CHARACTERIZATION AND UTILIZATION OF PSYLLIUM HUSK FOR THE PREPARATION OF DIETETIC COOKIES

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Abstract
Present research was carried out to characterize and utilize psyllium husk for preparation of dietetic cookies. Straight grade flour was replaced with psyllium husk in different combinations @ 5, 10, 15, 20 and 25%. Regarding characterization of psyllium husk, mean values obtained for moisture, ash, crude protein, crude fat, crude fiber and nitrogen free extract (NFE) in husk were 6.43±0.05, 3.85±0.04, 2.08±0.06, 0.09±0.01, 3.83±0.02 and 83.72±0.08%, respectively. Moreover, total dietary fiber and arabinoxylan content were 76.63±1.32 and 46.71±2.14%, respectively. Physical characteristics of dietetic cookies i.e. diameter and spread ratio were diminished with the addition of husk while thickness was increased. Results regarding storage of the cookies showed increase in diameter and spread ratio whilst thickness depicted decreasing trend. Chemical assay revealed higher crude protein content in control cookies. Whereas, moisture, ash, crude fiber, NFE along with dietary fiber and arabinoxylan contents were higher in psyllium husk based cookies. Softer cookies with low gross energy were obtained with the addition of psyllium husk. Conclusively, psyllium husk based cookies showed gradual enhancement in dietary fiber content as the amount of husk was increased in the recipe. The resultant cookies may have potential to manage the lipid profile and glucose concentrations in human subjects.

Key words: psyllium husk, dietary fiber, arabinoxylan, dietetic cookies, physico-chemical properties.

Introduction
Dietary components and human health have established links reflecting the pivotal role of nutrients in normal body functioning. The health grievances like obesity, hypercholesterolemia, diabetes mellitus and cardiovascular disorders (CVD) are associated with improper nutrient intake and deskbound life style. In this context, functional foods are one of the emerging implementations gaining attention as preventive and curative device against various health infirmities (Urala et al., 2007; Bacha, et al., 2011).
Psyllium (Plantago ovata) commonly called Isabgol is an annual herb originated from West Asia. The species is indigenous to Mediterranean region, West Asia and extending up to Sind in Pakistan (Singh and Virmani, 1982). The genus Plantago has over 200 species of which two; P. ovata and P. psyllium are commercially cultivated round the globe. Psyllium was introduced as a medicinal plant by Indian Muslims and seeds were firstly collected from some wild species. In Pakistan, it was firstly cultivated in Lahore and Multan districts and then moved to Bengal, Mysore and Indian Coromandel coast (Husain, 1977). The husk (outer covering of seed) is obtained as milling product of the seed yielding 10-25% of dried seed weight. Considering chemical composition, the resultant husk is containing 6.83% moisture, 0.94% protein, 4.07% ash and 84.98% of total carbohydrates (Guo et al., 2008). Psyllium husk is used in food, pharmaceutical and cosmetic industry. In foods, it is used in ice cream, instant juices, breakfast cereals and in bakery products like biscuits, cakes, breads and muffins with varying functional and health aspects (Ziai et al., 2005).
Primarily, its imperative use was as a laxative and colon cleansing agent. It is assumed that dietary fiber from psyllium husk may help in weight management and fat loss by acting as bulking agent. In this context, considerable factors are increasing satiety, reducing caloric intake, digestion rate and fat absorption (Cummings et al., 2004). Like other herbs, psyllium is used traditionally as medicine and its consumption has been expanded due to its recognized nutraceutical potential. It is used in the treatment of
constipation, diarrhea and ulcerative colitis as reported by Ramkumar and Rao, (2005). Considering such pharmacological aspects, use of this herb has increased as an anti-obesity, hypoglycemic and hypocholesterolemic agent (Anderson et al., 2000; Moreyra et al., 2005; Ziai et al., 2005; Pal et al., 2011).

The health improving properties are attributed to its active fiber fraction the arabinoxylan (AX); a polysaccharide containing heteroxylan, with main monosaccharides; arabinose and xylose, collectively referred as arabinoxylan (Marlett and Fischer, 2003; Fischer et al., 2004). This active fraction of psyllium husk, the arabinoxylan is a highly branched polysaccharide constituting more than 60% of the weight of psyllium husk. Exclusively, arabinoxylan from psyllium husk is resistant to fermentation as compared to those extracted from wheat, oat or barley (Van-Craeyveld et al., 2008). Psyllium husk may also have a symbiotic relation with medicines being used to reduce the problems related to obesity, dyslipidemia and CVD. Different cereal and vegetable based soluble and insoluble fibers are in use to overcome the menace of high cholesterol and glycemic disorders. The foremost fiber sources are psyllium husk, oat, guar gum and some other cereals. However, psyllium husk fiber appears one of the effective sources with least adverse effects (Galisteoa et al., 2010). It has high water soluble fiber that soothes the lipid profile and glycemic response in individuals with hypercholesterolemia. High fiber diets increase peripheral insulin sensitivity in healthy adults (Karhunen et al., 2010).

