EVALUATION OF PHYSICO-CHEMICAL AND ORGANOLAPTIC CONSTITUENTS OF POTATO PEEL FORTIFIED BUSCUITS.

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خلاصہ

پروٹین، فائبر، امینو ایسڈ، معدنیات اور ضروری فیٹی ایسڈ کا اچھا ذریعہ سمجھے جانے والے آلو کے چھلکے والے بسکٹ تیار کرنے کے لئے تحقیق کی گئی۔ نمونے T0 (گندم کا آٹا 100٪)، T1 (95٪ گندم کا آٹا 5٪ آلو کے چھلکے کے پاؤڈر کے ساتھ)، T2 (گندم کا آٹا 90٪، آلو کے چھلکے کا پاؤڈر 10٪)، T3 (گندم کا آٹا 85٪ آلو کے چھلکے کے پاؤڈر کے ساتھ 15٪)، T4 (گندم کا آٹا 80٪ آلو کے چھلکے پاؤڈر کے ساتھ 20٪)، T5 (گندم کا آٹا 75٪ آلو کے چھلکے کے پاؤڈر کے ساتھ 25٪) کمرے میں اسٹور ریج کے 90 دن کے دوران 15 دن کے وقفے پر جسمانی، کیمیائی اور آرگنولیپٹک خصوصیات کے لئے مطالعہ کیا گیا تھا۔ درجہ حرارت بسکٹ کی چوڑائی اور پھیلاؤ عنصر آلو کے چھلکے کے اضافے میں اضافے کے ذریعہ بالترتیب 45.07 سے 40.94 ملی میٹر اور 45.19 سے 37.74 رہ گیا، جبکہ موٹائی 9.98 سے بڑھ کر 10.85 ہو گئی۔ بسکٹ میں نمی اور کاربوہائیڈریٹ کا مواد اسٹور ریج کے وقفے کے ساتھ بڑھ گیا ہے جبکہ راکھ، پروٹین، چربی، فائبر اور توانائی مخالف رجحان کو ظاہر کرتی ہے۔ اسٹور ریج کے دوران حسی خصوصیات میں کمی دیکھی گئی۔ رنگ میں زیادہ سے زیادہ کمی 35.77٪ T5) (T5، ذائقہ، T5 میں ساخت (29.37٪) اور مجموعی طور پر قابل قبولیت T5 (56.16٪) میں بھی دیکھی گئی۔ نتائج سے پتہ چلتا ہے کہ T5 جسمانی کیمیکل خصوصیات کے سلسلے میں بہترین نتیجہ دکھاتا ہے اور ٹی T1 کو پینل میں قابل قبول آرگنولیپٹک اتحادی پایا گیا۔ اعداد و شمار کے تجزیے میں بسکٹ کے نمونوں کے معیار اور حسی صفات پر علاج اور ذخیرہ کرنے کے نمایاں (پی<0.05) اثر کو ظاہر کیا گیا۔

Abstract

Research was conducted to develop potato peel powder blended biscuits that is considered as a good source of protein, fiber, amino acids, minerals and essential fatty acids. For this purpose 5 trials with control with different ratio of wheat and potato peel powder were used and studied for physical, chemical and organoleptic characteristics at the 15 days interval during 90 days of storage at room temperature. Width and spread factor of the biscuits decreased from 45.07 to 40.94 mm and 45.19 to 37.74, respectively by increasing the supplementation of potato peel powder, while thickness increased from 9.98 to 10.85. The content of moisture and carbohydrates in the biscuits increased with storage interval while ash, protein, fat, fiber and energy shows the opposite trend. A decrease in sensory attributes was observed during storage. Maximum decrease in color was observed in T_5 (35.77%), taste in T_5 (42.00%), texture in T_5 (29.37%) and in overall acceptability was also observed in T_5 (56.16%). Results showed that T_5 shows best result with respect to the physicochemical properties and T_1 was found acceptable organoleptically to the panel. Statistical analysis showed significant ($p < 0.05$) effect of treatments and storage on the quality and sensory attributes of biscuit samples.

Key Words: Potato Peel Powder, Biscuit Preparation, Storage Interval, Physico-chemical Constitutes, Organoleptic Attributes.

