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The Impact of Formulated Gluten Free Flour on the Dietary Pattern of Celiac Pakistani Patients

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ABSTRACT

Present study is intended to introduce indigenously formulated gluten free flour (GFF) in the diet of selected celiac patients and to evaluate the effect of its induction on their dietary patterns. Indigenous sources including rice, corn and daal mung were used in the formulation of GFF. Fifty diagnosed celiac patients were selected from Sheikh Zayed Medical Complex, Lahore and Mayo Hospital, Lahore, Pakistan, after approval from the corresponding review boards and given GFF for a period of four months. Pre and post treatment assessment of food intake, compliance, appetite, meal patterns and meal satisfaction of the study participants was done. Caloric and macronutrient consumption of the study participants was more than the recommended dietary guidelines before and during the feeding trial. A maximum of flour consumption was observed in the study participants of 9-13 years. No significant difference was found in the food intake from starch, milk, meat and fruit groups during the treatment phase. Mean carbohydrate exchanges of all age groups were more than recommended for their respective age groups. Highest wheat (gluten) consumption was reported in the study participants of 19 to 30 years of age before the feeding trial and was reduced significantly with GFF induction. Meanwhile milk, meat, fruit and vegetable intake of the study participants was less than the recommended intake. A significant increase in vegetable intake was observed with GFF administration. The improvement in compliance, appetite, meal regularity and meal satisfaction of the study participants was noticeable in all age groups but the change was more prominent in children.

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SAN conceived and designed the study. SI performed the experimental work, analyzed the data and wrote the article. SK helped in writing the article.

Key words
Celiac disease, gluten free flour, dietary patterns, appetite, compliance.

INTRODUCTION

Celiac disease is an autoimmune, chronic inflammatory disorder of the small intestine resulting from the ingestion of gluten (Jafri *et al*., 2008). Although gluten free diet (GFD) could heal the injured intestine, the intolerance to gluten is permanent and will recur with the reintroduction of gluten (See and Murray, 2006).

GFD represents a constant, restrictive burden and negative peer pressure on the patient due to less palatability, high cost and unavailability (Sunder *et al*., 2007). Energy intake of celiac patients has been reported to be lower and the diet unbalanced, with a higher percentage of energy as fat and a lower percentage of energy as carbohydrates (Bardella *et al*., 2000). Dietary patterns of celiac patients have revealed that their high intake of fat and protein was due to an extra amount of egg, meat and cheese in the diet rather than the use of commercially available GFDs (Bardella *et al*., 2000).

Studies carried out by Hopman *et al*. (2006) and Martin *et al*. (2013) on the contrary, have revealed that energy and macronutrient intake of celiac patients were almost the same as of normal population. Increased energy intake with higher carbohydrate and lower fat intakes in comparison with controls have also been documented (Zuccotti *et al*., 2013). The appetite of celiac patients have been found to be depressed in certain cases and quite enhanced in others. Precarious appetites and high ghrelin levels have been seen in untreated or non compliant patients (Lanzini *et al*., 2006). These symptoms settle down quickly, in few days after initiation of the GFD (Arigo *et al*., 2011).

Strict adherence to a GFD is considered as a key aspect of treatment, however, various studies in Europe found poor adherence in many celiac patients especially in preadolescents, adults and asymptomatic patients. Meanwhile higher compliance rates have been found in children (Green and Cellier, 2007; Mulder *et al*., 2013; Pietzak, 2005). Observance of the dietary advice given by physicians has been found to be generally low in celiac patients. Most of the patients have been reported to be interested in novel therapeutics rather than adhering to GFD (Aziz *et al*., 2011). Poor palatability of GFD has been reported as the top most reason for non compliance (Celiac Society of Ireland, 2014).

Food intake of celiac patients of in Pakistan has a neglected concern. No local gluten free substitute is available commercially. Present study aims to assess the existing dietary patterns of celiac patients, to introduce

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indigenously formulated gluten free flour in their diet and to reassess the effect of its induction on their dietary patterns.

Table I.- Age and gender distribution of the study sample.

