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Nutritional and Sensory Attributes of Brown Teff and Buckwheat Flour Usage in Indian Foods

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Abstract

Certain foods like wheat would cause an allergic reaction in Celiac disease patients because of the protein, gluten that is present in wheat. This can cause damage in the cell lining of the small intestine in such individuals. The requirement for gluten-free grains is more due to the increasing incidences of celiac disease and gluten sensitivity problems. Teff, a minor crop (Eragrostis teff – Brown teff) unlike other cereals has received very less recognition in the food industry due to its recent emergence as a food crop. Buckwheat (Fagopyrum esculentum – common buckwheat) is a pseudocereal and an evergreen crop that is available throughout the year. These grains are gluten free and serve as an essential advantage for celiac disease patients as these grains would contribute to the major portion of their diet. Teff and buckwheat require less water for cultivation and therefore are the best suited for cultivation in South India and many other parts of the country where there is water scarcity during any time of the year. Due to these advantages of Teff and Buckwheat, there is an increased need to utilize these grains to enjoy their health benefits especially by those who are gluten sensitive. The study conducted is an experimental study with 3 phases. The purpose of the study was to prepare an adai (a type of dosa or a South Indian crepe) ready mix for celiac disease patients which would be time efficient and also provide them with adequate nutrients. Specific nutrient, chemical, microbial and sensory analysis was performed for the two combinations of adai mix using standard protocols and the results are discussed. With reference to the t-test result, the sample with a higher proportion of teff and a lesser proportion of buckwheat (60:40) was the most preferred. The preference of this product had also increased with the days of storage.

Keywords

Buckwheat, Celiac disease, Gluten free, Gluten sensitivity, Teff.

INTRODUCTION

Celiac disease (CD) is an auto-immune disease that has affected the entire globe since 1888. The CD patients are intolerant to gliadin which is an alcohol soluble fraction of gluten. It was earlier found to be dominating in the western countries but now it is found to have spread worldwide. A meta-analysis conducted by the celiac disease foundation in the year 2018 revealed that its global incidence was 1.4% and was much reported in South America, Africa, North America, Asia, Europe and Oceania. In India, Celiac Disease was higher in the northern belt of the country when compared to the southern portion because of the major difference in the diet within the nation as the northern part of the country has wheat as their staple food while the southern part of the country has rice as their staple food [1]. Celiac disease was higher in female individuals than in male. Children were more susceptible than adults [2]. The growth in celiac disease led to the increasing demand for the cultivation of gluten free grains. Due to the fast growing influence of the Western world on India, the International Symposium on Wheat Disorders held in January 2019, concluded that there is a five-fold increase in the prevalence of CD in India since the 1960s which is due to the modern cultivation of hexaploid wheats which have high antigenic glutens that are largely capable of inducing celiac disease [3]. India lacks the availability of a variety of gluten-free products. Hence, there is an urgent need in the country for gluten free foods in the market [1].

Teff, a gluten-free grain is a tropical cereal and a member of the family Poaceae, subfamily Eragrostoidae, which suffices its scientific name as *Eragrostis teff* (Plate 1). The constituent profile of teff indicates that it has several advantages as an ingredient in foods and beverages throughout the world [4]. It is a cereal which can withstand unfavourable seasons where most of the other cereals cannot survive [5]. It can be used as a substitute for rice and wheat [6] and an ingredient that blends well into the Indian cuisine such as *idli*, *dosa*, porridge, *roti* and gluten-free breads [7].

Buckwheat is a gluten-free pseudocereal of the Polygonaceae family [8]. Two types of buckwheat, namely, common buckwheat and tertiary buckwheat are used throughout the world [9]. The advantages of buckwheat in preparing noodles, pancakes, and muffins have made it one of the most widely consumed products in many countries, like India, China, Japan, Nepal, Canada and Ukraine [10].

MATERIALS AND METHODS

Experimental Design and Sample Processing

The present work was conducted through an experimental study design and was performed in two phases (Table 1) in order to develop an instant *adai* mix (which is ready-to-cook product and developed to satisfy the need of fast preparation, consumers' desire, high quality, healthy products) [11] with

the incorporation of buckwheat and brown teff flours in two different proportions of 60:40 and 40:60 (Table 2). The developed *adai* mix was subjected to nutrient, chemical, microbial and sensory analysis in the first day and end of the 14 day storage period.

