International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 03-10-2025, Accepted: 02-11-2025, Published: 17-11-2025
Volume 10, Issue 6, 2025, Page No. 25-28

Sensory evaluation and nutrient composition of antioxidant rich cornflakes

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Abstract
The purpose of this paper is to investigate the development of antioxidant rich cornflakes by using the Corn flour, Barley flour, Ragi flour, Carrot flour, Quinoa flour and Sunflower seed flour. Sensory analysis was performed to evaluate the organoleptic properties such as color and appearance, body and texture, taste and flavor, overall acceptability. The antioxidant activity of the product was assessed using the DPPH (2,2 diphenyl-1-picrylhydrazyl) Asay. Antioxidants are compounds that inhibit oxidation, a chemical reaction that can produce free radicals and chain reactions that may damage the cells of organisms. Quinoa is high in fiber, vitamins and minerals. Quinoa seeds contain all essential amino acids and has high biological value. All the ingredients used as the source of antioxidants by a partial substitution of yellow corn flour, all samples were evaluated for their sensory quality attributes, nutritional value and the production cost of different samples were also studied. This study was conducted to develop and examine the effect on sensory attributes, nutrient and antioxidant properties of Cornflakes prepared by incorporation of Corn flour, Barley flour, Ragi flour, Carrot flour, Quinoa flour and Sunflower seed flour in different proportion. Four different types of treatments were prepared by incorporating corn flour ranging from 100g,55g,45g,35g and 25g, Barley flour ranging from 10,15,20,25 and 5g Ragi flour was constant for all the treatments, Quinoa flour ranging from 10,15,20,25 and 10 g of sunflower seed was also constant for all the treatments. The products were evaluated for sensory attributes based on 9 Point Hedonic Score. The results suggested that cornflakes incorporated in the ratio of (45:15:5: 10:15:10) T_2 was liked very much. The data obtained for Proximate analysis, Mineral and Antioxidant content was done by using AOAC methods. Differences among the Sensory Score and nutrient content of the developed food product was done by using various Statistical Analysis Methods like ANOVA, CD and 't' test. Cornflakes. The best treatment of the developed product had the moisture content of 4.83% ,ash content of 2.27g per 100g and protein content of 7.06g per 100 g ,fat content of 20.68g per 100g,fiber content was 1.98g per 100g ,carbohydrate content as 65.16g per 100g and the energy content was 475 Kcal.The cost of the dry ingredients for preparing antioxidant rich cornflakes per 100 g were Rs.26.14 for T_0, Rs.26.98 for T_1, Rs.31.31 for T_2, Rs.32.59 for T_3, Rs.33.89 for T_4.The prices are very suitable for the Indian market; the investigated antioxidant rich cornflakes were cheaper than market products and high nutritive value. Therefore, it could be recommended to consume cornflakes to provide children with part of their daily requirements of protein, energy, phosphorous, calcium and iron. Thus, it can be concluded that incorporation of antioxidant rich ingredients like Corn flour, Barley flour, Ragi flour, Carrot flour, Quinoa flour and Sunflower seed flour can be utilized for preparation of different food products which enhances the Nutritional Content and improves Sensory Acceptability.

Keywords: Nutritional assessment, cornflakes, yellow corn, barley, ragi, carrot, sunflower seed, antioxidant rich ingredients, carbohydrate, protein

Introduction

Previously published studies reported that a plethora of antioxidants such as phenolic and flavonoid molecules might be effective to keep blood glucose level within permissible range (Hanhineva *et al.*, 2010) [7]. Among several diabetes treatment approaches, the bioactive compounds/ antioxidants obtained from different plants are becoming more attractive due to their multiple target sites in body (Mahomoodally *et al.*, 2012). The term antioxidant is widely used but rarely defined. One suggested definition is that an antioxidant is a substance that, when present at low concentrations compared with those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate'. Antioxidants are compounds that inhibit oxidation, a chemical reaction that can produce free radicals and chain reactions that may damage the cells of organisms. Antioxidants such as thiols or ascorbic acid (vitamin C) may act to inhibit these reactions. To balance oxidative stress, plants and animals maintain complex systems of overlapping antioxidants, such as glutathione. α-Tocopherol (vitamin E) is an essential nutrient which acts as a chain breaking antioxidant preventing the propagation of free radical reactions in all cell membranes in the human body. Ascorbic acid (vitamin C) is also an antioxidant which protects against free radicals. Carotenoids, flavonoids and polyphenols, α-lipoic acid, glutathione etc. are the other non-enzymatic antioxidants. These antioxidants play diverse physiological role in body by inhibiting the process of oxidation, even at relatively small concentration.

