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Formulation of Water Chestnut Flour and Ragi Flour Biscuits for Celiac Patients and Study on Their Nutritional Attributes and Sensory Evaluation

Research Article

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Abstract

Introduction: The study was designed to carry out to formulation of biscuits enriched with calcium, iron and folic acid for the patients diagnosed with celiac disease. Celiac disease is said to be an autoimmune disorder which occurs because of the absence of transglutamase enzyme in the patients. With the consumption of gluten in food sources like wheat, semolina etc., the patient suffers from inflammation. To avoid the indigestion caused amongst the patients suffering with celiac disease one must follow up gluten-free products in the diet.

Objective: The objective of this research was to prepare the nutritional rich biscuits using gluten-free products i.e., water chest flour and ragi flour. Method: - Research papers were studied related to the benefits of ragi and chestnut flour and reviewed the finding of each article. Five forms of biscuits were prepared a) Control A (100% Water chestnut flour), b) Control B (100% Ragi flour), c) Sample 1 (50% WCF & 50% RF), d) Sample 2 (25% WCF & 75% RF) and e) Sample test 3 (75% WCF & 25% RF). The recipe of nutrients rich biscuits was standardized on the basis of sensory evaluation.

Result and Conclusion: It was observed that the biscuits prepared with 75% of water chestnut flour and 25% of ragi flour (Sample E) were most acceptable. The nutritional analysis of the biscuits revealed that the total fat content was 31.8g/100 gms, calcium content in the biscuits was found to be 5.7 mg/100 gms and the iron content was tested as 3.1mg/100gms. Water chestnut and ragi are said to be rich in calcium and iron and are safe for patients suffering with celiac disease due to their gluten-free property. The calcium deficiency leads to bone and teeth disorder and iron deficiency leads to anaemia. Although these are natural sources of gluten free foods but gluten cross contamination should be avoided during production.

Keywords: Gluten-free biscuits; Celiac disease; Transglutamase; Enzyme; Sensory evaluation; Nutritional analysis

Introduction

Celiac disease is a disorder which causes inflammation in the small intestine due to ingestion of gluten in genetically susceptible individuals [1]. This disorder is caused due to the absence of transglutamase enzyme in the individual's body. Malabsorption of nutrients such as iron, folic acid, calcium and fat-soluble vitamins causes inflammation. Establishment of a gluten free diet is a key evidence for the clinical and mucosal recovery which states that the enteropathy is gluten induced. It is said that on average 1 in 200 is likely to get affected with symptoms mostly appearing in the adulthood. To prevent inflammation, gluten-free diet should be given to the patients [2]. It has been observed that even after the consumption of gluten-free diet patients suffer from various deficiencies such as calcium, iron, fibre and folic acid [3]. Nowadays, many gluten-free products are available in the market but the nutritional value of these products cannot be established. Water chestnut and Ragi are the most easily accessible gluten-free sources among the others available.

Water chestnut (*Eleocharis dulcis*), is a plant which belongs to the Trapaceae family and is popularly known as Singhara in India. It is a great source of nutrients and is known to have positive effects on physical health. It is rich in many invincible nutrients such as essential amino acids (4-7%), vitamins E and vitamin B-complex, minerals (potassium, calcium, phosphorus and magnesium), sugar (20-32%), starch (50-60%), dietary fibre (4-10%) and low amount

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of fats (2-4%) [4-10]. The edible portion of the plant which is mainly the fruit, is cherished for its gluten-free content [11] and possesses many therapeutic properties such as antimicrobial activity, antidiabetic activity, analgesic activity, anti-inflammatory activity, morpho-physiological activity, astringent, antileprotic agent, urinary discharges, sore throat, anaemia, osteoporosis and bronchitis [12].