Phases of the study

The phases of the study are as follows:

Table 1. Phases of the study

Phases	Activity
Phase I	Development and Standardisation of the preparation of instant *adai* mix
Phase II	Assessment of the instant *adai* mix for the following on the first and 14th day of storage: a) Specific nutrient analysis b) Microbial analysis c) Chemical analysis d) Sensory analysis

Plate 1 [*Source: Whole Grains Council]*

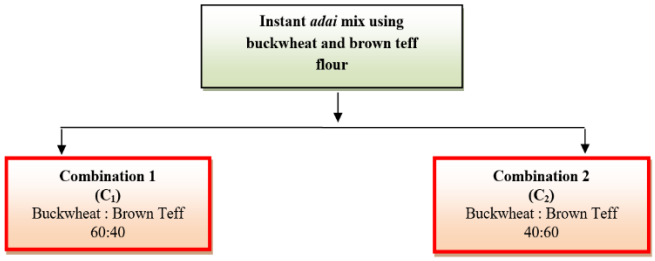
Brown Teff seeds from Gadag, Karnataka

Buckwheat groats

Phase I

Development and standardsation of the preparation of instant adai mix

The instant *adai* mix was prepared in two different proportions of buckwheat to brown teff flour.



Ingredients used in instant *adai* mix

The proportion of ingredients used in the preparation of instant adai mix is presented in Table 2.

Table 2. Ingredients of Instant adai mix using Buckwheat BW) and Brown Teff flour(Teff)

Ingredients	Combination 1(C1) 60:40 BW:Teff	Combination 2(C2) 40:60 BW:Teff
Urad dhal (g)	50	50
Channa dhal (g)	50	50
Toor dhal (g)	50	50
Brown Teff flour (g)	60	40
Buckwheat flour (g)	40	60
DryWhole Red chillies (nos)	3	3
Dry Curry leaves (sprigs)	2	2
Dry Ginger pieces (tsp)	¼	¼
Dehydrated onion (no.)	1	1

The number of portions was 5 *adais* per combination

Phase II

Assessment of the instant adai mix on the first and 14th day of storage

The instant *adai* mix was subjected to the following analysis on the 1st and 14th day of storage:

a) Specific nutrient analysis
b) Microbial analysis
c) Chemical analysis
d) Sensory analysis

Specific Nutrient Analysis

The carbohydrate content was estimated through the difference method and the protein content was determined by the Kjehldahl method [12]. Fat content was analysed with the Soxhlet method [12]. The dietary fibre level was also analysed in order to obtain the fibre content of the *adai*. Calcium and iron content was determined adopting standard protocols [12]. Moisture content was calculated applying standard procedures [13]. The most important test for a gluten free product was the gluten test and it was performed using the Gluten Food Allergen test method [13].The nutrient

analysis was done on the first t and 14th day of storage.

Microbial analysis

The microbial analysis of the instant *adai* mix was performed on the first and 14th day of storage. The samples were analysed for the Total Bacterial Count (TBC) adopting spread plate count [13].

Chemical analysis

The chemical stability of the *adai* mix was studied on the first and 14th day by assessing the pH and water activity levels [14] [15].

Sensory analysis

Sensory evaluation of the 2 combinations of instant *adai* mix was done on the first and 14th day of storage by a panel of 30 semi-trained members. A 5 point Hedonic Scale Score card was used to assess the samples for colour, texture, taste and overall acceptability. A maximum score of 5 was given for excellent, 4 for very good, 3 for good, 2 for fair and a minimum of 1 was given for poor quality.

Statistical analysis

The data was subjected to the calculation of Arithmetic mean.

Specific nutrient content of instant *adai* mix

Products made from corn, rice, amaranth, buckwheat, quinoa, teff, sorghum and wild rice are gluten-free grain products [16]. In this study, gluten free instant *adai* mix was prepared using buckwheat and brown teff flour in two proportions [C1 (60:40) and C2 (40:60)]. They were assessed for their nutrient content on the first and 14th day of storage.

RESULTS AND DISCUSSION

Prescribing gluten-free diet can be effective in the treatment of gluten- related disorders like celiac disease. According to the literature, the diet can help in clearing skin lesions and heal small bowel mucosa, decrease IgA and epidermal transglutaminase deposits in the skin, and reduce the need for oral medicines in the patients [17] [18] [19] [20]. Improved cerebellar functions are noticed in patients avoiding gluten [21]. Gluten avoidance may cure some gluten-sensitive disorders through the modulation of gut microbiome. It can alter the gut bacterial population in CD patients[22] [23]. Both genetic and environmental factors result in T1Diabetes (T1D), and gluten intake is also suspected [24]. The gluten avoidance reduced hypoglycemia in children with T1D and CD [25]. HbA1c levels improved in children with T1D and CD avoiding gluten [26] [27].

