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Formulation and characterization of antioxidant rich cornflakes

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Abstract
The aim of present study is to formulate antioxidant rich cornflakes incorporated with Corn flour, Barley flour, Ragi flour, Carrot flour, Quinoa flour and Sunflower seed flour. Sensory scores of the product such as color, body and texture, taste, flavor and overall acceptability was analyzed by Hedonic scale. Then nutritional compositions include moisture, ash, protein, fat carbohydrate, energy was analyzed by AOAC method. Data was analyzed by Analysis of variance (Two-way ANOVA or Two-way classification) technique treatment of the developed food products. The result of sensory score revealed that Treatment (T_2) found to be the best. The result of the study showed that Corn flour, Barley flour, Ragi flour, Carrot flour, Quinoa flour and Sunflower seed flour, enhance the nutritive value of antioxidant rich cornflakes.

Keywords: Sensory scores, yellow corn, barley, ragi, carrot, sunflower seed, antioxidant rich cornflakes, formulation

Introduction

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). Additionally, these antioxidants may also counterbalance the activity of two digestive enzymes i.e., α-amylase and α-glucosidase, stimulate insulin production/secretion from pancreatic β cells and also enhance glucose channels opening in various body tissues (Hanhineva *et al*., 2010) [7].

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 chemic al 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.

The major reason behind CVS diseases is oxidative stress and hence with the help of antioxidant decreases the oxidative stress. It is generally accepted that most of, if not all, the beneficial health effects of flavonoids are attributed to their antioxidant and chelating capacities (Khurana and Venkataraman,2013) [9].

The additive and synergistic effects of phytochemicals in fruits, vegetables and whole grains are responsible for their health benefits. Sorghum, millet and barley were found to contain reasonable levels of dietary fibre and antioxidant properties. Barley is a cereal grain with a chewy texture and mild, nutty flavour. Eating whole grains, such as hulled barley, has been linked to a decreased risk of chronic diseases and death. 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.

Maize contains around 11 percent of protein. It is good source of carotene and it also contains thiamine and folic acid in appreciable amounts. Maize is like any other cereals, rich in calories and is used in supplementary nutrition programmes and ICDS programs to feed malnutritional children.

Quinoa is a grain with exceptional nutritional value. Quinoa has high concentrations of protein, all essential amino acids, unsaturated fatty acids and a low glycaemic index (GI); it also contains vitamins, minerals and other beneficial compounds, and is gluten-free by nature. Quinoa is easy to cook and has versatility in preparation. Quinoa and its product are rich, not only in macronutrients, such as protein, polysaccharides and fats, but also in micronutrients such as polyphenols, vitamins and minerals (Repo-Carrasco, 2010).

Carrots (Daucus carrot) have been a favourite vegetable for a long time, due to their nutritive value and culinary uses. Carrot is the richest source of beta-carotene among all the root vegetables. The carrot is an herbaceous plant containing about 87% water, rich in mineral salts and vitamins (B, C, D, E). Raw carrots are an excellent source of vitamin A and potassium; they contain vitamin C, vitamin B6, thiamine, magnesium, folate (also known as vitamin B9 and natural folic acid).

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. Sunflower

seeds excellent food source of vitamin E. As vitamin E is an antioxidant that may protect against heart disease by getting rid of harmful molecules called free radicals that can lead to atherosclerosis.

Wheat is consumed mostly in the form of flour obtained by milling the grain. Indian wheat is hard and the moisture content is usually 8-10 percent. Wheat proteins are rich in glutamic acid and low in Tryptophan. Glutamic acid and aspartic acid are present in amide form as glutamine and asparagine.

Breakfast cereals manufacturers aim to supply products for children and pay attention to taste (sweet flavourings), textures(crispness) and nutrition (vitamins and minerals, in particular). In Eastern Europe, consumption is very low (under 0.10kg per capita) and breakfast cereals are eaten as largest and most established market. It must be noted that the breakfast cereals with milk does not apply, mainly for physiological reasons; lactose is not digested by Asian children. The popularity of breakfast cereals really stems from their nutritional content.

Material 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.

Processing of Ingredients: All the ingredients including corn, sunflower seed, barley, carrot, quinoa and ragi were processed for making the flour from this ingredient.

