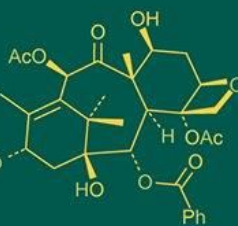
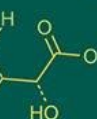


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Development and process standardization of gluten free energy bar with quinoa seeds and whey

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Abstract

Considering the general health benefits of quinoa and the improved usage of whey, a study was done to develop a minimally processed gluten-free quinoa energy bar with the goodness of whey protein. Preliminary studies were undertaken to assess the compatibility of various components; as a result of the testing, the quantity of peanut was established at 30 g and the amount of dates was chosen as 30% of the basic peanut. Three sets of goods were made with various amounts of whey and quinoa. Following statistical analysis of the sensory scores of each treatment, Q1 (quinoa 20% and whey 30%), R2 (quinoa 30% and whey 35%), and P1 (quinoa 40% and whey 30%) had the greatest sensory scores and were chosen for further.

Keywords: Quinoa, whey, energy bar, gluten free

Introduction

Snack bars are a convenient and healthy ready-to-eat food which supply balanced nutrients and abate hunger (King, 2006; Ryland *et al.*, 2010) ^[13, 22]. Energy bars, also known as energy snacks, fruit bars, space food sticks, and protein bars are becoming more and more well-liked among customers and offer numerous health benefits. The product is designed to provide people with energy to help them perform various tasks in their lives more effectively. These bars are highly versatile foods and provide nutritional benefits like high-quality proteins, polyunsaturated fatty acids, minerals, vitamins, and fibre apart from necessary energy. They are convenient and are available in easy-to-store and carry packages (Lagouri, 2019) ^[14]. The global protein bar market size was \$4.66 billion in 2019 and is expected to reach \$7.03 billion by 2027. (Fortune Business Insights, 2020) ^[8]. The growing demand for energy bars to meet a variety of consumer needs has resulted in different type of product innovations and an increase in the use of healthy ingredients. Consumers such as athletes and sports persons, who do not have adequate time for a full meal, require energy bars as a quick source of energy. However, people on diet and individuals with nutritional problems or irregular meals can also utilize energy bars for nourishment. The addition of labels, such as gluten free, vegan, low fat, low calorie, no added sugar, and sweeteners, to these bars propel the market growth.

In the present study gluten free ingredients were selected and aims the development of minimally processed gluten free bar. Celiac disease (CD) is a genetically linked autoimmune disorder that is triggered by consuming protein gluten, which is present in several cereals like wheat, rye, barley so that the people with celiac disease must completely avoid consumption of gluten. Gluten-free diet is only lifelong treatment for celiac patients. Consumers wishing to eat carbohydrates yet avoid gluten can choose from a variety of substitutes formulated and labelled as gluten-free. These foods are typically developed using one or more gluten-free grains like corn, quinoa, amaranth, arrowroot, millets and rice. Quinoa is an ancient grain of South America, which is known as a super food having great demand these days for its outstanding nutritional and health value. Quinoa (*Chenopodium quinoa* Willd) is one among the best-known gluten-free grain because it contains very little or no prolamins (James, 2009) ^[12]. Keeping in the view of overall health benefits of quinoa and the better utilization of whey, the aim is to develop a gluten-free quinoa energy bar with the goodness whey protein.

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Materials and Methods

The present study was performed in dairy engineering and dairy technology laboratories of College of Dairy Science and Technology, Pookode under Kerala Veterinary and Animal Sciences University, Wayanad.

Selection and pretreatment of ingredients

All the ingredients, including peanuts, quinoa seeds and dates were procured from the local market of Wayanad, Kerala. Whey was prepared in the laboratory from toned milk and the prepared by the procedure given by Shanaziya *et al.* (2018) [23] for paneer. The ingredients were subjected to initial pre-treatment before blending. Peanuts were deskinning and roasted, dates were washed, pitted and crushed, whey was pasteurized. Quinoa was also washed, dried and roasted.