Age and gender distribution	f(%)
Age(years)	
1-3	6(12.0)
4-8	12(24)
9-13	17(34)
14-18	4(8)
19-30	6(12)
31-50	5(10)
Gender	
Male	25(50)
Female	25(50)

METHODS

A total of 50 diagnosed celiac patients (diagnosis confirmed through endoscopy and serum anti bodies IgG and IgA) were recruited on volunteer basis from the Gastroenterology and Pediatric Department of Sheikh Zayed Medical Complex and Mayo Hospital, Lahore, Pakistan (Table I). All the required formalities of corresponding review boards of the hospitals were met (Ref No: F.38/NHRC/Admn/IRB/346). Patients selected belonged to middle or low socio-economic status (Nagra *et al*., 1984).

A detailed diet history of the study participants was obtained. It provided information regarding their compliance, appetite, meal patterns and meal satisfaction. Responses were measured on a likert scale of 1-5. Food intake was assessed by using 24 h food recall and food frequency checklist (Mahan and Escott Stumps, 2008). The adopted food frequency checklist was modified by the addition of commonly used local food items in Pakistan. It also included the serving sizes and preparation methods to authenticate the information provided in the 24 hour recall. Owing to illetracy and poor understanding of the study participants, detailed information about the utensils they were using at home was taken and the food quantity was estimated as precisely as possible.

Cooking fat intake of study participants was calculated by interviewing the mother about the amount of oil/ghee used in cooking in grams or cooking spoons and the amount of food eaten by each study participants. Fat content per serving of food was calculated and the fat intake of the study participants was calculated according to the serving of food eaten. Oil/ghee capacity of standard cooking spoons and different sizes of *doi* (wooden spoons used for cooking) were converted into standard measurements.

Exchange lists were used for the calculation of carbohydrates, proteins and fats in grams. Total calories were calculated by converting the grams with the factors of 4, 4 and 9 for carbohydrate, protein and fat, respectively. For packaged snacks, juices, cola drinks and dietary supplements, available nutrition information on the labels was used.

The caloric requirements were calculated individually for each study participant by first calculating estimated energy requirements (EER) for the particular age group and gender. The activity level was taken as sedentary for all study participants as they were involved only in very light activity (Mahan and Escott Stumps, 2008).

Carbohydrate requirement was calculated as 55% of the total calories; protein 15% of the total calories and fat 30% of the total calories. The calories were then converted in grams.

Gluten free flour containing 50% rice flour (*Oryza sativa*) made from basmati rice, 33% dehulled mung bean flour (golden gram-*Vigna radiate*), 17% dehulled and de germed corn flour (*Zea mays*) and 0.5% xanthan gum was prepared in bulk and packed in 5 kg bags. The flour was checked for its proximate analysis using AOAC (2005) standard procedures. Prepared flour contained 13% protein, 0.6% fat, 1.2% ash, 2.1% crude fiber and 72% nitrogen free extract.

After thorough dietary assessment study participants were given 5 kg GFF and I kg biscuits prepared from GFF. They were instructed in detail on the use of this flour for making standard, sweet and stuffed chappati (unleavened flatbread) / paratha (pan fried chapatti), pancakes, ladu (South Asian sweet), halwa (dense, sweet confection made from a variety of flours and nuts) and even pakoras (popped balls made from gram flour, spices and baking soda). Furthermore, study participants/attendants were suggested to buy separate preparation and cooking paraphernalia for the patient to prevent contamination with the wheat flour. GFF was provided at intervals, time interval was based on the reporting of study participant /attendant that his flour has finished. Study participants were reassessed after four month period.

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) Version 20.0. Paired t-test was applied to assess the difference between pre and post test values.