Product Formulation: The antioxidant rich *cornflakes were* prepared with the incorporation of *corn flour, sunflower seed flour, quinoa flour, barley flour* and *carrot flour, Ragi 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. The best treatment includes corn flour 45%, barley flour 15 %, quinoa flour 15% and sunflower seed flour 10%, ragi flour 5%, carrot flour 10%. Baking was done in oven at temperature between 100-150^0 C and baking time was 30-45 min.

Sensory characteristics of the antioxidant rich cornflakes: The sensory evaluation of the cornflakes for their acceptability was done by the panel of 5 judges selected from the faculty member and it was done with the help of score card based on the 9-point Hedonic scale.

Nutritional analysis of antioxidant rich cornflakes: Nutritional analysis was conducted following procedure to determine the nutritional composition of the developed products, including the antioxidant activity 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.

Shelf life of cornflakes: The most acceptable treatments of prepared products cornflakes (T_2) was obtained by sensory evaluation and packed in low density polyethylene (LDPE) pouches for the study of storage. and kept at room temperature for shelf-life study. Shelf life of best treatment (T_2) of the product includes TPC, Coliform, Yeast and Mold count was taken at intervals of 0 days,15 days,30 days,45 days, 60 days, 75 days, 90 days for over a period of time until that the microbial counts reached the unacceptable limits as per the Bureau of Indian Standard (BIS,2002).

Statistical analysis: The data obtained was subjected to statistical analysis of variance (ANOVA), CD, t-test, Z-test and correlation (Gupta, 2005) [6]. A significance difference between the treatments was determined by using CD (critical difference) test, t- test was performed for comparing the difference in the nutritional content of the developed food products (Chandel,2006).

Result and Discussion

Method of preparation of cornflakes

All the ingredients were taken in required amounts as mentioned above. It was cooked in water and made a thick consistency solution. It was beaten up for 10 minutes. Then it was spread into the butter paper and was kept into oven for 100-150 ^{0} C for 30 -45 minutes. It was checked in between the time and when cooked properly then it was drawn out of the oven and also given the diamond shape in between the cooking when it was not dried properly. After completion of cooking, it was taking out of oven and kept for few minutes till cooled properly then it was taken out in the tray.

Sensory characteristics of the antioxidant rich cornflakes

Color and appearance: Table 1 presents the sensory evaluation results for four treatments (T_0, T_1, T_2 and T_3) for antioxidant rich cornflakes assessing attributes such as color and appearance, body and texture, taste and flavor and overall acceptability. Among the treatments, T_2 achieved as the most emerged and consistently scoring the highest scoring across all attributes. $T_{2\ achieved}$ a score of 8.02 in color and appearance followed by T_3 (7.46), T_0 (7.9), T_1 (7.9) and T_4 (7.01) respectively. For color and appearance T_2 scored 8.02 indicating visually appealing presentation that likely contributed to its superior acceptability. While T_0, T_1, T_3, T_4 were moderately liked by the panel of judges.

Body and texture: Table 1 shows the mean scores of cornflakes in relation to body and texture which indicates that T_2 scored 8.25 had the highest score followed by T_0 (8.1), T_3 (7.32), T_1 (7.30) and T_4 (7.2) respectively. Scoring shows that T_2 was liked very much while T_0, T_3, T_1, T_4 were moderately liked by the panel of judges.

Taste and flavor: Table 1 shows that the mean scores of antioxidant rich cornflakes in relation to taste and flavor which indicates that the T_2 scored 8.30 had the highest score followed by T_0 (7.8), T_3 (7.15), T_1 (6.5) respectively. Scoring shows that T_2 was liked very much while T_0, T_3 were moderately liked but $T_{1\ was}$ slightly liked by the panel of judges.

Overall acceptability: Table 1 shows that the mean scores of antioxidant rich cornflakes in relation to overall acceptability which indicates that the T_2 scored 8.32 had the

highest score followed by T_0 (7.43), T_3 (7.40), T_1 (7.33) and T_4 (7.10) respectively. Scoring shows that T_2 was liked very much while T_0, T_3, T_1 and T_4 were moderately by the panel of judges.