The husk obtained after milling is white hydrophilic material forming clear and colorless mucilaginous gel after water absorption. Its carboxymethyl derivative is fibrous and mucilaginous in taste (Fischer et al., 2004). This fiber has laxative effect with the increment of increased fecal output and stool frequency. It has a wide application in functional foods, thickener in ice cream, application in cosmetics and printing as well as drug in pharmaceutical industry (Singh, 2007). Research indicates that husk is quite safe to use in functional and nutraceutical foods. The FDA has approved the use of food products containing psyllium husk due to its associated health claims (Leeds, 2009). For supplementation of fiber, cookies are appreciated by the consumers due to appealing taste and better storage stability. Bakery products are prepared from different dosage of psyllium husk and previous literature suggested that replacement of psyllium husk up to 50% is possible without detrimental change in quality (Ganji and Kuo, 2008). Psyllium husk is becoming popular as therapeutic agent against various physiological ailments. Therefore, it is desire need to explore the indigenous food sources for the welfare of the society (Sahu, 2011). Keeping in view the above facts, present research was designed to characterize locally available psyllium husk variety namely Plantago ovata Forsk followed by the preparation of dietetic cookies.

Materials and Methods

Characterization of husk and product development was carried out in Postgraduate Research Laboratory, National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad.

Procurement of raw materials

Indigenous psyllium husk (Plantago Ovata Forsk) was purchased from Qarshi Industries (Pvt.) Ltd. Pakistan. For the preparation of dietetic cookies, non-nutritive sweeteners including aspartame and sorbitol were used. The sweeteners, straight grade flour and shortening were procured from the local market.

Characterization of psyllium husk

The husk was characterized for various aspects like proximate analysis, dietary fiber and arabinoxylan content.

Chemical characteristics: The chemical composition of husk was estimated through moisture, crude fat, crude fiber, crude protein, total ash and nitrogen free extract (NFE) determination.

Moisture content: Psyllium husk was analyzed for moisture content by using air forced draft oven (Model: DO-1-30/02, PCSIR, Pakistan). The sample was dried at 105±5°C to constant weight and calculations were made (AACC, 2000; Method No. 44-15A).

Crude protein: For determination of crude protein, nitrogen percentage was estimated through Kjeltech Apparatus (Model: D-40599, Behr Labor Technik, GmbH-Germany). The protein was calculated by multiplying percent nitrogen with conversion factor (AACC 2000; Method No. 46-10).

Crude Fat: Crude fat in oven dried sample was estimated by Soxtec System (Model: H-2 1045 Extraction Unit, Hoganas, Sweden). Sample weighing 5g was used for extraction of crude fat with petroleum ether. After extraction, residue was dried till constant weight (AACC, 2000; Method No. 30-10).

Crude fiber: After fat extraction, husk sample was examined for crude fiber through Labconco Fibertech (Labconco Corporation Kansas, USA). Fat free 2g sample was digested firstly with 1.25% H2SO4 and finally with 1.25% NaOH. The residue was dried at
Dietary Fiber:
Crude fiber% + Total ash%)

NFE (%) = 100 – (Crude protein% + Crude fat% + Crude fiber% + Total ash%)

Nitrogen Free Extract (NFE)
NFE (%) = 100 – (Crude protein% + Crude fat% + Crude fiber% + Total ash%)

Dietary Fiber: Determination of dietary fiber was done using the method described by Prosky et al. (1984). The sample in duplicate was treated with buffers (40mL, pH 8.2, 24°C). Stirring of samples till uniform dispersion of samples was done on magnetic stirrer. Alpha-amylase solution (50µL) was added and sample was heated at 95-100°C for 35 min. After cooling, protease solution (100µL) was added and incubation was done for 30 min at 60°C. Following the same procedure amyloglucosidase solution (200µL) was added and samples were incubated. Precipitation was done with 4 vol. of 95% ethanol and sample was filtered and dried. The obtained residue was divided into two parts which were further used for protein and ash determinations. Total dietary fiber was determined by subtracting the protein and ash contents determined in dried residues. The total dietary fiber was calculated following the formula given in respective method.

Determination of arabininoxylan
Arabininoxylan content of husk sample was isolated followed by derivitization of sample for monosaccharides determination and subsequently calculated the arabininoxylan.