Introduction

Potato (*Solanumtuberosum* L.) belongs to Solanaceae family. Potato vegetation is dated back to South America around 500 B.C and over centuries, it is the fourth leading crop grown worldwide (Leo *et al.* 2008). The annual production of potato is 367.75 million tons globally, in Pakistan its production is 169.1 hectares with 4160.1 tones production and in KPK its production is 105.6 tons under 7.2 hectares respectively (FAO stat, 2015).

Potato is the key stone in human diet (Bradshaw *et al.* 2009) because it is a good source of carbohydrate, protein, minerals and vitamins and is also one of the richest sources of antioxidants (Buono *et al.*2009). The potato processing industry generates around 3 to 5 % of the weight of potato in the form of waste as peel which causes environmental problems when decomposed by micro-organisms. Potato peel is a good source of several beneficial functional ingredients including natural antioxidants, phenolic compounds and fibers (45%) (Dhingra *et al.* 2012).

Potato peel demonstrates anti-hyper-glycemic effect (Singh & Rajini, 2004), protects from cardio-vascular diseases (Sharoba *et al*. 2013), decrease in level of cholesterol and intestinal glucose absorption (Rodriguez *et al.* 2006).

Consumer interest is increasing in functional foods and this has led to the demand of such products in the market. The development of fiber enriched staple foods is an important contribution to a broader supply of food products with health beneficial effect. Therefore, different sources have been incorporated as raw material into cereal products which have health benefits (Masoodi and Chauhan, 1998). Adequate amount of dietary fiber found in potato peel, was used in bread manufacturing to enhance the fiber content (Gandhi *et al.* 2013). Food residues for example potato peels (Dhingra *et al*., 2012) could be incorporated into cake making. Baked goods are suitable food product for supplementing dietary fiber from potato peel powder particularly biscuits are well thought-out as the most feasible and acceptable carriers for nutritional supplements (Hussain *et al*. 2011) worldwide. In Pakistan wheat is a staple food and consumed in a variety of form like bread, chapatti, cake, biscuits etc. Wheat flour although carbohydrates is considered as a rich source though it lacks considerable amount of fibers, biomolecules and minerals as antioxidants to fulfill the increasing demands of nutrition of the vulnerable populations (Kulkarni and Joshi, 2013). Biscuits can be modified to fulfill particular nutritional requirements of whichever targeted population (Al-Sayedand Ahmed, 2013). Hence this research work was initiated and the aim of this study was to prepare fiber rich cookies by utilizing the waste of vegetable (potato peel) processing industries.

Materials and Methods

Sample Collection: This research work was conducted in the Department of Food Science and Technology at The University of Agriculture Peshawar. The wheat flour and potato samples were procured from the nearby market of Peshawar.

Sample Preparation: The peel was dried in an oven at 60° C to constant moisture. After drying it was milled into flour and passed through a 60 mesh sieve to get fine homogenous powder and stored in a dry and cool place for the further processing (Khalifa *et al.* 2015).

Wheat flour (fine) and potato peel powder was taken in different proportions to get the composite flour for the biscuits preparation. Manufacturing of biscuits were taken place according to (AACC, 2010) method No. 10-52 using the following recipe table. Shortening and sugar were creamed together so that a uniform mass of these components was obtained. The composite flour and the baking powder were sifted 3 to 4 times using 75 micron sieve and then added to the shortening mass of sugar. Rolling pin was used to roll it out and a cookie cutter of two inch diameter was used for cutting purposes. Biscuits were then baked at a temperature of 180ºC for 10 minutes duration and then at room temperature the biscuits were cooled for 1hr. For further analysis polyethylene bags were used to pack the biscuits.

Physical Analysis: The physical analysis of biscuits was carried out for their thickness, width and spread factor by using (AACC, 2010).

Chemical Analysis: Moisture content was analyzed in drying oven at 70 C for 24 hours, Ash content in muffle furnace at 550 C for 5 hours, fat content in soxhlet apparatus by using petroleum ether as solvent, protein content through kjeldhal apparatus and fiber content through acid (2.5% H_2SO_4), base (2.5% NaOH) digestion (AACC, 2010).

Nitrogen Free Extract (%): Carbohydrate (NFE%) was calculated by subtracting the values of moisture, fat, protein, ash and fiber from hundred (AACC, 2010).