Development of energy bar

The energy bar was developed as per the procedure given by Nadeem *et al.*, (2011) [17] with required modifications. The energy bars were prepared by puffing of quinoa seeds by roasting for 2 to 3 minutes and course grounded. The peanuts were roasted and 3/4th portion of the peanuts were ground into a smooth paste and 1/4th portion was course grounded. The mazafati dates were deseeded manually and grind to a smooth paste. The whey was the prepared by the procedure given by Shanaziya *et al.* (2018) [23] for paneer. The prepared whey has concentrated to 60⁰ Brix. During the pre-trials it was found that whey with 60⁰ Brix is suitable for energy bar preparation. The dry ingredients were mixed in pre-formulated level and finally weighed amount of whey is added and mix into a homogenous mass. The mixture spread into sheets of uniform thickness in a steel tray. Kept the sheets for 2 h in refrigeration temperature for setting. After setting time, sheets were cut into bars and bring into room temperature. Finally packing was done in aluminium foil.

Sensory Evaluation

Sensory evaluation of samples was carried out by a consumer panel using 9-point hedonic scale developed by Peryam and Pilgrim (1957) [21]. Flavour, Colour and appearance, Sweetness, Body and Texture, Mouthfeel and Over acceptability were the parameters selected for the study. In 9-point hedonic scale, score 1 represents disliked extremely and score 9 represents liked extremely. Samples with proper markings with random numbers were served to judges in sensory laboratory with appropriate facilities. All treatments to the optimum product was done based on the sensory scores obtained.

Statistical analysis

The sensory responses such as flavour, colour and appearance, sweetness, body and texture, mouth feel and overall acceptance obtained as a result of 9-point hedonic sensory evaluation were subjected to Chi-square analysis using SPSS software (version 26.0). The data were expressed as mean values with standard deviation.

Proximate analysis

Compositional analysis including moisture content, crude ash, crude fat, crude fiber and crude protein content were done and expressed in dry matter basis (AOAC, 1990) [1], in triplicates. The total amount of carbohydrate was calculated by deducting the sum of other ingredients from hundred.

Energy Value

The calorific value of the sample was calculated according to Nielsen (1998) [18]. The total crude protein, crude fat, and carbohydrate were multiplied by the factor value (for each gram of protein and carbohydrate, 4 kcal of energy is obtained and 1 g of crude fat provides 9 kcal of energy); $\text{energy} = (\text{crude protein} \times 4) + (\text{carbohydrate} \times 4) + (\text{crude fat} \times 9)$.

Gluten analysis

Gluten free analysis of energy bar was adopted from FSSAI manual for analysis of cereal and cereal products 2020.

Results and Discussion

Preliminary trials were conducted to test the compatibility of various ingredients, on the basis of the trials the quantity of peanut was fixed at 30 g and that of dates was selected as 30% of the base peanut. Higher concentration of quinoa (>40%) showed undesirable flavour and whey concentrated to more than 60% increased salty flavour.

Selection of Levels of Whey and Quinoa

The optimisation of energy bar was performed by varying the quantities of concentrated whey and quinoa. The sets selected for the final trial were first (Q) quinoa 20% and whey (30% (Q1), 35 % (Q2) and 40% (Q3)), second quinoa quinoa 30% and whey (30%(R1), 35 %(R2) and 40% (R3)) and third quinoa 40% and whey 30% (P1), 35 %(P2) and 40% (P3). Statistical analysis was conducted on the above trials (Table1, Table 2, Table 3) and treatment with highest sensory score from each set of trials were selected for further studies. From table 1 it can be observed that with different level of whey and 20% quinoa had significant effect ($p < 0.05$) on characteristics like flavour, colour, mouthfeel and overall acceptability but had no effect on the body of the product. Table 2 and 3 shows that increasing the quinoa content to 30% and 40% did not have any significant effect on the sensory scores of colour, mouthfeel and overall acceptability but have a significant effect on the body of the products. From each treatment Q1 (quinoa 20% and whey 30%), R2 (quinoa 30% and whey 35%) and P1 (quinoa 40% and whey 30%) were having the highest sensory scores and were selected for further comparison. Table 4 reveals that on sensory comparison of selected treatments R2 obtained highest sensory score, hence R2 was selected as standardised product for further analysis. It can also be observed that optimised product had higher scores compared to control. The web diagram of sensory evaluation of final treatments using 9-point hedonic scale is given in figure 1 and the picture of final product is given in figure 2.