Isolation: In 100g husk sample, arabininoxylan was isolated by using alkali method. The sample was heated in KOH solution for two hrs followed by centrifugation at 6000xg for 20 min at 4°C. The supernatant was taken for precipitation and kept the precipitates overnight at refrigeration temp in absolute ethanol (final concentration of 65% v/v) and centrifuged (Cleemput et al., 1995). The arabininoxylan fiber thus obtained was finally freeze dried for 4 hrs.

Derivitization of precipitates: Arabininoxylan was derivitized for monosaccharide determination (Vallance et al., 1998). Standard gum (1-2mg) and individual monosaccharide standard samples (1mg each) were heated in water bath at 100°C for 30 and 10 min, respectively, with triflouroacetic acid (0.1mL, analytical grade, undiluted). Then samples were allowed to cool at room temperature before pyridin (0.2mL, analytical grade) was added to the vials. Hexamethyle dizilazane (0.3mL, derivitization grade) and triflouroacetic acid (5 drops, analytical grade, undiluted) were added to the samples. The samples were shaken vigorously for 30 sec and allowed to stand for 1 hr prior to analysis. Later, 0.1mm samples were removed and placed directly into vials. The material was heated for 30 min at 105°C with triflouroacetic acid (0.1mL, analytical grade, undiluted) in water bath. The samples were shaken vigorously for 30 sec and allowed to stand for 1 hr prior to analysis.

Determination of monosaccharides: The arabininoxylan isolated from psyllium husk was fractionated to determine monosaccharide. The analysis was carried out by using gas chromatography (Agilent 6890 GC technology) equipped with Microsoft detector (Agilent 5973 MS Detector) whilst DB-5 column (30m×0.25mm ID and film thickness of 0.25µm, Agilent, Palo Alto, CA, USA) was used with methyl polysiloxane polymer. Helium (He) was used as carrier gas at constant flow rate of 1.3mL. min⁻¹. Temperatures for injector and MS source were maintained at 280 and 230°C, respectively. The column temperature program consisted of injection at 65°C and hold for 2 min. with temperature increase of 6°C min⁻¹ to 300°C for an isothermal hold of 15 min. The MS was operated in the electron impact mode with ionization energy of 70ev. The samples were analyzed in the splitless mode (splitless time: 30 sec). The acquired data was processed with HP-Chemstation Software (Mendeiros and Simoneit, 2007).

Product development
Preliminary trials were carried out for the development of dietetic cookies supplemented with psyllium husk. The rationale was to obtain an acceptable quality product. After fixing the recipe, different treatments of cookies were made and evaluated for various quality traits.

Preparation of dietetic cookies
Six different treatments of cookies were prepared using varying levels of psyllium husk (Table 1) according to the instructions of AACC (2000). The recipe followed for control was: 500g commercial straight grade flour (CSGF), 250mL sorbitol, 0.84g aspartame, 220g vegetable shortening and 7g baking powder.

All the treatments were analyzed fortnightly from 0 day to two months storage for physical, chemical and sensory characteristics with the objective to select the

best treatment as functional food against life style-related disorders.

Table 1: Different treatments of dietetic cookies

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Flour (%)</th>
<th>Psyllium husk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>$T_1$</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>$T_2$</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>$T_3$</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>$T_4$</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>$T_5$</td>
<td>75</td>
<td>25</td>
</tr>
</tbody>
</table>

$T_0$ = control

Physical analyses of cookies
Cookies were analyzed for physical traits like diameter (mm), thickness (mm) and spread factor according to their respective methods in AACC (2000). Diameter (D) of six cookies was measured. The cookies were kept horizontally to take reading. For duplicate reading cookies were rotated at an angle of 90° and repeated the procedure for average calculation.
Likewise, thickness (T) was calculated by measuring the height of six cookies with ruler kept on top of one another. The practice was repeated twice and average value was presented in (mm). Spread factor (SF) was calculated by incorporating the values of D and T in subsequent formula;

$$SF = \left( \frac{D}{T} \times CF \right) \times 10$$

$CF$ = Correction factor

Chemical composition of cookies
The proximate analyses of cookies regarding crude protein, crude fat, crude fiber, total ash and nitrogen free extract (NFE) were estimated on dry weight basis by their respective procedures as mentioned in the preceding section.

Gross energy
Gross energy (Cal/g) was calculated by combusting the sample using the Oxygen Bomb Calorimeter (C-2000, IKA WERKE). Initially, 0.5g of sample was weighed and fed to calorimeter piston, after internal burning at high pressure the energy generated was measured automatically and reading was displayed on the screen of Bomb Calorimeter as described in the method of Krishna and Ranjhan (1981).