A gluten free *adai* mix (ready to cook) was prepared using buckwheat and brown teff flours to benefit individuals with celiac disease. The mix was prepared in two proportions of buckwheat to brown teff flours (60:40 and 40:60) and was subjected to nutrient, chemical, microbial, and sensory analysis on the first and 14th day of storage. The energy, carbohydrate, protein, fat, dietary fiber, calcium and iron in 100g of C1 and C2 are presented in Table 3. The percentage contribution of different nutrients by C1 and C2 is compared with the RDA for an adult woman (sedentary lifestyle). This table also presents the assessments of these nutrients on day 14 of storage. A comparison of nutrient content of C1 and C2 on day 1 with that of day 14 will reveal any changes or deterioration in the nutrient content of the instant *adai* mix on storage.

From Table 3, we can infer that the carbohydrate and energy contents of C1 and C2 are more or less similar but are higher than that contributed by wheat. It can also be noticed from the table that C1 and C2 contribute 54 per cent of the daily carbohydrate requirement. There was no significant change in the carbohydrate content on the 14th day of storage.

The nutrient composition of the gluten-free diet is the major factor for the consumers and food industries. Though gluten avoidance reduces the symptoms and promotes intestinal healing in CD patients, long-term adoption to gluten avoidance may result in the deficiency of certain nutrients. In addition, gluten-free products are with high levels of fat, sugar, and sodium compared to products with gluten [28]. Many pasta materials devoid of gluten have higher levels of carbohydrates and sodium [29] [30]. Materials free from gluten are generally poor sources of protein and fiber [28] [31]. Gluten-free products are not fortified or enriched like other regular products, and hence they are lower in folic acid, iron, niacin, thiamin and riboflavin [32] [33]. Formulation of these materials without affecting their sensory appeal has to be improved [34].

CD patients following gluten avoidance exhibited less intake of minerals like iron, calcium, selenium, magnesium, zinc, and vitamins like folic acid , niacin, thiamin, riboflavin, vitamins A and D [35] [36] [37] [38] [39] [40]. The acceptable macronutrient distribution range (AMDR) for carbohydrate prescribed by the Institute of Medicine is 45%-65% of energy. The contribution of carbohydrate by the instant *adai* mix is 54 per cent which is 20 per cent of the daily energy requirement of an adult woman with a sedentary lifestyle.

Protein

It can be observed from Table 3 that C1 and C2 are exceptionally good sources of protein contributing 16 to 18 g which is higher than what is present in wheat. ICMR recommends 55 g of daily protein intake for an adult woman. C1 and C2 provide nearly 30 per cent of the protein requirement. Therefore, this instant *adai* mix may be an excellent source of protein for not just adults alone but also for children suffering with gluten intolerance. There was no significant difference in the protein content of both the combinations of instant *adai* mix on storage.

Fat

ICMR recommends 20 g of visible fat intake in a day. C1 and C2 provide 2.8 to 3.23 g of fat which is double than that of what is in wheat flour. Literature shows that teff and buckwheat predominantly contain unsaturated fatty acids.

There was no change in the fat content of the instant *adai* mix on day 14 of storage.

Table 3. Comparison of specific nutrient content of C1 and C2 with RDA and wheat nutrients for days 1 and 14 of storage

Nutrients	RDA of adult woman (sedentary worker) ICMR & IOM	Wheat flour	Day 1				Day 14	
			C1 BW : Teff 60 : 40	% RDA Cont-ributed by C1	C2 BW : Teff 40 : 60	% RDA Cont-ributed by C2	C1 BW : Teff 60 : 40	C2 BW : Teff 40 : 60
Energy (Kcal/ day	1900	321.9	383.47	20.2	380.2	20	382.8	382.99
Carbohydrates (g/day)	130	64.72	70.3	54.1	71.0	54.6	72.0	73.2
Protein (g/day)	55.0	10.59	18.3	33.3	17.3	31.5	17.4	16.0
Fat (g/day)	20	1.47	3.23	16.2	3.00	15	2.80	2.91
Dietary Fiber (g/day)	40	11.23	17.2	43	18.2	45.5	22.1	19.4
Calcium (mg/day)	600	39.36	56.2	9.4	122	20.3	34.5	74.8
Iron (mg/day)	21	3.97	89.9	428.1	122	580.9	91.7	100.4
Moisture (%)	-	<13 % BIS (1979)	5.19	-	5.73	-	4.78	4.93
Gluten (g)	-	13.1-14 (Kasarda, 2013)	BLQ (LOQ : 1.0)	-	BLQ (LOQ : 1.0)	-	-	-