RESULTS

Pre and Post assessment caloric and macronutrient intake of majority of the study participants was higher than the recommended dietary guidelines (Table II). Maximum flour was consumed by the study participants of 9-13 years (Table III). When compared with the American guidelines 2010, mean carbohydrate exchanges of all age groups were more than recommended for their respective age groups (Table IV). Milk, meat/ meat substitutes, fruit and vegetable intake of the study participants was found to be less than the recommendation. An increase in vegetable consumption was observed with GFF administration in all age groups and significantly in the study participants of 9 to 13 years. Fat intake was higher in the age group of 19 to 30 years both pre and post treatment (Tables V, VI). The highest wheat (gluten) consumption was reported in the study participants of 19 to 30 years of age and minimum consumption in study participants of age 14 to 18 years (Table VI). Lunch and dinner meals were regularized with GFF use. The improvement in compliance and appetite were noticeable in all age groups but the change was more notably in children (Table VII). Improvement in satiety and meal satisfaction was also reported in almost all study participants (Table VIII).

Table II.- Effect of gluten free flour on percent caloric, carbohydrate, protein and fat requirement consumed by celiac patients of different age groups.

Age (yr)	Caloric requirement (%)		Carbohydrate requirement (%)		Protein requirement (%)		Fat requirement (%)	
	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment
1-3	155.24±50.21	128.00±20.21	138.64±69.54	128.16±17.88	142.83±32.95	129.65±32.06	191.88±41.56	126.87±29.04*
4-8	122.84±37.21	143.82±31.06	112.51±34.67	128.20±23.55	114.83±42.45	123.41±23.87	145.80±52.59	182.65±67.54
9-13	111.15±41.28	129.81±20.88	114.00±54.48	124.33±19.13	110.87±42.50	107.11±18.22	106.07±37.91	151.20±39.28*
14-18	112.38±40.44	119.23±28.05	102.92±40.85	103.32±22.39	102.18±38.27	106.05±31.79	134.82±43.85	154.99±44.25
19-30	109.22±34.15	109.35±26.68	88.62±34.03	93.71±33.83	106.06±48.96	96.43±36.04	148.58±50.46	144.51±24
31-50	105.76±37.14	86.64±22.34	96.93±23.90	86.00±24.18	100.25±28.73	93.82±16.89	124.69±68.89	84.22±41.18

Means in a row (% fat requirement) followed by asterisk (*) are significantly different at $p<0.05$

DISCUSSION

All age groups of study participants on an average were consuming more than 100% of their caloric requirement before and after the feeding trial. The caloric intake of the study participants was significantly ($p<0.05$) increased in the age group of 4 to 13 years and decreased in the age group of 31 to 50 years after GFF induction. Carbohydrate consumption represented was 85-140% of their mean carbohydrate requirement before the consumption of GFF. Significant ($p<0.05$) increase in carbohydrate intake took place in the study participants of 4 to 8 years only. Average protein intakes suggested that the study participants were consuming more than 100% of their mean recommended intake (Table II). No significant difference was observed in the pre and post treatment groups regarding the quantity of protein intake. It was, however, important to notice that before GFF consumption the source of protein was chiefly cereals especially rice providing partially complete proteins. After GFF use, intake of complete protein was substantially increased through the mung bean flour (golden Gram-Vigna radiate) present in the GFF. This was evidenced by a significant improvement in their serum protein and albumin levels (Imran *et al.*, 2014).

Table III.- Carbohydrates, protein and fat content of the gluten free flour (GFF) consumed by celiac patients of different age groups.

Age (yr)	Energy (%)	Carbohydrate (%)	Protein (%)	Fat (%)
1-3	32.85±14.28	47.76±20.45	36.08±17.94	2.06±0.95
4-8	36.02±11.19	59.17±15.93	44.92±14.86	1.82±0.85
9-13	38.73±8.70	60.23±13.79	50.32±11.86	2.03±0.57
14-18	26.47±15.13	45.52±27.54	32.22±19.79	1.22±0.64
19-30	26.69±7.94	47.14±11.09	33.20±9.55	1.23±0.57
31-50	29.62±12.96	44.96±21.15	29.39±13.39	2.02±1.05

Table IV.- Daily intake of food exchanges of starch, milk, meat and substitutes before and after the consumption of GFF by celiac patients of different age groups.