Texture analysis
Texture of cookies was measured through texture analyzer (model TA.XT plus, Texture Technologies Corp.) equipped with 3-point bend attachment (TA-92), a heavy-duty platform (TA-90) and stainless steel blade (TA-92). The resistance of the cookies to fracture was measured. Three cookies were selected randomly and applied to the base of analyzer. The internal gap adjustment of the base was set to place the cookie properly. Gap of base and distance of blade were kept constant for all samples. The data was obtained in the form of force-deformation curve indicating force, rupture distance, and gradient. Settings included pretest speed of 5mm/s, test speed of 3mm/s, posttest speed 10mm/s, distance 20mm and trigger force 50g (Piga et al., 2005).

Dietary fiber and arabinoxylan determination
Dietary fiber of cookies was determined following the method described by Prosky et al. (1984). For determining arabinoxylan content, the isolation of arabinoxylan was accomplished by alkali method (Cleemput et al., 1995) followed by derivitization of isolates (Vallance et al. (1998). Finally, monosaccharides (arabinose and xylose) were determined by using GC-MS (Mendeiros and Simoneit, 2007) followed by arabinoxylan calculation as discussed in preceding section for husk sample.

Statistical analysis
The data obtained was subjected to statistical analysis using Cohort version 6.1 (Costat-2003). Level of significance was estimated by using the analysis of variance technique (ANOVA) using two factor factorial under complete randomized design (CRD). Further, Least Significant Difference test (LSD) in cookies were applied for comparing means (Steel et al., 1997).

Results and Discussion
Present study was planned to formulate dietetic cookies with psyllium husk having potential to manage lipid profile and other allied parameters in normal and hypercholesterolemic subjects. For the intention, project was contemplated in two phases; firstly, psyllium husk was characterized for its constituents emphasizing on fiber fraction in general and arabinoxylan in particular. Second phase comprised of product development in which dietetic cookies were prepared with varying levels of
psyllium husk and tested for different parameters during two months storage. 

**Characterization of psyllium husk**

Compositional estimation of the supplement (husk) is important because addition of husk in cookies may play a mandatory role in the adjustment of physical and chemical characteristics. Chemical analysis is also important to assess the efficacy of the supplement. Thus, husk was examined for its constituents including moisture, ash, protein, crude fat, crude fiber and nitrogen free extract (NFE) along with dietary fiber especially the arabinoxylan content, the physiologically active component against different ailments.

**Chemical composition**

Mean values for moisture, ash, crude protein, crude fat, crude fiber and NFE in husk were 6.43±0.05, 3.85±0.04, 2.08±0.06, 0.09±0.01, 3.83±0.02 and 83.72±0.08%, respectively (Table 2). The results are similar to the findings of Marlett and Fischer (2003) as they reported values for protein, ash, and total carbohydrates as 35.0, 33.5 and 902.4mg/g, respectively in husk. Present results are also in corroborated with the finding of Guo et al. (2008), they found moisture, ash, protein, fat and NFE values in psyllium husk as 6.83±0.04, 4.07±0.02, 0.94±0.00, 0.04±0.11 and 84.98±4.26%, respectively.

**Table 2: Compositional analysis of psyllium husk**

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Quantity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Moisture</td>
<td>6.43±0.05</td>
</tr>
<tr>
<td>2. Ash</td>
<td>3.85±0.04</td>
</tr>
<tr>
<td>3. Crude protein</td>
<td>2.08±0.06</td>
</tr>
<tr>
<td>4. Crude fat</td>
<td>0.09±0.01</td>
</tr>
<tr>
<td>5. Crude fiber</td>
<td>3.83±0.02</td>
</tr>
<tr>
<td>6. Nitrogen free extract (NFE)</td>
<td>83.72±0.08</td>
</tr>
<tr>
<td>6.1. Dietary fibers</td>
<td>76.63±1.32</td>
</tr>
<tr>
<td>6.1.1. Arabinoxylan</td>
<td>46.71±2.14</td>
</tr>
</tbody>
</table>

**Dietary fiber and arabinoxylan**

In psyllium husk, total dietary fiber and arabinoxylan contents were 76.63±1.32 and 46.71±2.14%, respectively (Table 2). Earlier, Guo et al. (2008) explored the chemistry of psyllium husk and noted total carbohydrates up to 84.98% considering it as dietary fiber. In the current study, value for dietary fibers showed variation with the work of Guo et al. (2008) might be due to varietal differences and estimation methods.

Earlier studies supported the current results that arabinoxylan content in husk is ranging from 45 to 60% further indicated that the major fractions are arabinose and xylose whilst minor fractions include some other sugars and uronic acid. Considering psyllium husk as source of dietary fiber some researchers inferred that arabinoxylan is the active fraction helpful to manage various physiological ailments (Fischer et al., 2004; Saghir et al., 2008).