BLQ – Below Limit of Quantification LOQ – Limit of Quantification

Dietary fiber

According to ICMR recommendations, a person's daily dietary fiber intake should range between 20 to 40 grams [41]. Wheat contributes 11.23 g/100g whereas C1 and C2 provide 18 grams of dietary fiber on an average. Thus this instant *adai* mix is also a good source of dietary fiber which may benefit not only individuals with gluten intolerance but also people suffering from obesity, constipation, hyperlipidemia and hyperglycemia.

Calcium

Baye [42] reports that teff is a good source of calcium. In this study, the calcium content increased as the proportion of teff increased. Thus C2 had higher calcium content than C1 and wheat flour. The Indian Council of Medical Research recommends 600 mg/ day of calcium for both genders but the average daily intake of calcium is only 400–500 mg per day in South Asia and India [43]. Inclusion of teff and buck wheat in one's diet may substantially contribute to the daily calcium intake thus benefitting individuals with low bone mineral density.

Iron

Iron is abundant in C1 and C2 (Table 3). In the samples where the composition of teff is higher, the iron content of the mix is also high. The RDA of iron for non-vegetarians differs from that of the vegetarians. The RDA for the vegetarians is 1.8 times higher than that of non-vegetarians. Heme iron from meat is more bioavailable than non-heme iron from plant-based foods. But non-vegetarian diet increases the absorption of non-heme iron [41]. Most of the Indians receive iron from vegetarian diet including cereals [44]. The findings of this study prove that the instant *adai* mix is an excellent source of iron which can benefit anemic individuals. Variations in dietary fiber, calcium and iron content on day 14 of storage may be due to sample variation since dietary fiber and minerals are fairly stable in foods on storage.

Moisture content

Department of Plant Sciences from the North Dakota State University states that the moisture content of *maida* flour should not exceed 13 per cent. Table 4 shows that the moisture content of the *adai* mix is less than 6 %. Moisture content of foods is inversely related to their shelf life. Lower

the moisture content, longer will be the shelf life of dry food products.

Gluten avoidance awareness and health consciousness may influence food choices, and results. Proper follow-up and nutrition awareness are needed [29] [38] [39]. In addition, quality of ingredients in products free from gluten has to be improved [30] [38]. Gluten avoidance also supports weight management in normal individuals [45].

Body weight reduction associated with gluten avoidance might be due to health- conscious behaviour [46], reduction in carbohydrates, and low availability of gluten-free food materials [47]. Hence it is difficult to verify that gluten elimination results in weight loss.

Gluten

According to CODEX Standards [45], the gluten level of any gluten-free product must be below 20mg/kg in total. In the present study, the gluten content of instant *adai* mix is below the limit of quantification (BLQ) which proves that it can be termed as 'gluten-free instant *adai* mix'. This is because, teff and buckwheat used in the preparation of the instant *adai* mix are gluten-free grains.

Storage stability of instant *adai mix*

Using specific tests on the first and 14th day of storage, the chemical and microbial quality of the instant *adai* mix was evaluated to determine its storage stability.

Chemical analysis of instant *adai* mix

The water activity and pH of C1 and C2 on the first and 14th day of storage were assessed to determine the chemical quality of the instant *adai* mix. Table 4 divulges the results of chemical quality of the combinations.

Water activity

Water activity (a_w) is an important parameter when food materials are stored. According to CODEX Alimentarius commission [48], the water activity (a_w) of low-moisture foods should be well below 0.85. Milled grain products such as flour should be within the scope of the standard. All the samples had a_w below 0.85 (Table 4). Restricting water activity inhibits the growth of microbes, provides long shelf life and permits safe storage of certain products without refrigeration. As water is a universal solvent, water activity affects the reaction rates of degrading chemicals. Low water activity of C1 and C2 on day 14 of storage indicates that they remained stable for 14 days.

pH

In Table 5, the pH of C1 and C2 ranged between 6.38 and 6.46 and they did not show any significant change on storage. They are near neutral range and hence the digestion may not be a problem.