Table 1: Average sensory scores of different sensory attributes of treatments of Cornflakes

Treatments	Color and appearance	Body and texture	Taste and flavour	Overall accaptability
Scores				
T_0	7.9	8.1	7.8	7.43
T_1	7.22	7.30	6.5	7.33
T_2	8.02	8.25	8.30	8.32
T_3	7.46	7.32	7.15	7.40
T_4	7.01	7.2	7.11	7.10

Nutritional composition of the developed products

Table 2: Antioxidant properties of control and Organoleptically best treatments of prepared products

Antioxidant properties	Cornflakes(T_0)	Cornflakes(T_2)
Beta-carotene (µg)	391.25	46500
DPPH (%)	NIL	33.18
Total Flavonoid Content (mg)	5	47.5
Total Phenolic Content (mg)	110	4.37
Ascorbic Acid (mg)	NIL	6.15

The table no 2. presents the antioxidant properties in control (T_0) and best treatments (T_2) of developed products: Cornflakes (T_2). The primary parameters include beta carotenoid (2,2-diphenyle-1-picrylhydrazyl), Total flavonoid content, Total phenolic content and ascorbic acid which are known for their antioxidant effect and health benefits. Beta carotene is a precursor of vitamin A and is a potent antioxidant. cornflakes exhibited that the beta carotene is very high in amount that is 46500 micro gram in cornflakes in comparison of control (T_0) which is only 391.5 micro gram. The Antioxidant DPPH free radical scavenging activity (%) of cornflakes (T_2) is 33.18 while it was negligible in control (T_0) .Total Flavonoid content in cornflakes (T_2) was 47.5 mg ,which is higher than the control (T_0) which is only 5 mg. Total Phenolic content of the cornflakes (T_2),which was 4.37 mg which is lower than the control (T_0) which is 110 mg. Ascorbic acid in cornflakes(T_2),which is 6.15 mg while it is negligible in control(T_0).DPPH activity has a stronger free radical scavenging potential ,which is helpful in reducing oxidative stress and preventing many diseases such as cardiovascular disease and also helpful in Diabetes Mellitus.Regarding flavonoid content which contributes to antioxidant activity and also has an anti-inflammatory effects which is good for our health. Ascorbic acid is also an antioxidant which protects against free radicals. Vitamin C reduces the risk of upper GI tract, cervix cancer and cardiovascular diseases. It is powerful antioxidants scavenging free radicals in aqueous compartment.

Shelf life of antioxidant rich cornflakes

Table 3: Total Plat Count and Yeast and Mold count of best treatment of breakfast products Cornflakes

Storage period(day)	Cornflakes (TPC-log CFU/g)	BIS Standard (TPC)	Cornflakes Yeast/Mold Count (CFU/g)	BIS Standard (Yeast/Mold)
0	1.0×10^3	Not more than 5×10^4 cfu/g	NIL	Not more than $1X10^{3}$ cfu/g
15	1.1×10^3		NIL	
30	1.2×10^3		NIL	
45	$1.1X10^3$		NIL	
60	$1.5X10^3$		NIL	
75	$4.1X10^3$		NIL	
90	6.1×10^3		35.45	

This table no 3. presents the microbial stability of cornflakes over a 90-day storage period focusing on total plate count (TPC) and yeast/mold count as indicator of microbial activity. The total plate count for the best treatment (T_3) of cornflakes varied during different storage periods, ranging from 1.1×10^3 CFU/g to 6.1×10^3 CFU/g respectively within the 90 days storage period, it still remained within the acceptable limits defined by the BIS (2006) standard. This indicates that the microbial quality of the cornflakes was maintained at a satisfactory level throughout the storage period.

Yeast and Mold

The yeast and mold count for the best treatment of cornflakes were consistently absent and under the limit across all testing intervals from 0 to 90 days, complying with the BIS standard of $1x\ 10^3$ CFU/g, this highlights the strong resistance of these products to fungal contamination ensuring their safety during long term storage.

Conclusion

The finding of present study reveals that developed products were rich in antioxidants properties. The incorporation of Corn flour, Barley flour, Quinoa flour, Sunflower seed flour, Carrot flour and Ragi flour contributed to high antioxidant properties. The $_{\text{treatment}}$, T_2 (45:15:15:10:10:5) was highly acceptable on the basis of overall acceptability for the antioxidant rich cornflakes and the product was found safe for the 90 days.

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