Ragi (*Eleusine coracana*) is the largest cultivated crop among other cereals in India. The finger millet is well known for its nutritional composition and has a good impact on health [13]. The nutritional values in the 100g of the crop is seen as - Moisture (12%), protein (7.7 g), fat (1.5 g), ash (2.6 g), crude fibre (3.6 g), carbohydrates (72.6 g), calcium (350 mg), iron (3.9 mg), thiamine (0.42 mg), riboflavin (0.19 mg), niacin (1.1 mg), and energy (1406KJ). Additionally, there is presence of 5.6% weighed husk. There is good amount of protein, fat and minerals (like calcium, iron and phosphorus) in finger millet as compared to rice, corn and sorghum [14]. Ragi can therefore be used in the development of any gluten-free product due to absence of gluten from the crop [15].

The Indian bakery industry has picked up a growth momentum since 2004 and has grown at a rate of 9.0% from 2010 onwards, mainly impacted by the increased demand for convenience products and health food products. Within all bakery products, biscuits and cookies are widely consumed by the rural as well as urban population. This is generally because of a longer shelf life, easy to bake recipe, effective marketing and low-cost production. They are also available in varied tastes and textures customized as per consumer demand [16].

The bakery products like biscuits are mostly based on wheat flour or refined flour and the replacement with water chestnut and ragi flours will be beneficial for the celiac patients due to their gluten-free properties along with increased nutritional quality and their health benefits on nutrient deficient individuals. Therefore, an attempt has been made to develop water chestnut and ragi based nutritious biscuits. Nutritional and sensory evaluation of these biscuits has also been carried out.

Materials and Methods

A research study was conducted in the laboratory of the Department of Nutrition and Dietetics, Manav Rachna International Institute of Research and Studies, Manav Rachna International University, Faridabad, India. The study included primary as well as secondary research.

Many scholarly articles and research papers proved beneficial in gaining theoretical understanding of the subject. This helped in finalizing the ingredients for the product to be developed and the parameters used to measure its success. The gluten-free product was then developed in the laboratory after many rounds of experiments. To test the product on the selected parameters of the study, a primary research was conducted where the final products were tasted by a neutral sample population and the results were recorded for further analysis. Statistical analysis was then performed to check the performance of these products on the parameters selected. The results have been presented towards the end of this paper.

Procurement of raw materials

The raw materials required for the development of the gluten free products were purchased from the local market. This included Water chestnut and Ragi flour, powdered sugar, oil, baking powder and milk.

Formulation

In order to make the biscuits, all the raw materials weighed as per recipe (chestnut flour, ragi flour, powered sugar, baking powder and oil) were taken together in a bowl and mixed well. Then milk was gradually added to prepare dough by kneading together all the ingredients. The dough needs a resting period of 15 minutes at room temperature. Then flat sheets were formed using the dough prepared, which was molded and dropped on the baking trays. These trays were then placed in oven for baking. After baking at 180 ˚C for 20-25 minutes, the trays were taken out from the oven, and the biscuits were given a cooling period of 30 minutes at room temperature to become finally ready for consumption (Figure 1).

Physical properties

Many variants of biscuits were made using different combinations of Water chestnut flour and Ragi flour. 100 grams biscuits were considered for determining the physical properties of each variation. The two control samples of the biscuits were Control Sample A which was prepared by 100% Water chestnut flour whereas Control Sample B was prepared by 100% Ragi flour. The test samples were prepared by combining both the flours in different variations such as Sample C was prepared by using 50% ragi flour and 50% water chestnut flour, Sample D was prepared by using 75% ragi flour and 25% water chestnut flour and Sample E was prepared by using 25% ragi flour and 75% water chestnut flour. The biscuits so formed were crispy and had average thickness as compared to biscuits formed with refined wheat flour.

Sensory evaluation

Sensory analysis is a logical practice which administers the laboratory design and statistical examination and determination to the use of human senses for the purpose of estimating consumer products. The practice depends upon panels as sensors, on whom the products were tested and the responses were recorded. With the application of statistical techniques to the results, it was possible to make inferences and insights about the products under test. Most

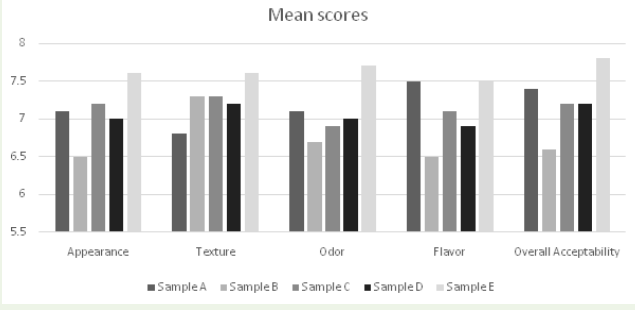

Figure 1: Process flow chart.