Energy Calculation: For energy calculation conversion factors are used: 9 $kcalg^{-1}$ of lipid and 4 $kcalg^{-1}$ of carbohydrate and protein described by (AACC, 2010).

Sensory Evaluation: Sensory evaluation of all the samples was done in terms of color, taste, texture, and overall acceptability by presenting prepared biscuits to the panel of judges by using nine point Hedonic Scale described by (Larmond, 1977).

Statistical Analysis: Obtained data from different treatments was analyzed statistically in STATISTIX 8.1 software by using two factorial ANOVA and mean values were compared by simple (LSD) least significance difference test at 5% level of significance according to the described method of (Steel and Torrie, 1997).

Table 1. Recipe for biscuit preparation

S. No.	Ingredients	Amount (grams)
1.	Flour (wheat + potato peel)	500
2.	Sugar	250
3.	Industrial fat	250
4.	Baking powder	6
5.	Salt	0.037
6.	Egg	1

Table 2 Effect of applied treatment and storage on the width (mm), spreadratio and thickness of potato peel fortified buscuits.

Parameters	Treatments	Storage intervals(15 days)							%increase
		Initial	15	30	45	60	75	90	
Width	T0	44.8	44.9	45.0	45.0	45.1	45.1	45.2	0.73
	T1	42.5	42.6	42.6	42.6	42.7	42.7	42.8	0.58
	T2	41.8	41.8	41.9	41.9	42.0	42.0	42.1	0.74
	T3	41.1	41.2	41.2	41.3	41.3	41.4	41.4	0.72
	T4	40.9	40.9	41.0	41.0	41.0	41.1	41.1	0.61
	T5	40.8	40.8	40.9	40.9	40.9	41.0	41.1	0.60
Spread Factor	T0	44.1	44.3	44.7	45.1	45.5	46.0	46.4	5.11
	T1	41.1	41.4	41.7	42.1	42.4	42.7	43.15	4.62
	T2	39.4	39.7	39.9	40.2	40.5	40.8	41.1	4.11
	T3	38.1	38.4	38.6	38.8	39.1	39.3	39.5	3.49
	T4	37.5	37.8	38.0	38.2	38.4	38.6	38.8	3.35
	T5	37.2	37.3	37.5	37.7	37.9	38.1	38.2	2.78
Thickness	T0	10.1	10.1	10.0	9.98	9.90	9.82	9.74	-4.42
	T1	10.3	10.2	10.2	10.1	10.1	9.99	9.92	-4.06
	T2	10.6	10.5	10.4	10.4	10.3	10.3	10.2	-3.52
	T3	10.7	10.7	10.6	10.6	10.5	10.5	10.4	-2.86
	T4	10.8	10.8	10.7	10.7	10.6	10.6	10.5	-2.84
	T5	10.9	10.9	10.8	10.8	10.8	10.7	10.7	-2.24

The data represents in their respective rows and columns are the average of three replicates. T0= 0% PPP and 100% wheat flour, T1= 5% PPP and 95% wheat flour, T2= 10% PPP and 90% wheat flour, T3= 15% PPP and 85% wheat flour, T4= 20% PPP and 80% wheat flour, T5= 25% PPP and 75% wheat flour.

Table 3 Effect of applied treatment and storage on the moisture, ash, protein, fat and fiber % of potato peel fortified buscuits.