In human diet fruits and vegetables constitute the major sources of carotenoid. Carotenoids are thought to be responsible for the beneficial properties of fruits and vegetables in preventing human diseases including cardiovascular diseases, cancer and other chronic diseases. They are important dietary sources of vitamin A.

Whole grains are rich in phytochemicals and provide unique bioactive compounds that are complementary to those in fruits and vegetables when consumed together. The additive and synergistic effects of phytochemicals in fruits, vegetables and whole grains are responsible for their health benefits.

Cereals reported with high antioxidant capacity include sorghum, wheat, barley, millet and amaranth. Hulled barley contains fibre and other plant chemicals that are beneficial for health. The main type of fibre in barley is beta-glucan, a soluble fibre that forms a gel when combined with fluid. Beta-glucan, which is also found in oats, may help lower cholesterol and improve blood sugar control. Additionally, barley contains antioxidants such as vitamin E, beta-carotene, lutein and zeaxanthin, which help protect against and repair cell damage caused by oxidative stress. Barley may help lower blood sugar and insulin levels, which may reduce your risk of diabetes

Maize contains around 11 percent of protein. It is good source of carotene and it also contains thiamine and folic acid in appreciable amounts.

Quinoa is a grain with exceptional nutritional value. Quinoa is easy to cook and has versatility in preparation. Quinoa is considered one of the best vegetal protein sources, as its protein levels are similar to those found in milk and higher than those present in cereals such as wheat, rice and maize (Bastidas *et al.*,2015). Carrots (Daucus carrot) is the richest source of beta-carotene among all the root vegetables; therefore, it holds an important position among vegetables. Carrots are nutritionally storing a goldmine of nutrients. No other vegetable or fruit contains as much carotene as carrots, which the body converts to vitamin A. Sunflowers *(Helianthus annus* L.) is one of the world's leading oilseed crops. Sunflower oil ranks second only to soybean oil in world vegetable oil production. Whole sunflower kernels and high protein sunflower meal can be incorporated into human food formulations (Joseph *et al*., 2009). Sunflower seeds are a good source of plant protein, providing 6 grams of 12 percent of the Daily Value per ounce. Sunflower seeds excellent food source of vitamin E. Finger millet is commonly known as ragi (Eleusine coracana). The finger millet proteins are rich in two of essential amino acids (methionine and tryptophane) and substantial amounts of the essential amino acids, except lysin (Fernandez *et al.,* 2003) [4]. Finger millet is a good source of iron and calcium.

Materials and Methods

Procurement of raw materials

The raw materials were purchased from the local market of Gangotri Nagar area, Prayagraj. Corn, Sunflower seed, Barley, Carrot, Quinoa, Ragi and other ingredients required for study were purchased from the local market of Prayagraj. These samples were cleaned by hand to remove dust, dirt and broken seeds from it. Samples were sealed and placed in plastic bags and stored until used.

Product Formulation: The antioxidant rich breakfast product *cornflakes were* prepared with the incorporation of *corn flour, barley flour/powder, Ragi flour, carrot flour, quinoa flour/powder* and *sunflower seed flour.* Main ingredients were replaced on the basis of trail to ascertain the level of acceptability. For each product, the basic recipe (T_0) was served as control and four treatments T_1, T_2, T_3 and T_4 respectively was prepared, where the amount of one or more ingredient was varied. These ingredients were mixed in different ratio in the developed products and served as T_0 T_1, T_2, T_3 and T_4.

Sensory evaluation of antioxidant rich cornflakes: The sensory evaluation of the product was done by the panel of 5 judges selected from the faculty member of the Ethelind College of Community Science. The various sensory attributes like color and appearance, body and texture, flavor and taste, overall acceptability were assessed. The sample was placed before the judges with sample code. The judges were requested to evaluate the prepared product with the help of score card on the 9-point Hedonic Scales (Color and Appearance, Consistency, Taste and flavor and Overall Acceptability). The evaluation was done on the 9-point Hedonic scale-based score card (Sri Lakshmi,2018).