Age	Starch		Milk		Meat and substitutes	
(yr)	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment
1-3	6.75±2.42	7.86±1.82	2.42±0.79	2.27±0.92	1.05±0.90	0.87±0.66
4-8	8.87±3.73	9.94±2.66	1.34±1.01	1.33±0.78	1.97±1.40	1.67±0.90
9-13	11.05±6.42	10.93±2.49	1.37±0.97	1.26±0.75	1.51±1.16	1.01±0.82
14-18	13.24±6.19	11.30±2.90	1.12±0.55	0.55±0.51	2.58±1.67	2.61±1.40
19-30	13.76±6.84	12.61±6.12	1.40±0.54	1.23±0.77	4.53±3.79	3.26±2.71
31-50	12.35±7.11	10.62±5.20	1.83±1.48	1.77±0.90	2.81±1.59	2.29±1.20

Recommended exchanges:
Carbohydrates: 1-3yrs, 3; 4-8 yrs, 4 to 5; 9-13yrs, 5 to 6; >13 yrs, 6 to 11.
Milk: 1-3yrs, 2; 4-8 yrs, 2; 9-13yrs, 3; >13 yrs, 2 to 3.
Meat and Substitute: 1-3yrs, 2, 4-8 yrs, 3 to 4; 9-13yrs, 5; >13 yrs, 5 to 6 (Whitney and Rolfes, 2013).

Table V.- Daily intake of food exchanges of fruit, vegetable and fat before and after the consumption of GFF by celiac patients of different age groups.

Age	Fruit		Vegetable		Fat	
(yr)	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment
1-3	1.58±2.21	0.88±0.99	0.23±0.27	0.27±0.21	5.88±3.39	4.78±2.20
4-8	0.97±0.74	0.91±0.94	0.24±0.23	1.01±1.23	7.48±4.14	9.79±3.78
9-13	0.37±0.48	0.19±0.25	0.29±0.30	1.04±0.90*	5.47±3.55	10.29±3.14*
14-18	0.53±0.52	0.42±0.66	0.86±1.10	1.28±0.68	10.08±4.87	13.15±4.40
19-30	0.66±0.52	1.02±1.53	0.84±0.68	1.92±1.79	13.55±7.59	13.47±3.73
31-50	0.75±0.80	1.23±1.30	1.43±1.54	1.92±1.01	10.55±6.86	7.44±7.03

Means in a row followed by asterisk (*) are significantly different at $p<0.05$
Recommended exchanges:
Fruit: 1-3yrs, 2; 4-8 yrs, 2 to 3; 9-13yrs, 3; >13 yrs, 3 to 4.
Vegetable: 1-3yrs, 2; 4-8 yrs, 3; 9-13yrs, 4 to 5; >13 yrs, 4 to 5.
Fat: 1-3yrs, 3; 4-8 yrs, 3; 9-13yrs, 4 to 5; >13 yrs, 5 and above according to the caloric req (Whitney and Rolfes, 2013).

Study participants of the age group of 1-3 years consumed almost double their mean fat requirement before the trial. Their intake was significantly ($p<0.05$) reduced after treatment. Fat intake was, however, significantly ($p<0.05$) increased in the patients of 4 to 13 years (Table II).

The results of studies carried out by Hopman *et al.* (2006) and Martin *et al.* (2013) have also revealed that energy and macronutrient intake of celiac patients were almost the same as of normal population. Some other studies have shown a high average energy intake of celiac patients, with more carbohydrate and low fat intakes as

compared with controls. These studies have also shown that patients who strictly adhere to a GFD ingest fewer calories than non compliant patients (Barera *et al.,* 2000; Capristo *et al.,* 2000)**.** This was consistent in the present study especially in female study participants of 19 years and above. Female study participants in this age group who were more compliant had very little food choices within their budget as some of them had children to feed. They were found to be consuming semi starvation diets based on tea and little rice.