Parameters	Treatments	Storage Intervals(15 days)							% Increase
		Initial	15	30	45	60	75	90	
Moisture %	T0	2.6	2.64	2.68	2.72	2.76	2.8	2.82	7.80
	T1	2.95	2.98	3.01	3.08	3.12	3.15	3.19	7.52
	T2	3.15	3.19	3.21	3.24	3.27	3.3	3.33	5.41
	T3	3.41	3.43	3.46	3.48	3.51	3.53	3.56	4.21
	T4	3.47	3.48	3.5	3.53	3.57	3.6	3.62	4.14
	T5	3.56	3.58	3.6	3.63	3.66	3.68	3.71	4.04
Ash %	T0	1.95	1.92	1.9	1.87	1.84	1.81	1.78	-8.72
	T1	2.47	2.44	2.41	2.38	2.35	2.32	2.29	-7.29
	T2	3.18	3.13	3.1	3.08	3.05	3.03	3.01	-5.35
	T3	3.41	3.39	3.37	3.35	3.33	3.31	3.29	-3.52
	T4	3.5	3.49	3.47	3.36	3.45	3.43	3.4	-2.86
	T5	3.6	3.59	3.57	3.58	3.56	3.55	3.53	-1.94
Fat %	T0	19.0	18.9	18.8	18.6	18.2	18.1	17.8	-5.99
	T1	19.1	19.0	18.7	18.6	18.4	18.2	18.1	-5.48
	T2	19.2	19.1	19.0	18.8	18.7	18.5	18.3	-4.98
	T3	19.3	19.2	19.1	18.9	18.7	18.5	18.4	-4.70
	T4	19.5	19.4	19.2	19.2	19.1	18.9	18.8	-3.33
	T5	19.6	19.5	19.4	19.3	19.1	19.0	18.9	-3.26
Protein %	T0	7.66	7.6	7.48	7.37	7.28	7.21	7.15	-6.66
	T1	7.71	7.65	7.63	7.57	7.49	7.38	7.31	-5.19
	T2	8.12	7.98	7.95	7.88	7.85	7.81	7.77	-4.31
	T3	8.35	8.31	8.28	8.25	8.2	8.16	8.08	-3.23
	T4	8.75	8.72	8.69	8.63	8.58	8.52	8.48	-3.09
	T5	8.94	8.91	8.87	8.81	8.77	8.75	8.68	-2.91
Fiber %	T0	10	9.95	9.91	9.86	9.82	9.77	9.73	-2.70
	T1	10.2	10.1	10.1	10.1	10.0	10.0	9.98	-2.35
	T2	13.5	13.4	13.4	13.3	13.3	13.3	13.2	-2.22
	T3	13.8	13.7	13.7	13.6	13.6	13.5	13.5	-2.17
	T4	14.9	14.8	14.8	14.7	14.7	14.6	14.6	-2.01
	T5	16.7	16.6	16.6	16.5	16.5	16.4	16.4	-1.79

The data represents in their respective rows and columns are the average of three replicates. T0= 0% PPP and 100% wheat flour, T1= 5% PPP and 95% wheat flour, T2= 10% PPP and 90% wheat flour, T3= 15% PPP and 85% wheat flour, T4= 20% PPP and 80% wheat flour, T5= 25% PPP and 75% wheat flour.

Table 4 Effect of applied treatment and storage on carbohydrate (%) of potato peel fortified biscuits.

Treatments	Storage Intervals(15 days)							%Increase
	Initial	15	30	45	60	75	90	
T0	58.77	58.97	59.15	59.57	60.07	60.30	60.64	3.08
T1	57.50	57.71	58.07	58.25	58.53	58.90	59.13	2.94
T2	52.77	53.07	53.26	53.56	53.78	54.04	54.37	2.76
T3	51.62	51.87	52.03	52.30	52.57	52.85	53.07	2.73
T4	49.87	50.04	50.28	50.52	50.56	50.83	51.04	2.30
T5	47.56	47.67	47.89	48.08	48.29	48.49	48.68	2.29

The data represents in their respective rows and columns are the average of three replicates. T0= 0% PPP and 100% wheat flour, T1= 5% PPP and 95% wheat flour, T2= 10% PPP and 90% wheat flour, T3= 15% PPP and 85% wheat flour, T4= 20% PPP and 80% wheat flour, T5= 25% PPP and 75% wheat flour.

Table 5 Effect of applied treatment and storage on Energy (Kcal) of prepared biscuit samples.

Treatments	**Storage Intervals(15 days)**							**%Decrease**
	Initial	15	30	45	60	75	90	
T0	436	436	436	435	433	433	432	1.10
T1	433	432	431	430	430	429	428	1.05
T2	417	416	416	415	414	414	413	0.87
T3	414	413	413	412	411	411	410	0.84
T4	410	409	409	409	408	408	407	0.58
T5	402	402	402	401	400	400	400	0.55

The data represents in their respective rows and columns are the average of three replicates. T0= 0% PPP and 100% wheat flour, T1= 5% PPP and 95% wheat flour, T2= 10% PPP and 90% wheat flour, T3= 15% PPP and 85% wheat flour, T4= 20% PPP and 80% wheat flour, T5= 25% PPP and 75% wheat flour.

