenously. Liquid glucose was used to bind puffed quinoa seeds together and was then moulded into bar form. Spicy puffed quinoa bar was packed in low density polyethylene pack after cooling for 1 hour at 27 ºC.

Fig 3: Spicy Puffed Quinoa Bar

2.2.5 Sensory Evaluation
Sensory evaluation of bar was conducted by 30 semi-trained panel members from the department of Food Technology, Kongu Engineering College. Panelists who are fit, free from health issues and allergies, and willing to participate were only selected. The study was done in a clean, ventilated, noise free, odour less, isolated and well illuminated area. The samples were coded using random three digit numbers and served to panelists with written instructions for evaluating in terms of appearance, taste, odour, flavour, texture and overall acceptability. Scores were provided based on 9 point hedonic scale with 1 indicating the least score (Dislike Extremely) and 9 indicating the highest score (Like Extremely). Panelists were instructed to drink water in between the evaluation of samples. They were also asked to answer the questionnaire provided [24, 25].

2.2.6 Statistical Analysis
Statistical analysis was conducted for the sensory data by one way analysis of variance using Minitab 19 statistical software. The data was expressed as mean ± standard deviation and the difference between samples was considered significant if its level of significance $p<0.05$. Tukey pairwise comparison test was done to compare the difference between samples [26].

3. Results and Discussion
The appearance, taste, odour, flavor and texture profile of chocolate enrobed bar was given significantly higher rating than sweet bar. Compared to spicy bar, chocolate enrobed bar received significantly higher rating for taste profile. Though there is no significant difference in flavor and odour rating between spicy bar and chocolate enrobed bar, spicy bar was provided with significantly higher rating than sweet bar. In terms of texture, spicy bar was given significantly higher rating than sweet bar and chocolate enrobed bar. As the liquid glucose used in development of spicy bar has very low unbound moisture content, it does not affected the crispiness of puffed quinoa much and so texture rating was higher for it [27, 28]. Moreover, the structural integrity of bar was superior if liquid glucose was used as a binder. Kumar *et al*. (2018) found that nutrient bar containing liquid glucose as binder received higher texture rating than the bar sample without liquid glucose and with jaggery binder [29]. Though spicy bar has good texture profile, a significantly lower rating was provided for taste profile as the spiciness was overwhelmed and dominated only on the top layer of bar. The overall acceptability of chocolate enrobed bar (7.83) was significantly higher than both spicy bar (6.66) and sweet bar (6.33). Similar findings have been reported by Ravindra and Sunil (2018) in which the formulation of puffed cereal bar containing chocolate and gulkand received higher overall acceptability than the bar sample without chocolate [30]. From the questionnaire, it was found that the lower rating of sweet bar is attributed to its weak integrity, bland flavor and lack of much crispiness compared to other samples.

Table 1: Hedonic scale scores for sensory attributes of bar

Product Type	Appearance	Taste	Odour	Flavour	Texture	Overall Acceptability
Sweet Bar	7±0.44^{b}	6.5±0.38^{b}	6±0.32^{b}	6.13±0.30^{b}	5.66±0.33^{c}	6.33±0.48^{b}
Spicy Bar	7.33±0.30^{ab}	5.66±0.42^{b}	7.33±0.56^{a}	7.0±0.38^{a}	7.63±0.21^{a}	6.66±0.40^{b}
Chocolate Enrobed Bar	8±0.33^{a}	7.66±0.30^{a}	7.66±0.44^{a}	7.33±0.33^{a}	6.66±0.42^{b}	7.83±0.33^{a}

Values within the same column that do not share same superscript differ significantly (p<0.05)

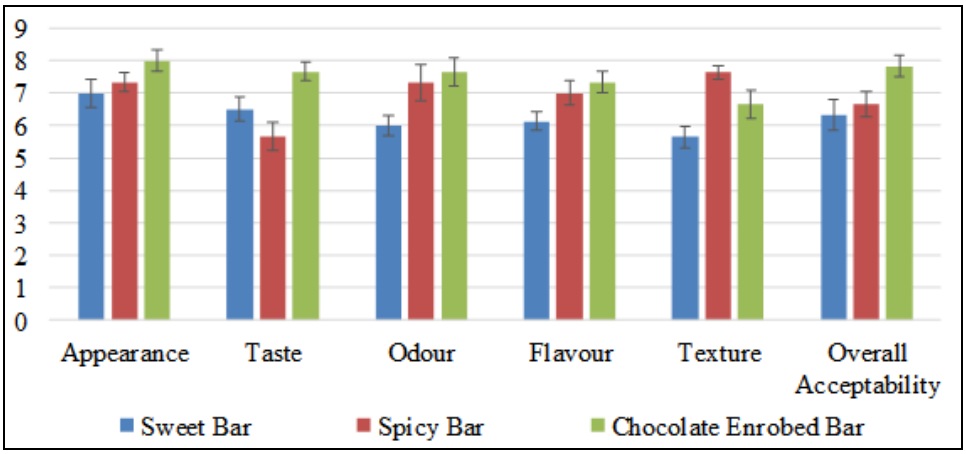

Fig 4: Sensory attributes of Puffed Quinoa bar types

4. Conclusion

The nutritious and bio functional quinoa has potential to significantly alleviate nutritional deficiency if consumed regularly. Puffing quinoa and development of convenient ready to eat snack bar would be a sustainable approach to make quinoa easily available and accessible to mass population especially targeting children. On sensory evaluation, it was found that chocolate enrobed puffed quinoa bar received significantly higher overall acceptability than sweet puffed quinoa bar and spicy puffed quinoa bar types. Usage of liquid glucose together with sugar syrup as binder would improve sensory quality and structural integrity. Increasing awareness about quinoa and its wide cultivation should be encouraged for commercial production of quinoa based bar.

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