Proximate Analysis

The chemical composition of energy bar is given in the Table 5

Moisture Content

The moisture content in the quinoa energy bar is approximately 11% which is less than the result reported in nutri-energy bar (15%) (Wandhekar *et al.*, 2020) [26]. Similar results were seen in protein-energy bars prepared by using dates, apricots, cheese and whey protein isolate (Jabeen *et al.*, 2020) [11] and energy bar from quinoa pop with oats, honey, and nuts (Basantes *et al.*, 2023) [3].

Crude protein

The developed quinoa bar contain approximately 29.5% crude protein, researchers reported that snack bars with a high ratio of protein/carbohydrate can improve post meal and diurnal glucose profiles in patients with type 2 diabetes and insulin resistance (Williams *et al.*, 2006) [27]. Proteins are necessary to support growth, tissue repair, and protection (Shang *et al.*, 2018) [24]. Usually, the protein necessary is influenced by the gender, age, activity level, body health, or physiological states (, Dullius *et al.*, 2018, Wolfe *et al.*, 2017) [7, 28]. Quinoa has got excellent amino acid profile and good amount of branched chain amino acids (Padmashree *et al.*, 2018) [19]. A combination of whey and quinoa gives superior protein content which is much higher than energy bars developed in other studies (Sharma *et al.*, 2021, Wandhekar *et al.*, 2020) [25, 26].

Crude Ash

The developed quinoa bar contains 2.5% of ash content. The observed ash value indicated the presence of essential minerals in the product, such as calcium, magnesium, potassium, and phosphorus, which are crucial for supporting various physiological functions and overall well-being (Bilge *et al.*, 2016) [5].

Crude fat

The energy bar had a significant crude fat content of 27.8%. This high-fat content may be attributed to the presence of healthy fats, which contribute to the bar's higher calorie density, as mentioned by Gill and Singh (2020) [9]. Nuts and seeds, as essential ingredients in an energy bar, are rich sources of fats and have been proven to exert a protective effect against cardiovascular disease development (Batoool *et al.*, 2022) [4].

Crude fibre

Champ *et al.*, (2003) [6] reported that the demand to increase

dietary fibre content in the daily diet is justified by the positive role of fibres in health and disease prevention, especially in digestive health, energy balance, cancer, and heart and diabetes problems. The crude fibre content in optimised energy bar is around 3.6%, this was comparatively similar to fibre content of nutri-bar (3.74%) (Wandhekar *et al.*, 2020) [26]. Crude fibre contains a considerable portion of dietary fibre which not only enhances the nutritional profile of the product but also provides potential health benefits (Madhu *et al.*, 2017) [15].

Carbohydrate

The formulated energy bar had a total carbohydrate content of 42.5 g/ 100 g of bar. Carbohydrates serve as the primary energy source, providing quick energy to the body, superior to any other macronutrient, and act as the primary fuel for exercise and metabolism. (Mul *et al.*, 2015) [16]. Significantly, in the energy bar, dates act as a natural sweetening agent, eliminating the need for added sugars, which makes it a safer choice for individuals with diabetes (Arshad *et al.*, 2022) [2].

Energy

The energy value of quinoa has calculated as 538.485 kcal per serving. According to Padmashree *et al.*, (2012) [20] energy bars are expected to around 200-300 calories, 7-15 g protein, 3-9 g of fat and 20-40 g of carbohydrates to athletes, the developed quinoa energy bar fares very high in the providing required nutrients. The energy bar developed by ho LH *et al.*, (2016) [10] has an energy value of 454.51 kcal.