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large consumer goods companies have departments dedicated to sensory evaluation. For assessing the acceptability of the product formulated through evaluation, score cards were prepared on the basis of different attributes like appearance, flavor, texture, odor, and overall acceptability.

9-point hedonic scale was used to perform the sensory evaluation [17]. A panel of 10 trained along with 20 untrained members were chosen for the process. Their honest expression was assessed to find out the most acceptable sample for the further evaluation.

Fat, Calcium and Iron analysis

Total fat of the biscuits prepared with different proportion of water chestnut flour and ragi flour were quantified according to (AOAC 2000).

The dry ashing of the samples was done in muffle furnace at 420 °C. The dry ash was then analysed for iron and calcium content. Soxtron fat extraction system was used to estimate the fat. Standard method mentioned in Rangana was used for the determination of calcium and iron [18].

Statistical analysis

Data of all the 30 panel members on the basis of 9-point hedonic scale, was collected on all the attributes like appearance, flavour, texture, odour, and overall acceptability. This was further considered for the study keeping in view the specific objectives of the study. An average score was calculated for each member for every sample for testing statistical difference. The data was analysed statistically using mean, standard deviation and a one-way ANOVA test [19].

The results obtained in the table are represented as mean ± standard deviation. Significant differences between the mean values were determined at a significance level of $p < 0.05$. The null hypothesis for the study suggested that the sample means are same and the alternative hypothesis suggested that the mean of all the samples are statistically different.

Results and Discussion

Sensory evaluation

The data regarding sensory acceptability of Water chestnut flour and Ragi flour biscuits is presented in Table 1.

The mean acceptability score of attributes of all the samples have been presented above in the table. It was found that all the three samples and the two controlled samples were significantly different on the basis of the appearance, texture, odor, flavor and overall acceptability. To confirm our results, ANOVA test was performed on the data using the hypothesis stated above. Sample Eemerges to be the most acceptable sample based on sensory evaluation (Figure 2).

Table 1: Mean Acceptability Score.

Groups	Count	Sum	Average	Variance
A	30	235.8	7.9	0.5
B	30	199.4	6.6	1
C	30	215.6	7.2	0.4
D	30	213.6	7.1	0.8
E	30	223	7.4	1.1

Values are expressed as mean ± standard deviation.

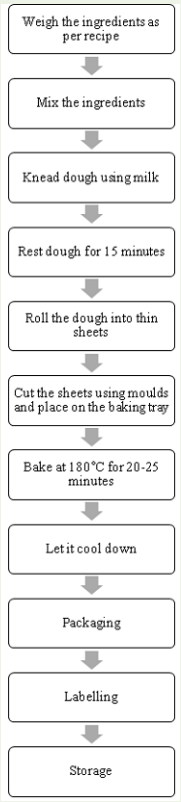

Figure 2: Graphical representation of the mean scores of different sensory attributes.

ANOVA test results

The table above presents the summary statistics of all the samples considered for the purpose of our study. The sum of the average scores of the attributes varies from 199.4 to 235.8. The average score range of 6-8 shows that the samples were appreciated by the panel. Further the null hypothesis has been tested using the ANOVA test (Table 2).

All of these samples are significantly different from each other in appearance, texture, odor, flavor and overall acceptability as the p value of the ANOVA test is less than 0.05. We reject the null hypothesis and accept our alternative hypothesis which states that the mean of the samples studied is statistically different from one another (Table 3).

Nutritional composition

Studies have shown that the water chestnut kernels are a rich source of high-quality proteins with essential amino acids, Vitamin-B complex and vitamin E, and other minerals such as phosphorus, potassium, iron, calcium, magnesium and phenolics including gallic and ellagic acid. It has been reported that due to its fibre content there is emulsifying, stabilizing, texturizing and thickening properties to dough, while its sugar content may enhance the colour and flavour when used at a certain level.