Table 6 Effect of applied treatment and storage on color, taste, texture and overall acceptability of potato peel fortified biscuits.

Parameters	**Treatments**	**Storage Intervals(15 days)**							**% Increase**
		Initial	15	30	45	60	75	90	
color	**T0**	8.6	8.3	7.8	7.6	7.2	6.9	6.4	-25.58
	T1	8.6	8.35	7.95	7.6	7.3	7.0	6.6	-23.27
	T2	8.5	8.17	7.76	7.3	6.9	6.5	6.1	-28.67
	T3	8.5	8.06	7.57	7.1	6.5	6.1	5.8	-31.23
	T4	8.1	7.7	7.28	6.8	6.4	6.0	5.5	-32.27
	T5	7.9	7.54	7.14	6.7	6.3	5.9	5.1	-35.77
taste	**T0**	8.7	8.3	7.6	7.2	6.4	5.5	5.4	-37.93
	T1	8.8	8.65	7.88	7.5	6.6	6.1	5.8	-34.68
	T2	8.6	7.8	7.4	7.0	6.3	5.6	5.2	-39.95
	T3	8.6	7.4	7.3	6.4	6.2	5.5	5.15	-40.46
	T4	8.6	7.1	7.01	6.3	6.1	5.3	5.0	-41.71
	T5	8.6	7.0	6.6	6.2	6.0	5.1	5.0	-42.00
texture	**T0**	8.5	8.4	7.6	7.3	6.8	6.7	6.3	-25.85
	T1	8.6	8.2	7.8	7.4	7.1	6.7	6.4	-25.00
	T2	8.5	8.1	7.7	7.3	6.9	6.6	6.1	-27.67
	T3	8.3	8.1	7.5	7.2	6.7	6.3	6.0	-28.28
	T4	7.9	7.8	7.4	7.1	6.5	6.1	5.6	-28.98
	T5	7.6	7.5	7.2	6.8	6.4	6.1	5.4	-29.37
Overall acceptability	**T0**	8.6	8.3	7.6	7.3	6.8	6.3	6.0	-42.50
	T1	8.7	8.4	7.8	7.5	7.0	6.6	6.3	-38.34
	T2	8.5	8.1	7.6	7.2	6.7	6.2	5.8	-47.34
	T3	8.5	7.8	7.4	6.9	6.5	5.9	5.6	-50.12
	T4	8.2	7.5	7.2	6.7	6.3	5.8	5.4	-52.69
	T5	8.1	7.3	6.9	6.5	6.2	5.7	5.1	-56.16

The data represents in their respective rows and columns are the average of three replicates. T0= 0% PPP and 100% wheat flour, T1= 5% PPP and 95% wheat flour, T2= 10% PPP and 90% wheat flour, T3= 15% PPP and 85% wheat flour, T4= 20% PPP and 80% wheat flour, T5= 25% PPP and 75% wheat flour.