Nutritional analysis of antioxidant rich cornflakes: Nutritional analysis was conducted following procedures to determine the nutritional composition of the developed food products ,including moisture,ash,fibre by AOAC (2012),total carbohydrates(difference method),fat (Soxhlet method), protein(Lowry's method),calcium (titration method),iron (colorimetric method) and total energy (KCAL/100g)=(4 X Protein)%+(9 X Fat)%+(4 X CHO)%Additionally the antioxidant acitivity of the food products was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method, which measures their ability to scavenge free radicals and protect oxidative stress.

Statistical analysis of antioxidant rich cornflakes: The data was analyzed using analysis of variance technique (ANOVA) to get the difference between the variables. Critical Difference and 't' test and other appropriate statistical analysis methods was used to interpret the data (Gupta 2005) [6].

Result and Discussion

Sensory evaluation of antioxidant rich cornflakes

The figure presents the sensory evaluation results for four treatments (T_0, T_1, T_2 and T_3, T_4) for antioxidant rich cornflakes assessing attributes such as colour and appearance, body and texture, taste and flavour and overall acceptability. Among the treatments, T_2 emerged as the most emerged and consistently scoring the highest scoring across all attributes. T_2 achieved a score of 8.02 in colour and appearance. Its body and texture were rated 8.25, reflecting the desirable texture while its taste and flavour was rated 8.30, reflecting appealing flavour profile and overall acceptability was rated highest as 8.32, establishing it as the best treatment. T_0 was ranked higher than the T_3. Its colour and appearance score of 7.9 and body and texture score of 8.1 indicate very much acceptability, while its taste and flavour score of 7.8 reflects moderate acceptability. But Overall acceptability score was 7.43 which indicates the moderately acceptable. In contrast T_3 showed moderate performance, with scores higher than T_1. Its colour and appearance score of 7.46 and body and texture score of 7.32 indicate moderate acceptability, while its taste and flavour score of 7.15 reflects a flavour profile that lacks the appeal of T_2. T_3's overall acceptability score was 7.40 which indicates the moderately acceptable. While T_1 was ranked higher than the T_4, with scores of 7.22 in colour and

appearance,7.3 in body and texture,6.55 in taste and flavour and 7.33 in overall acceptability. T_4 consistently ranked the lowest, with scores of 7.01 in colour and appearance,7.2 in body and texture,7.11 in taste and flavour and 7.1 in overall acceptability. These results indicate that T_4's visual appeal, taste and flavour, body and texture were perceived as the least desirable, needs significant formulations. The analysis highlights those improvements in colour, body and texture, taste and flavour contribute to overall product acceptance, as demonstrated by T_2 's superior performance.

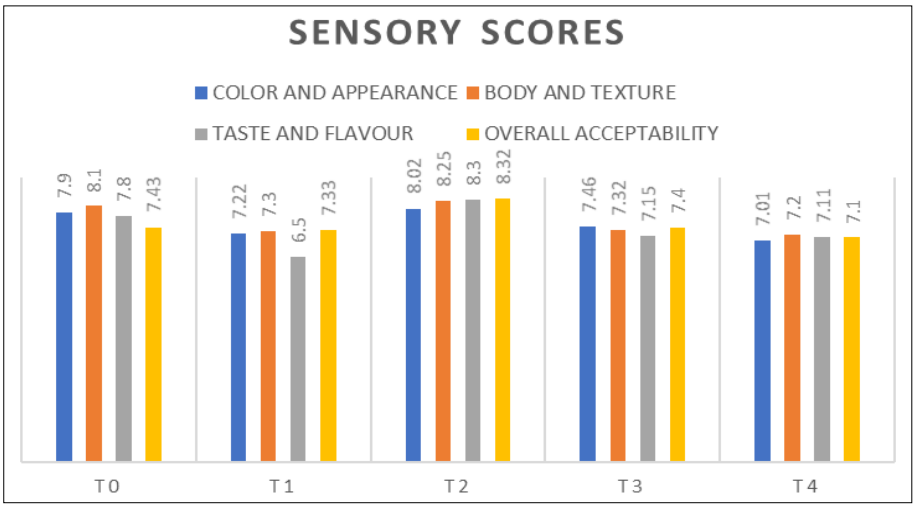

Fig 1: Average sensory scores of different sensory attributes of treatment sample of prepared Cornflakes