Microbial analysis of instant *adai* mix

For determining the microbial quality of the instant *adai* mix, the Total Bacterial Count (TBC) of C1 and C2 on the first and 14th day of storage was assessed (Table 4). Total bacterial count provides an estimate of the total number of aerobic organisms in food [49]. According to the Centre of Food Safety [50], ready-to-eat food mix must have a TBC <10^3. Table 5 shows that the TBC of C1 and C2 on days 1 and 14 are well within the reference level. Hence the microbial quality of the instant *adai* mix was good for 14 days.

Table 4. Water activity, pH and TBC of C1 and C2 on first and 14th day of storage

Parameters	Standard references	Wheat flour	Day 1		Day 14	
			C1 BW : Teff 60:40:00	C2 BW : Teff 40 : 60	C1 BW : Teff 60:40:00	C2 BW : Teff 40 : 60
Water activity (a_w)	0.85	< 0.70	0.035	0.048	0.054	0.114
pH	6-6.3	6-6.8	6.38	6.45	6.45	6.46
TBC (cfu/g)	-	-	8300	5600	6900	9600

Sensory analysis of instant *adai* mix

Sensory analysis helps to estimate, analyze, and interpret response to food qualities through the functions of the receptors of the nervous system. It is also an essential component of a food product development [51]. Bread made of fermented teff flour is better than that of unfermented teff flour [52]. Consumers are satisfied with the taste and texture of products free from gluten, and efforts to improve their taste is necessary [53].

The sensory attributes of the instant *adai* mix were assessed for the samples C1 and C2 on the first and 14th day of storage (Table 5). C2 had the highest overall acceptability score for days 1 and 14. This sample had a lesser proportion of buckwheat and a higher proportion of teff (40:60). Even on day 14, C2 had the highest acceptability score and hence its preference was not influenced by storage.

Cost calculations

Gluten-free materials are of high cost compared to their counterparts with gluten. Moreover quality gluten-free

materials are not easily available. In addition poor people living in rural areas cannot purchase them easily. Cost involved in the preparation of C1 and C2 is given in Table 6.

Due to confusion surrounding gluten sensitivity, cost and low availability of gluten-free products, gluten avoidance can be difficult for many individuals. But the disadvantages in avoiding gluten in their diet are meager compared to the health benefits after avoiding gluten. The patient has to balance the deficiencies of nutrients in the gluten-free diet. It is generally accepted that dietary awareness and counseling have to be given to help such patients.

Table 5. Sensory evaluation scores of C1 and C2 on 1st and 14th day of storage

Sensory attributes	Day of storage	C1				C2			
		Excellent	Very good	Good	Fair	Excellent	Very good	Good	Fair
Colour	Day 1	10	19	6	4	14	14	5	1
	Day 14	4	14	3	3	13	10	2	1
Flavour	Day 1	1	14	13	2	7	11	11	1
	Day 14	3	15	9	3	7	14	9	0
Texture	Day 1	4	15	8	3	6	14	8	2
	Day 14	4	16	8	2	5	21	3	1
Appearance	Day 1	7	16	10	1	12	14	8	0
	Day 14	5	12	7	2	10	10	4	2
Overall Acceptability	Day 1	2	19	8	1	10	13	6	1
	Day 14	3	14	10	2	4	17	6	3

Table 6. Cost of preparation of C1 and C2

Ingredients	Cost per kg (Rs.)	Quantity of ingredients used for Preparation of C1(g)	C1(60:40) (BW:Teff) Cost(Rs.)	Quantity of ingredients used for Preparation of C2(g)	C2(40:60) (BW:Teff) Cost(Rs.)
Teff flour	1200	40	48	60	72
Buck wheat	700	60	42	40	28
Urad dhal	250	50	12	50	12
Toor dhal	250	50	12	50	12
Moong dhal	250	50	12	50	12
Onion powder	100	5	1	5	1
Dried ginger powder	100	5	1	5	1
Curry leaves	-	5	0	5	0
Red chillies	250	5	1.25	5	1.25
Total cost			**129.25**		**139.25**

CONCLUSION

Through this study we can conclude that teff and buckwheat are two gluten free grains that can be utilized effectively in South Indian cuisine. *Adai* is a typical South Indian dish that is consumed for both breakfast and dinner. In the present study teff and buck wheat flours were used in *adai* preparation. This was done in order to observe the adaptation of teff and buckwheat to the South Indian cuisine and also among the South Indian community. It was found through the nutrient analysis that the developed instant *adai* mix was a good source of dietary fiber, calcium and iron. Therefore, teff and buckwheat can also be included in the diet of weight watchers, diabetics, individuals with hyperlipidemia, low bone mineral density and anaemia.

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