**Product development**

The control and psyllium husk containing cookies were analyzed for physical and chemical traits on fortnightly basis during two months storage. Likewise, gross energy and texture were estimated during the entire study on respective intervals.

**Physical characteristics of dietetic cookies**

It is the prime objective of the bakers and consumers that product should be of acceptable quality in the first look. For the reason being, the control and psyllium husk supplemented cookies were evaluated for physical characteristics like diameter, thickness and spread ratio.

**Diameter:** Means for the effect of treatments on diameter of the cookies presented a decreasing trend (Table 3). The diameter of control cookies ($T_0$) was 44.94±0.08mm that decreased with increase of psyllium husk and minimum value 40.86±0.08mm was recorded in cookies containing 25% psyllium husk ($T_5$). During two months storage, means for diameter ranged from 41.95±0.06 to 42.20±0.06mm while maximum value appraised at 60 days showing increasing trend in diameter as function of storage (Table 4).

The significant effect of treatment on diameter of cookies may be due to addition of fiber that alters dough rheology and allied characteristics in baked products. During storage, fiber addition may also be a factor for deterioration having potential to absorb moisture from the surroundings. Similarly, significant differences due to treatments and storage were also observed by Hussain et al. 2006. They also found decreasing trend in cookies diameter due to addition of fiber content.
**Thickness:** Thickness increased gradually due to treatments with increasing level of psyllium husk as indicated in Table 3. Means for thickness were estimated as 10.24±0.06mm in control cookies whereas maximum value 11.02±0.08mm in T5. Results for storage period explicated in Table 4 showed reduction in thickness as means determined at zero days was 10.85±0.02 that decreased to 10.05±0.02mm at 60 days. Regarding present study, in different treatments of cookies sugar was replaced with other sweeteners hence no reduction in thickness was observed. Another possible justification for variation in thickness within treatments is that flour was replaced with husk thereby decreased starch and protein contents resulting gradual condensation of dough that consequently increased thickness. Findings of Sharif et al. (2005) are analogous to the instant results as they reported significant increase in thickness of bakery products considering fiber the principal factor for this change, they further recommended that up to 20% replacement of flour with fiber is acceptable in bakery products.

**Spread ratio:** Means for spread ratio in Table 3 indicating diminution trend due to treatments as values ranged from 42.63±0.14 to 37.09±0.16 in T0 to T5, respectively. Whereas, results regarding the effect of storage presented in Table 4 revealed that spread ratio increased during two months as minimum value was observed at the initiation of the study (38.69±0.07) while maximum (39.67±0.07) perceived at the termination stage. Highly significant results in spread ratio due to treatments and storage are function of variations in diameter and thickness. Both of these parameters varied with addition of psyllium husk and absence of sugar, eventually affected the spread ratio. Previous studies of Hussain et al. (2006) and Sharif et al. (2009) strengthened the current results as they reported significant effect of fiber addition on spread ratio of cookies. They further elucidated that spread ratio decreased as function of fiber and the possible reason may be the absorption of moisture that increased the diameter and accordingly affected spread ratio.

### Table 3. Effect of treatments on physical characteristics of dietetic cookies

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>Spread ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 = control</td>
<td>44.94±0.08a</td>
<td>10.24±0.06c</td>
<td>42.63±0.14a</td>
</tr>
<tr>
<td>T1 = 5% of psyllium husk</td>
<td>42.60±0.07b</td>
<td>10.39±0.07b</td>
<td>40.24±0.16b</td>
</tr>
<tr>
<td>T2= 10% of psyllium husk</td>
<td>41.85±0.07c</td>
<td>10.65±0.07b</td>
<td>39.29±0.16c</td>
</tr>
<tr>
<td>T3= 15% of psyllium husk</td>
<td>41.22±0.07c</td>
<td>10.83±0.06a</td>
<td>38.06±0.14d</td>
</tr>
<tr>
<td>T4= 20% of psyllium husk</td>
<td>40.95±0.08d</td>
<td>10.93±0.08a</td>
<td>37.46±0.17c</td>
</tr>
<tr>
<td>T5 = 25% of psyllium husk</td>
<td>40.86±0.08d</td>
<td>11.02±0.08a</td>
<td>37.09±0.16f</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different.