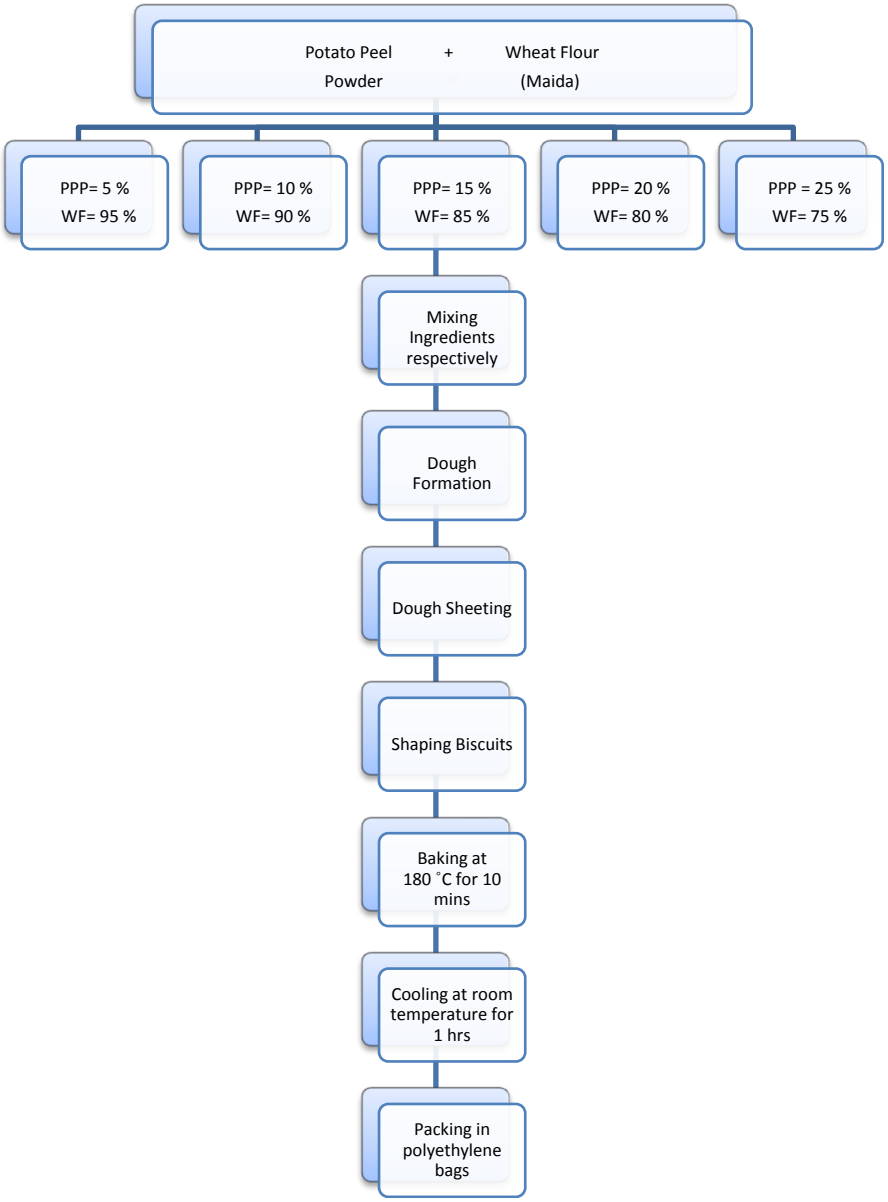

Fig. 1. Schematic diagram for product preparation (AACC, 2010: method No. 10-52)

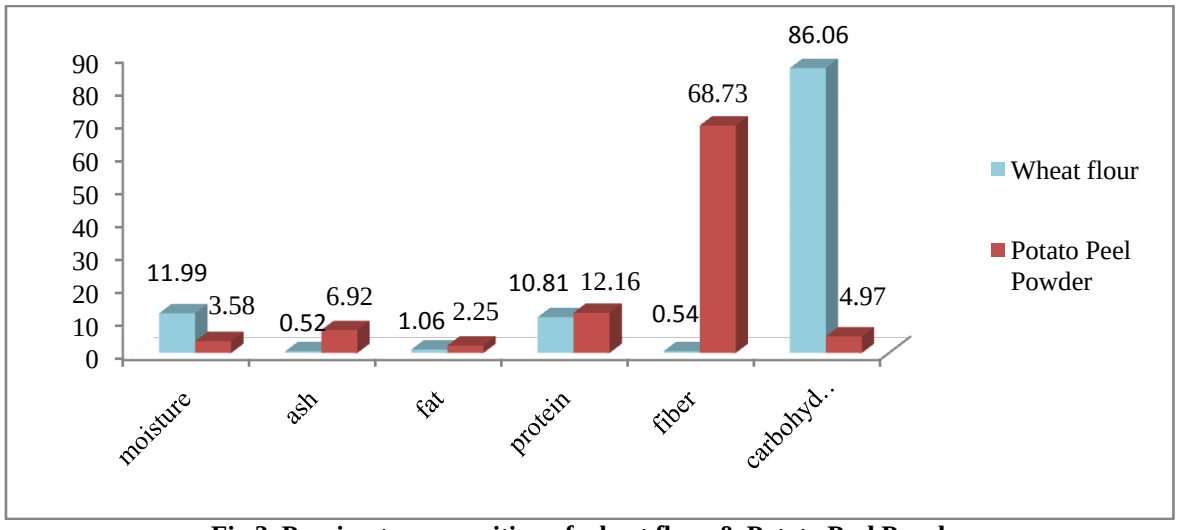

Fig.2. Proximate composition of wheat flour & Potato Peel Powder

Results and Discussion

Schematic diagram for product preparation is shown in Fig 1, while the recipe for preparation of potato peel fortified biscuits is given in Table 1. Proximate composition of wheat flour and potato peel powder was analyzed and the prepared biscuits were analyzed physico-chemically and organoleptically.