Gluten analysis

The investigation revealed that the developed quinoa energy bar was completely gluten-free, making it particularly beneficial for individuals with celiac disease, in addition to its nutritional benefits.

Table 1: Sensory scores obtained for energy bar with 20% Quinoa and different levels of whey

QUINOA 20%					
WHEY	Control	Q1 (30%)	Q2 (35%)	Q3 (40%)	Chi square
Flavor	7.9±0.547	8.6±0.223	7.7±0.570	7.3±0.447	11.157*
Color	7.9±0.223	8.6±0.418	7.8±0.447	7.5±0.500	9.77*
Body and Texture	7.7±0.670	8.5±0.500	7.85±0.418	7.55±0.512	7.2 ^{ns}
Mouthfeel	7.7±0.670	8.62±0.216	7.72±0.605	7.5±0.500	9.755*
Overall Acceptance	7.8±0.670	8.6±0.223	7.8±0.670	7.5±0.500	9.951*

** - Significant at one percent level ($p < 0.01$), * - Significant at five percent level ($p < 0.05$), ns - not significant.

Table 2: Sensory scores obtained for energy bar with 30% Quinoa and different levels of whey

QUINOA 30%					
WHEY	Control	R1 (30%)	R2 (35%)	R3 (40%)	Chi square
Flavor	7.4±0.547	7.85±0.223	8.5±0.353	7.6±0.651	9.24*
Color	7.5±0.353	8±0.790	8.4±0.418	8±0.707	5.78 ^{ns}
Body and Texture	7.3±0.447	8±0.353	8.6±0.223	8±0.612	11.7**
Mouthfeel	7.52±0.522	7.7±0.447	8.2±0.570	7.7±0.570	6.06 ^{ns}
Overall Acceptance	7.4±0.418	7.9±0.418	8.4±0.418	7.8±0.570	8.04*

** - Significant at one percent level ($p < 0.01$), * - Significant at five percent level ($p < 0.05$), ns - not significant.

Table 3: Sensory scores obtained for energy bar with 40% Quinoa and different levels of whey

QUINOA 40%					
WHEY	Control	P1 (30%)	P2 (35%)	P3 (40%)	Chi square
Flavor	7.7±0.273	8.35±0.223	8±0.353	7.55±0.512	9.87*
Color	7.6±0.418	8.1±0.223	8±0.500	7.45±0.836	5.005 ^{ns}
Body and Texture	7.8±0.273	8.2±0.273	7.8±0.273	7.3±0.273	11.93**
Mouthfeel	7.9±0.223	8.1±0.223	7.85±0.335	7.5±0.790	2.83 ^{ns}
Overall Acceptance	7.6±0.418	8.2±0.273	8.1±0.418	7.5±0.707	5.92 ^{ns}

** - Significant at one percent level ($p < 0.01$), * - Significant at five percent level ($p < 0.05$), ns - not significant.

Table 4: Sensory Score obtained for energy bar Q1 (Quinoa 20% and whey 30%) R2 Quinoa 30% and whey 35%) P1 (Quinoa 40% and whey 30%)

	Control	Q1	R2	P1
Flavor	8.08±0.491	7.83±0.408	8.42±0.376	7.58±0.584
Color	7.91±0.204	8.08±0.204	8.34±0.408	7.91±0.376
Body and Texture	7.75±0.418	7.91±0.204	8.5±0.316	7.91±0.376
Mouthfeel	8.08±0.491	7.83±0.408	8.67±0.258	7.58±0.584
Overall Acceptance	8±0.547	7.92±0.491	8.67±0.258	7.62±0.541