### Table 4. Effect of storage on physical characteristics of dietetic cookies

<table>
<thead>
<tr>
<th>Storage (Days)</th>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>Spread ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>41.95±0.06b</td>
<td>10.85±0.02a</td>
<td>38.69±0.07c</td>
</tr>
<tr>
<td>15</td>
<td>41.99±0.05b</td>
<td>10.84±0.02a</td>
<td>38.76±0.07c</td>
</tr>
<tr>
<td>30</td>
<td>42.07±0.06a</td>
<td>10.26±0.02b</td>
<td>39.15±0.07b</td>
</tr>
<tr>
<td>45</td>
<td>42.13±0.06a</td>
<td>10.11±0.02b</td>
<td>39.38±0.07b</td>
</tr>
<tr>
<td>60</td>
<td>42.20±0.06a</td>
<td>10.05±0.02b</td>
<td>39.67±0.07a</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different.

**Proximate composition**

**Moisture:** Means for moisture in different treatments ranged from 3.07±0.07 to 3.35±0.07% (Table 5) showing progressive increase in moisture level with the addition of psyllium husk in cookies. The data presented in Table 6 explicated that in fresh cookies moisture content was 3.03±0.07% that increased to 3.34±0.01% at 60 days indicating uplift in this trait with the passage of time. Increase in moisture of cookies is due to increased psyllium husk level that has tendency to absorb water because of hydrophilic nature. Moreover, cookies were packed in bioriented polyvinylchloride (PVC) wraps and water absorption from the surrounding may also be a factor for increased moisture level during storage and this opinion is strengthened by work of Piga et al. (2005). The present results are in confirmatory with the outcomes of Uysal et al.
(2007) who reported significant effect on moisture by addition of fiber in oven-baked cookies. They concluded that in cookies, fiber improves the water holding capacity as compared to wheat flour resultantly increasing moisture level. Similarly, Pasha et al. (2002) also reported increase in moisture level in the dietetic cookies during storage.

### Table 5. Effect of treatments on proximate composition (%) of dietetic cookies

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture</th>
<th>Ash</th>
<th>Crude Protein</th>
<th>Crude fat</th>
<th>Crude fiber</th>
<th>NFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀ = control</td>
<td>3.07±0.07c</td>
<td>1.17±0.02f</td>
<td>8.04±0.07a</td>
<td>17.62±0.14a</td>
<td>0.39±0.012a</td>
<td>69.91±0.01a</td>
</tr>
<tr>
<td>T₁ = 5% of psyllium husk</td>
<td>3.21±0.06b</td>
<td>1.27±0.01e</td>
<td>7.74±0.06b</td>
<td>17.60±0.13a</td>
<td>0.52±0.016b</td>
<td>70.11±0.03a</td>
</tr>
<tr>
<td>T₂= 10% of psyllium husk</td>
<td>3.22±0.07ab</td>
<td>1.38±0.02d</td>
<td>7.37±0.08c</td>
<td>17.60±0.11a</td>
<td>0.65±0.017c</td>
<td>70.36±0.03a</td>
</tr>
<tr>
<td>T₃= 15% of psyllium husk</td>
<td>3.24±0.07a</td>
<td>1.49±0.02c</td>
<td>7.05±0.06d</td>
<td>17.56±0.13a</td>
<td>0.76±0.047d</td>
<td>70.52±0.01a</td>
</tr>
<tr>
<td>T₄= 20% of psyllium husk</td>
<td>3.25±0.06a</td>
<td>1.61±0.01b</td>
<td>6.65±0.06e</td>
<td>17.24±0.13b</td>
<td>0.90±0.016e</td>
<td>70.35±0.04a</td>
</tr>
<tr>
<td>T₅ = 25% of psyllium husk</td>
<td>3.35±0.07a</td>
<td>1.70±0.02a</td>
<td>6.27±0.06f</td>
<td>17.04±0.13b</td>
<td>1.03±0.019f</td>
<td>70.61±0.17a</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different

### Table 6. Effect of storage on proximate composition (%) of dietetic cookies

<table>
<thead>
<tr>
<th>Storage (Days)</th>
<th>Moisture</th>
<th>Ash</th>
<th>Crude Protein</th>
<th>Crude fat</th>
<th>Crude fiber</th>
<th>NFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.03±0.07e</td>
<td>1.44±0.02a</td>
<td>7.27±0.04a</td>
<td>17.92±0.01a</td>
<td>0.71±0.02a</td>
<td>69.18±0.03a</td>
</tr>
<tr>
<td>15</td>
<td>3.17±0.08d</td>
<td>1.42±0.01a</td>
<td>7.25±0.03a</td>
<td>17.75±0.02b</td>
<td>0.71±0.02a</td>
<td>69.33±0.04a</td>
</tr>
<tr>
<td>30</td>
<td>3.21±0.01c</td>
<td>1.44±0.02a</td>
<td>7.18±0.04ab</td>
<td>17.52±0.01b</td>
<td>0.71±0.02a</td>
<td>69.41±0.02a</td>
</tr>
<tr>
<td>45</td>
<td>3.27±0.01b</td>
<td>1.43±0.02a</td>
<td>7.14±0.04b</td>
<td>17.37±0.01c</td>
<td>0.71±0.02a</td>
<td>69.62±0.08a</td>
</tr>
<tr>
<td>60</td>
<td>3.34±0.01a</td>
<td>1.43±0.02a</td>
<td>7.01±0.03b</td>
<td>17.21±0.01c</td>
<td>0.70±0.02a</td>
<td>70.31±0.03a</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different