Proximate Analysis of wheat flour and potato peel powder: The proximate composition of potato peel powder and wheat flour including moisture (3.58, 11.99), ash (6.92, 0.52), fats (2.25, 1.06), fiber (68.73,0.54), protein (12.16, 10.81) and carbohydrate percent (4.97, 86.06) respectively (Fig 2). These results shows similarity with the findings of (Leo *et al.* 2008) who found the composition of potato peel in terms of protein content 10.76%, ash 10.56%, fat 4.98%, carbohydrate 4.97%, fiber 68.53% and also the similar results showed by (Sharoba *et al.* 2013) for wheat flour moisture 11.98%, protein 11.85%, fat 1.05%, ash 0.51%, fiber 0.54%, carbohydrate 86.04%, and potato peel powder moisture 3.57%, ash 6.91%, fat 2.25%, protein 12.17%, fiber 73.25%.

Physical analysis of biscuits: Physical analysis (width, thickness and spread factor) of potato peel enriched biscuits were described in Table 2 that shows their mean values were in the range of width (40.81-45.22), thickness (9.74-10.97) and spread ratio (37.20-46.43) under 90 days of storage. Width and spread factor follows increasing trend where in contrast thickness follows decreasing trend with respect to the storage interval. Minimum increase in width of biscuits according to storage interval was found in T1 while maximum increase were found in T2. Minimum decrease in thickness of biscuit according to storage interval were found in T5 while maximum decrease was found in T0. Minimum increase in spread ratio of biscuit according to storage interval were found in T5 while maximum increase was found in T0.

A decrease in the width of biscuits with increasing level of potato peel powder may be due to dilution of gluten (Ajila *et al.,* 2008). An increase in the thickness of the biscuits with increasing level may be considered due to fiber because potato peel is more fibrous product as compare to wheat flour (Buono *et al.,* 2009). On the other hand by increasing the level of spread factor the decrease in the ratio of width and thickness was may be due to function of fiber, the poor spread associated with biscuits made from composite flours may be associated with the changes in the elastic behavior of the dough (Hooda and Jood, 2005), decrease in spread ratio was may be due to the increase in relative quantity of hydrophilic additives, which compete for the water in the dough (Skrbic and Cvejanov, 2011). These results are in complete agreement with the findings of Qaisrani *et al.,* (2014).

Chemical Analysis: Chemical analysis (%moisture, %ash, %protein, %fat, %fiber) of the biscuits were described in Table 3 which shows their mean values were in the range of moisture (2.6-3.71), ash (1.78-3.6), protein (7.15-8.94), fat (17.88-19.61) and fiber (9.73-16.73) under 90 days of storage. The increasing trend of moisture content according to the storage interval were in contrast with ash, protein, fat and fiber content. This showed decreasing trend with respect to storage intervals. Minimum increase in moisture of biscuits according to storage interval was found in T5 while maximum increase was found in T0. Minimum decrease in ash of biscuit according to storage interval was found in T5 while maximum decrease was found in T0. Minimum decrease in protein of biscuit according to storage interval was found in T5 while maximum decrease was found in T0. Minimum decrease in fat of biscuit according to storage interval was found in T5 while maximum decrease were found in T0. Minimum decrease in fiber of biscuit according to storage interval was found in T5 while maximum decrease was found in T0.