Proximate Analysis

Table 5: Chemical composition of quinoa energy bar

Composition	Dry weight basis (%) ^a
Moisture	11±0.02%
Crude protein	29.535±0.75%
Crude Ash	2.5%±0.11
Crude fat	27.805±0.75%
Crude fibre	3.584±1.13%
Total solids	89
Carbohydrate	42.5 g/ 100 g

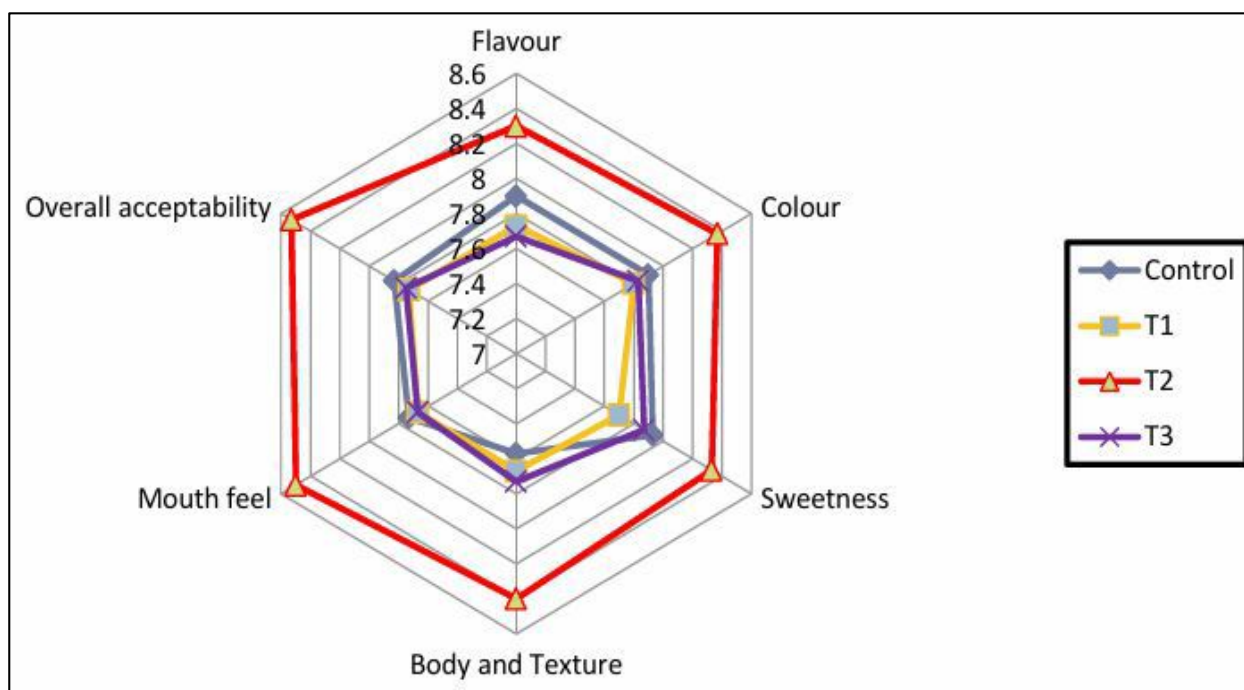
**Fig 1:** Web diagram of Sensory evaluation of different test group using 9-point hedonic scale



Fig 2: Optimized gluten free quinoa-based energy bar

Conclusion

The study aimed to develop a ready-to-eat, minimally processed, gluten-free energy bar designed to provide a high-energy content while maintaining nutritional quality and consumer convenience. The energy bar formulation comprising 30% quinoa and 35% whey concentrate (standardized to 60° Brix) demonstrated superior sensory attributes and nutritional value. The product exhibited an optimal balance of moisture, ash, fat, fiber, protein, and carbohydrates, enhancing its appeal as a health-oriented snack. The selected ingredients were gluten-free, and gluten analysis confirmed the absence of gluten, thereby making the product suitable for individuals with celiac disease. The formulation process avoids the use of harsh chemicals or heat treatments, thereby preserving the nutritional quality as well as healthier and wholesome product.

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