Maximum flour consumption, kcal, carbohydrate and protein contribution were observed in the study participants of 9-13 years (Table III). These study participants were found to be deriving an average of 26–39% of their total caloric intake from the GFF. This caloric contribution was in close conformity of the study by Zuccotti *et al.* (2013) who reported the caloric contribution of gluten free products to be 36.3% of daily. On an average about half of the carbohydrate and 30-50% of the protein ingested was contributed by the GFF. Percentage of fat contributed by the GFF was nominal.

Daily intake of food exchanges from different food groups by the study participants was assessed. It was estimated that mean intake of starch exchanges in the age groups of 14 to 18 and of 19 to 30 was the highest. Milk intake was appropriate only in the age group of 1 to 3 years. This food group along with providing high quality protein is the chief contributor of calcium (Dietary Guidelines for Americans, 2010). Milk intake was reduced during the trial period in study participants of 14 to 18 years. Milk consumption in other age groups remained more or less the same. It was however observed that almost half of the study participants were taking milk in the form of tea. This could substantially reduce amount of calcium absorbed (Gropper and Smith, 2012) (Table IV)

Meat and meat substitute intake of the study participants of 19 to 30 years was the highest and remained so after treatment. This food group provides not only protein but also contributed B vitamins (Dietary Guidelines for Americans, 2010). Mean intake of this food group was less than recommended for different age groups. Mean intake was lowest in children of 1 to 3 years. Further reduction in meat (and substitute) intake was observed in patients of 9 to 13 years during the feeding trial. Intake in other age groups remained almost unaltered (Table V).

Fruit and vegetable intakes of the study participants were low in all age groups. Age group of 9 to 13 year was consuming the least amount of both fruits and vegetables. Fruit intake of young study participants was better than the older age groups; however, their vegetable intake was considerably low. Vegetable intake

Table VI.- Effect of gluten free flour on the consumption frequency (intake/week) of chapatti (wheat), chapatti (other cereal), rice, bread (wheat) and biscuits (wheat) by celiac patients of different age groups.

Age (yr)	Chapatti (wheat)		Chapatti (gluten free cereal)		Rice		Bread (wheat)		Biscuits (wheat)	
	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment
1-3	1.33±2.80	0.00±0.00	2.33±2.88	0.00±0.00	6.33±1.63	3.50±1.87*	0.04±0.10	0.17±0.41	1.67±2.88	0.21±0.40
4-8	1.67±2.74	0.17±0.58	2.75±3.28	0.17±0.58*	6.25±1.42	1.88±1.81*	0.08±0.29	0.00±0.00	1.67±2.02	0.13±0.31*
9-13	0.88±2.32	0.41±1.70	3.13±3.41	0.47±1.70*	4.62±2.91	2.41±2.15*	0.12±0.33	0.06±0.24	0.78±1.85	0.34±0.84
14-18	0.00±0.00	0.00±0.00	1.50±1.91	0.00±0.00	6.00±2.00	4.06±3.47	0.00±0.00	0.00±0.00	0.25±0.50	0.00±0.00
19-30	3.50±3.15	0.08±0.20*	0.42±0.80	0.00±0.00	5.50±1.76	3.17±3.19*	0.50±1.22	0.17±0.41	1.67±2.66	0.04±0.10
31-50	1.50±3.08	0.05±0.11	0.25±0.25	0.00±0.00	6.40±1.34	4.20±2.59	0.10±0.22	0.05±0.11	0.30±0.45	0.20±0.45

Means in a row (chapatti (wheat), chapatti (other cereal), rice & biscuits (wheat) followed by asterisk (*) are significantly different at $p<0.05$

Table VII.- Effect of gluten free flour on the compliance and appetite of celiac patients of different age groups.