Nutritional composition of antioxidant rich cornflakes

Table 1: Nutritional composition of control and best treatment of cornflakes per 100 g

Nutrient/100 g	Treatment (T_0)	Treatment (T_2)
Moisture, %	8	4.83
Ash	1	2.27
Energy (KCal)	800	475
Carbohydrate	100	65
Protein	6.9	7.1
Fat	41.4	20.68
Fiber	7.3	2.0
Total sugar, %	25	11.4

The data depicted in Table 1 indicates that the ash content of control (T_0) is 1 % which is lower than the ash content of best treatment (T_2) of prepared product (Cornflakes) which was 2.27%. Ash concentration of food items might be utilized as an indication of mineral ingredient of the product. Minerals have a key part in many biochemical processes such as in optimum functioning of the nervous system, water and electrolyte balance**.** While that the energy content of control (T_0) is 800 Kcal which is higher than the energy content of best treatment (T_2) of prepared product (Cornflakes) which was 475 Kcal/100g, the carbohydrate content of control (T_0) was 100 gm which is higher than the carbohydrate content of best treatment (T_2) of prepared product (Cornflakes) which was 65 gm. It may be due to higher content of cornmeal added in control (T_0) that was 100 gm, while in best treatment (T_2) of prepared product, cornflakes it was just 45 g only.

Whereas the protein content of control (T_0) is 6.9 gm which is lower than the protein content of best treatment (T_2) of prepared product (Cornflakes) which was 7.1 gm. It may be due to addition of other ingredients in the best treatment of prepared product.100 gm corn contains 11.1 gm protein. The amount of cornmeal present in control was 100 gm while in the best treatment it was just 45 g. The quantity and quality of protein is playing a significant role in the diet. Proteins are fundamental elements of all biological tissues (Sanni and Oladapo,2008).

The fat content of control (T_0) was 41.4 gm which is higher than the fat content of best treatment (T_2) of prepared product (Cornflakes) which was 20.68 gm, which is just half of the control. There is large difference.

The Crude fiber content of control (T_0) was 7.3 gm which is higher than the fiber content of best treatment (T_2) of prepared product (Cornflakes) which was 2.0 gm. Crude fiber is a type of dietary fiber that is not easily digestible and is important for maintaining bowel regularity and preventing constipation. Fiber plays a very crucial role in the human nutrition. Fiber is a component of food that can't be digested absorbed (Gordon,1999).

The total sugar content of control (T_0) was 25 gm which is higher than the sugar content of best treatment (T_2) of prepared product (Cornflakes) which was 11.4 gm. Whereas the iron content of control (T_0) was 3.5 gm which is higher than the iron content of best treatment (T_2) of prepared product (Cornflakes) which was 2.29 gm.

The calcium content of control (T_0) is 6 gm which is than lower than the calcium content of best treatment (T_2) of prepared product (Cornflakes) which was 150 mg. Calcium is the essential elements required for several life processes. Calcium is required for the formation and maintenance of skeleton and teeth. It is required for normal contraction of muscle to make limbs move, contraction of heart for its normal function, nervous activity and blood clotting. Calcium presents in bones help to maintain the calcium level in plasma in the face of dietary calcium deficiency.

Conclusions

This study concludes that Quinoa can be incorporated in the form of flour into cornflakes and the acceptability of quinoa flour for about 50% of incorporation resulted the best. The incorporation of wheat flour, sunflower seed, carrot, quinoa, ragi flour, semolina contributed to high antioxidant properties while the use of ragi flour were responsible for the increased calcium in developed product. Pseudo cereal

like quinoa needs attention of consumers because of its superior nutritious quality in terms of protein, essential amino acids and minerals such as calcium and iron which lends itself a gluten free nutritious alternative for routine dietary alternative.

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