The test results of the nutritional content in the samples has been presented in Table 4 below. It has been confirmed that Water

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Table 2: Summary statistics.

Samples/Evaluation parameters	Appearance	Texture	Odor	Flavor	Overall acceptability
A	7.1 ± 0.7	6.8 ± 1.0	7.1 ± 0.8	7.5 ± 0.9	7.4 ± 0.8
B	6.5 ± 1.2	7.3 ± 1.0	6.7 ± 1.2	6.5 ± 1.4	6.6 ± 1.2
C	7.2 ± 1.0	7.3 ± 0.8	6.9 ± 1.1	7.1 ± 1.1	7.2 ± 0.8
D	7.0 ± 0.9	7.2 ± 1.0	7.0 ± 1.2	6.9 ± 1.5	7.2 ± 1.0
E	7.6 ± 1.6	7.6 ± 1.1	7.7 ± 0.9	7.5 ± 1.3	7.8 ± 1.1

Table 3: ANOVA test results.

Source of Variation	SS	df	MS	F	*P*-value	F critical
Between Groups	23.72	4	5.93	7.8	0	2.43
Within Groups		145	0.76			
Total		149				

Table 4: Nutritional composition in 100 g biscuits.

Sample	Fat	Iron	Calcium	Gluten
A	31.3 g	3.1 mg	2.6 mg	2.1 g
B	29.3 g	1.9 mg	4.9 mg	2.3 g
C	32.6 g	2.9 mg	7.6 mg	2.7 g
D	30.9 g	2.5 mg	6.2 mg	2.5 g
E	31.8 g	3.1 mg	5.7 mg	1.9 g

chestnut are rich in iron and finger millets are rich in calcium. As per the test results, sample E which is the most acceptable sample has fat (31.8 g/100 g), iron (3.1 mg/100 g) and calcium (5.7 mg/100 g) content along with great taste. It can be ascertained that these biscuits have five times more iron content as compared to wheat flour biscuits available locally. The test results show that there is 2-3% gluten in these samples of biscuits. The presence of gluten could be due to gluten cross contamination during production. This is possible if the raw materials were contaminated or if the kitchen utensils were not adequately clean.

Gluten cross contamination

There are many studies available which have proved that the gluten contamination is not a myth. In industrial food products, studies showed a contamination prevalence of 13.2% and in non-industrial food products, studies showed a contamination prevalence of 41.5%. As expected, industrial products labelled as gluten-free showed a lower percentage of gluten-contamination than non-industrialized [20].

In a different pilot study performed in India, among products made from naturally gluten-free grains, 35.9% of the flour samples and 85% of the oat samples (11.67-1830 mg/kg) were contaminated with gluten. In the case of flours, unbranded samples collected from local markets (70%) and directly from local mills (30%) showed gluten content above Codex safety levels which is 20-400 mg/kg. It is therefore advised, that the raw materials be tested for gluten before preparation of any gluten free product and utmost precaution is used while using common kitchen utensils for preparation of gluten free products [21-24].

Conclusion

The above study imposes the development of new gluten-free biscuits to cater to the ones diagnosed with Celiac disease. It is a technological challenge and an extensive area of development of gluten-free products as the demand for these products is increasing worldwide with the increase in the number of patients. The sensory studies carried out with biscuits has shown that biscuits prepared with using 75% water chestnut flour and 25% ragi flour are observed to be most acceptable. Both Ragi and Water chestnut flours are rich sources of calcium, iron and fat. Hence, the utilization of the flours will help improve the nutritional status of the consumer. It can be noted that the gluten content present in the most acceptable sample is well within the limits defined as per Codex safety levels. Sample E (most acceptable) biscuits contain 31.8 g fat, 3.1 mg iron, 5.7 mg calcium and 1.9 g gluten. These biscuits are therefore safe for consumption by celiac patients and are a great source for essential micronutrients such as iron and calcium.

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