Age (yr)	Compliance			Appetite		
	Pre treatment	Post treatment	% increase	Pre treatment	Post treatment	% increase
1-3	3.67±1.37	4.33±0.52	33.33±51.64	4.17±0.41	4.50±0.55	8.33±12.91
4-8	3.58±1.38	4.33±0.49*	57.64±114.01	3.83±1.19	4.42±0.67*	23.61±33.68
9-13	3.76±1.44	4.35±0.86*	34.31±57.20	3.88±1.17	4.65±0.86*	30.39±48.76
14-18	4.25±0.50	4.50±0.58	6.25±12.50	3.50±1.00	4.50±0.58	33.33±27.22
19-30	2.67±1.86	4.50±0.55	183.33±204.12	3.50±1.22	4.50±0.55*	38.89±38.97
31-50	3.20±1.30	4.20±0.45	71.67±128.51	4.40±0.55	4.40±0.89	2.00±26.60

Means in a row (compliance & appetite) followed by asterisk (*) are significantly different at $p<0.05$
Key: Compliance and appetite: 1, very poor; 2, poor; 3, good; 4, very good; 5, excellent.

Table VIII.- Effect of gluten free flour on the meal satisfaction of the celiac patients of different age groups.

Age (yr)	Breakfast satisfaction		Lunch satisfaction		Dinner satisfaction	
	Pre treatment	Post treatment	Pre treatment	Post treatment	Pre treatment	Post treatment
1-3	3.50±1.38	4.00±1.26	3.33±1.37	4.50±0.84	3.17±1.94	3.67±1.97
4-8	3.33±1.37	4.58±0.90*	3.17±1.19	4.50±1.00*	3.50±1.24	4.83±0.39*
9-13	4.00±1.27	4.82±0.53*	3.65±1.37	4.94±0.24*	3.47±1.33	4.94±0.24*
14-18	3.75±1.89	4.75±0.50	3.00±1.63	4.50±1.00	3.75±1.89	4.75±0.50
19-30	2.67±1.97	4.67±0.80*	3.67±1.75	4.67±0.82	4.17±1.60	4.67±0.82
31-50	3.60±1.67	3.80±1.64	2.80±1.48	3.80±1.64	3.20±1.79	3.80±1.64

Means in a row (breakfast, lunch & dinner satisfaction) followed by asterisk (*) are significantly different at $p<0.05$
Key: 1, never; 2, rarely; 3, sometimes; 4, often; 5, always.

was highest in the study participants of 31 to 50 years. After treatment with GFF fruit intake did not change significantly in any age group whereas, vegetable intake was increased in all age groups and significantly ($p<0.05$) in age group of 9 to 13 years. Intake increased to more than one exchange (half cup cooked vegetable) per day after treatment in all age groups except for age group of 1 to 3 years. The increase in vegetable intake was mainly due to the inclusion of chapatti made up of GFF. Over all intakes of fruits and vegetables was low as compared to the recommended intake of 2 - 2½ cup per day which could ensure adequate intakes of folate, magnesium, potassium, dietary fiber, and vitamins A, C, and K (Dietary Guidelines for Americans, 2010) (Table V).

Study participants in the age group of 19 to 30 years had the highest fat intake both before and after treatment. Fat intake significantly ($p<0.05$) increased after treatment in study participants of 9 to 13 years mainly due to the increased consumption of cooked salan (vegetable curry) with the chapatti. Fat intake of all the age groups was more than recommended (Whitney and Rolfes, 2013) (Table V).

More than half of the study participants were using banaspati ghee (hydrogenated fat) for cooking food. Plant oil, desi ghee (butter fat) and palm oil were reported to a much lesser extent. Zuccotti *et al.* (2013) have also documented that the saturated fat intake of celiac patients was significantly higher than recommended but these amounts were almost the same as being consumed by general population. These findings were in line with the results of the present study. It has been commented that strict GFD resulted in magnification of the already nutritionally unbalanced diet of adolescents by further increasing protein and fat consumption (Bardella *et al.*, 2000). It has also been pointed out that available gluten free products were not fortified with B vitamins and could worsen the deficiencies if proper diet containing meat, dairy products, fruits and vegetables and required supplements were not advised (Green and Cellier, 2007). Present GFF on the contrary normalized the intake of macronutrients and probably micronutrients by the addition of mung bean (golden gram-Vigna radiate) which has been considered a rich source of B complex vitamins.