**Ash:** Total ash increased gradually in the treatments from control (T₀) to cookies containing 25% psyllium husk (T₅) as depicted in Table 5. Means for ash in T₀ was 1.17±0.01% compared to 1.70±0.02% in T₅ indicating increase in ash percentage with incremental increase in psyllium husk. Regarding the effect of storage on ash content, data indicated non-significant differences (Table 6). The momentous increase of ash in various treatments is attributed to increased psyllium husk level as fiber provides sufficient amount of ash to the recipe, being a compositional constituent (Table 1).

Findings of Hussein et al. (2011) delineated a similar increasing trend in ash content due to fiber addition. Furthermore, Pasha et al. (2011) also reported increased mineral profile in the baked products attributed to high ash content of the composite flour. **Crude protein:** Decrease in protein content was observed by the addition of psyllium husk among different treatments of cookies (Table 5). Highest mean value 8.04±0.07% was reported in T₀ (control) that declined to 6.27±0.06% in T₅ (cookies containing 25% psyllium husk). Similarly, decreasing trend in protein was observed during storage varying from 7.27±0.04% in fresh cookies to 7.01±0.03% after two months (Table 6).

White flour is the main source of protein in cookies and replacement of flour with psyllium husk resulted decrease in protein content. Another reason for reduction in protein content may be owing to increased moisture content of the cookies that changed the overall chemistry of end product. Possible complex formation between husk and protein moiety may also be a factor for reduced estimation of protein and this opinion is supported by earlier work of Bilgicli et al. (2007), they reported decreased protein digestibility due to fiber content. Moreover, exploration of Uysal et al. (2007) conferred that adding up of fiber from fruit sources decreases protein content in cookies. **Crude fat:** Treatments showed slightly decreasing trend on fat percentage of cookies. The maximum mean value was recorded as 17.62±0.014% in control that declined up to 17.04±0.13% in T₅ (Table 5). Similar diminishing trend in fat level was observed during two months storage. The means (Table 5) for fat at zero days were 17.92±0.01% that gradually decreased to 17.21±0.02% at 60 days.
Treatments exerted slight decline in fat percentage might be due to increased fiber and moisture contents. Accordingly, Uysal et al. (2007) described reduction in fat percentage of cookies due to addition of wheat fiber. Present results are also in harmony with the findings of Pasha et al. (2002) that in bakery products increased moisture content may be one of the factors for declining trend in fat during storage.

**Crude fiber:** Means for crude fiber in different treatments are presented in Table 5. Minimum crude fiber was observed in T0 (0.39±0.01) nevertheless by adding up of psyllium husk it increased to 1.03±0.01% in T5 (cookies containing 25% psyllium husk). Storage exhibited non-momentous effect on this attribute (Table 6).

Regarding crude fiber in cookies, data exposed an increasing trend possibly due to adding up of psyllium husk as dietary fiber contributes in its inclination. The similar pattern was observed by Hussein et al. (2011) that supplementation of germinated fenugreek seeds flour resultantly enhanced crude fiber content in biscuits. Currently, the investigation of Pasha et al. (2011) elucidated that addition of fiber enriched mungbean flour resulted increased crude fiber content in bakery products.

**Nitrogen free extracts (NFE):** Psyllium husk addition to dietetic cookies explicated non-significant differences in NFE (Table 5). The data indicated that means for NFE ranged from 69.91±0.01 to 70.61±0.17% in T0 and T5, respectively. Similarly, storage exhibited non-significant differences; NFE varied from 69.18±0.03 to 70.31±0.03% at 0 and 60 days, respectively (Table 6).

**Dietary fiber (DF):** The means for total dietary fiber ranged from 0.96±0.02 to 8.09±0.05% in T0 and T5, respectively depicting a defined increasing trend with progressive increment of psyllium husk (Table 7). As compared to T0, the dietary fiber content in T1 was 2.19±0.07% that gradually increased to 8.09±0.05% in T5. Means recorded for dietary fiber varied from 4.45±0.08 to 4.40±0.08% revealing statistically non-significant differences as function of storage. Enhanced dietary fiber in different treatments owes to supplementation of cookies with psyllium husk containing high fiber contents. Similar results are assessed by other researchers that incorporation of fiber enriched sources boost the dietary fiber in resultant bakery products. The current results are supported by the work of Vega-Lopez et al. (2001) indicating significant increase for this trait in cookies supplemented with fiber. The results by Nassar et al. (2008) showed 14.71 and 15.31% dietary fiber content in biscuits supplemented with 25% pulp and citrus peel, respectively. Whereas, Sharif et al. (2009) reported increase in dietary fiber ranging from 7.63 to 11.01% in cookies containing 30 and 50% rice bran, respectively.