An increase in the moisture content of biscuits with increasing level of potato peel powder were due to the higher water holding capacity of potato peel. Fiber has a strong capacity to absorb water so products having significant amount of fiber can bind a noticeable amount of water (Uysal *et al*., 2007). Moreover, cookies were packed in polypropylene bags and water absorption from the surrounding may also be a factor for increased moisture level during storage (Piga *et al.,* 2005).The increased level of potato peel increased the ash content of biscuits as adequate amount of ash is resulted to the recipe from fibers (Hussain *et al*. 2011). Protein content does not change during storage. An increase in the fat content of biscuits with increasing level of potato peel powder may be due to the increased level of fiber in potato peel, (Sharoba *et al*., 2013) illustrated that the oil holding capacity is a technological property related to the chemical structure of the plant polysaccharides (Biswas *et al.,* 2011). The study of (Pasha *et al.,* 2011) elucidated that crude fiber content of bakery products increased with the incorporation of fiber enriched mung-bean flour. These results are in complete agreement with the findings of (Yetunde and Chiemela 2015).

Carbohydrate (Nitrogen Free Extract): Carbohydrate (nitrogen free extract) of the biscuits were described in Table 4 which shows the mean values were in the range (47.56-60.64) under 90 days of storage. Carbohydrates level was found in increasing order with respect to storage intervals. Minimum increase in carbohydrates of biscuits according to storage interval was found in T0 while maximum increase was found in T5.A decrease in carbohydrates of biscuits with increasing level of potato peel powder may be due to the fact that potato peel powder contains less amount of carbohydrates as compare to wheat flour. The results are linked to the

conclusion of (Moraes *et al.*,2010) ranging from 56.76 to 43.24% who examined the nutritional value of cakes supplemented with whole flaxseed flour.

Energy Value: Energy value of the biscuits was described in Table 5 that shows the mean values were in the range of (400.17-436.90) under 90 days of storage. Energy value was found decreasing with respect to storage intervals. Minimum decrease in energy of biscuits according to storage interval was found in T5 while maximum decrease was found in T0.A decrease in energy of biscuits with increasing level of potato peel powder may be the accumulation of fiber despite of source decreases the high energy value of cookies (Uysal *et al.,* 2007).The results are in accordance to the conclusion of (Bilgicli *et al.,* 2007).

Sensory Evaluation: Sensory evaluation (color, taste, texture, overall acceptability) of the biscuits is described in the Table 6that shows the mean values in the range of color (5.1-8.68), taste (5-8.88), texture (5.41-8.6) and overall acceptability (5.17-8.72) under 90 days of storage. Color, taste, texture and overall acceptability showed decreasing trend with respect to storage intervals. Minimum decrease in color of biscuits according to storage interval was found in T1 while maximum decrease was found in T5. For the taste of biscuits minimum decrease was found in T1 where as maximum decrease was found in T5 with storage. Maximum decrease in texture and overall acceptability was found in T5 where as minimum decrease was in T1.

A decreasing trend in the color of biscuits with increasing level of potato peel powder may be due to the brown color of potato peel which became dark brown with high temperature during baking could be the possible cause of these color changed in the supplemented biscuits (Srivastava *et al.,* 2012). (Raymundo *et al.,* 2014) also reported that the biscuits became darker with increasing level of fiber and this effect is a result of a more pronounced non-enzymatic browning when wheat flour is replaced by fiber with different sugar compositions. (Srivastava *et al.,* 1996) reported that the color is also affected by oxygen and non-enzymatic reactions throughout storage. The decrease in taste of the biscuits with increasing level of potato was due to splitting of sugar and high percentage of acidity affect product's taste or flavor. The two most common glycol alkaloids found in potatoes are alpha-chaconine and alpha-solanin, produce a bitter taste. (Laguna *et al.,* 2014) reported that containing higher water content produce an extensive gluten structure and result in harder texture of biscuits. So the biscuits containing high amount of potato peel powder showed a decreasing trend in texture. A decrease in overall acceptability of the biscuits with increasing level of potato is the effect of color taste and texture as these are the attributes that depends upon the acceptability of consumer. (Gandhi *et al.,* 2013) reported that up to 10% apple pomace flour could be incorporated in the formulation of cakes. Our outcomes are in agreement with the work of Al-Sayed and Ahmed. (2013).

Conclusion

The present study revealed that the biscuit samples with 25% potato peel powder that is T5 showed best results for physicochemical attributes where as T1 that is fiber enriched biscuit with 5 % potato peel powder gained highest score for sensory evaluation by showing best results for color, taste, texture and overall acceptability when compared with other treatments. So potato peel powder enrichment in biscuits is recommended up to 5%. It is recommended that further research work should be conducted to utilize potato peel powder on industrial scale.

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