Food frequency checklist revealed that mean intake of wheat chapatti was less than twice per week in all age groups except for the patients of 19 to 30 years who reported to eat wheat chapatti more frequently. After

the GFF trial, its consumption was absolutely stopped in the study participants of 1to 3 years and 14 to 18 years and reduced significantly in other age groups as well. Intake of chapatti made from gluten free cereals (mainly corn flour) was more frequent in younger study participants. Intake was completely curtailed in the study participants of 1 to3 years and those above 14 years of age. Frequency of intake was significantly (p<0.05%) reduced in the rest of the study participants as well. These observations showed the acceptance of the test GFF, which almost completely replaced the flour they were previously using (Table VI).

The intake of rice was high in the study participants of all age groups. Its consumption was reduced with GFF use. Frequency of wheat bread consumption, although rare, was reported by the study participants. Mothers reported that despite strict surveillance young study participants consumed wheat bread when ever got chance. No consumption of wheat bread was reported by study participants of 14 to 18 years and its frequency reduced in all age groups with GFF consumption. Intake of wheat biscuits was very common in all age groups, especially the young children. A reduction in their intake was observed overall and significantly in patients of 4 to 8 years (Table VI).

To conclude, study participants of 19 to 30 years had the highest frequency of consuming wheat containing products, whereas patients of 14 to 18 years had the least. After treatment with GFF its consumption was reduced to a great extent in all age groups. Food habits regarding cereal intake of the study participants indicated that wheat chapatti and wheat biscuits were the wheat items consumed more frequently by the patients and therefore proper gluten free substitutes to replace these items was considered important. Once substitution was available, intake of wheat and consequently gluten was substantially reduced.

Although extra money was being spent to increase meat, egg and fruit consumption of the study participants, their intake of these food items was still low and major contributor of proteins remained the cereals. These findings are partially variant to those reported by Bardella *et al*. (2000) who suggested that the high intake of fat and protein by celiac patients was due to an extra amount of egg, meat and cheese in the diet rather than the use of commercially available gluten free foods.

Compliance with the GFD has been considered a matter of great concern in the treatment of celiac disease. Results of the present study were indicative that the study participants of 14 to 18 years were most highly compliant whereas, lowest compliance was reported by study participants of 19 to 30 years. None of the age group reported 100% compliance to the GFD. High compliance was reported in all age groups after treatment with GFF. Significant (p<0.05) improvement was observed in patients of 4 to 8 and of 9 to 13 years of age (Table VII).

It has been reported that the majority of children and adolescents between 12 and 17 years of age had the highest prevalence of coping problems (Karwautz *et al.*, 2008). Pietzak (2005) had also reported high compliance rates in children and low in adolescents and asymptomatic patients. The results of the study at hand, on the contrary, suggested that study participants of 14 to 18 years were the most compliant and adult study participants were the least. This could be attributed to the different social setups. In a Pakistani culture children before marriage are taken better care of by their parents. Consequently their adherence to GFD was better. However, after marriage when this lot enters parenthood, become more careful about their children at the cost of their own health. Since all gluten free substitutes to wheat are expensive, the compliance is compromised by economic constraints.

Appetite of the study participants of 1 to 3 and of 31 to 50 years was good. Appetite significantly (p<0.05) improved in the study participants of 4 to 13 and of 19 to 30 years of age with the use of GFF (Table 6). Appetite of celiac patients has been found to be very poor or totally lost in certain cases and increased in others. These symptoms settle down quickly, in few days after initiation of the GFD (Arigo *et al.*, 2011). In the present study, increased appetite, decreased appetite, post meal abdominal discomfort, asthmatic cough and chewing difficulty were the main contributing factors affecting food intake in the study participants. Results further suggested that the level of satisfaction from all three meals was low before the GFF trial. It was increased after treatment in all patients (Table VIII). This suggested that improved compliance also increased meal satisfaction. This increase was most noticeable in study participants of 19 to 30 years. In the light of foregoing discussion it may be concluded that the consumption of GFF in various meals was quite satisfying for the study participants because of increased satiety and improved compliance.

CONCLUSION

Induction of GFF increased the vegetable intake of celiac patients. It significantly improved their compliance, appetite and meal satisfaction.

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