**Table 7. Effect of treatments on dietary fiber, arabinoxylan, gross energy and hardness of dietetic cookies**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DF (%)</th>
<th>AX (%)</th>
<th>Gross energy (kcal/g)</th>
<th>Hardness (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 = control</td>
<td>0.96±0.02f</td>
<td>0.07±0.01f</td>
<td>4.83±0.29a</td>
<td>178±0.47a</td>
</tr>
<tr>
<td>T1 = 5% of psyllium husk</td>
<td>2.19±0.07e</td>
<td>1.06±0.04e</td>
<td>4.78±0.21b</td>
<td>159±0.58b</td>
</tr>
<tr>
<td>T2 = 10% of psyllium husk</td>
<td>3.59±0.06d</td>
<td>1.63±0.04d</td>
<td>4.71±0.20c</td>
<td>143±0.60c</td>
</tr>
<tr>
<td>T3 = 15% of psyllium husk</td>
<td>5.12±0.03c</td>
<td>2.87±0.05c</td>
<td>4.68±0.20d</td>
<td>135±0.65d</td>
</tr>
<tr>
<td>T4 = 20% of psyllium husk</td>
<td>6.45±0.10b</td>
<td>3.23±0.08b</td>
<td>4.65±0.24e</td>
<td>113±0.78e</td>
</tr>
<tr>
<td>T5 = 25% of psyllium husk</td>
<td>8.09±0.05a</td>
<td>3.41±0.08a</td>
<td>4.62±0.22f</td>
<td>110±0.60f</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different

**Arabinoxylan (AX):** It has been assessed that AX percentage increased with the gradual increase of psyllium husk in various sample of cookies (Table 7). The value for this parameter in control was 0.07±0.01% that significantly increased to 3.41±0.08% in T5. During storage, AX level remained in the range of 2.09±0.06 to 2.02±0.06% from zero to 60th day, respectively exhibited non-significant decreasing trend (Table 8).

Treatments containing psyllium husk possessed high arabinoxylan content as compared to control certainly due to ample amount of this fraction in husk. Earlier studies by Van-Craeyveld et al. (2009) and Saghir et al. (2008) supported the current results inferring that psyllium husk comprised of 45-60% of arabinoxylan. Analysis of dietetic cookies as therapeutic food for vulnerable segment showed that psyllium husk has pronounced effect on rheology and composition of product. Psyllium husk based cookies due to high dietary fiber and arabinoxylan contents confirm as suitable dietary intervention against life style-related disorders.
Table 8. Effect of storage on dietary fiber, arabinoxylan, gross energy and hardness of dietetic cookies

<table>
<thead>
<tr>
<th>Storage (Days)</th>
<th>DF (%, ±0.08a)</th>
<th>AX (%, ±0.06a)</th>
<th>Gross energy (kcal/g, ±0.27a)</th>
<th>Hardness (g, ±0.26a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.45±0.08a</td>
<td>2.09±0.06a</td>
<td>4.72±0.27a</td>
<td>148±0.26a</td>
</tr>
<tr>
<td>15</td>
<td>4.43±0.08a</td>
<td>2.06±0.06a</td>
<td>4.72±0.27a</td>
<td>143±0.27b</td>
</tr>
<tr>
<td>30</td>
<td>4.40±0.08a</td>
<td>2.04±0.06a</td>
<td>4.71±0.29a</td>
<td>139±0.27c</td>
</tr>
<tr>
<td>45</td>
<td>4.37±0.08a</td>
<td>2.02±0.06a</td>
<td>4.71±0.28a</td>
<td>135±0.28d</td>
</tr>
<tr>
<td>60</td>
<td>4.35±0.08a</td>
<td>2.00 ±0.06a</td>
<td>4.70±0.28a</td>
<td>133±0.28e</td>
</tr>
</tbody>
</table>

Mean values carrying same letters in a column are not significantly different.

Gross energy
Respective means in Table 7 indicated highest value in control (4.83±0.29kcal/g) that reduced gradually with progressive increase of psyllium husk and the lowest value was recorded in T_5 (4.62±0.22kcal/g). However, the effect of storage on gross energy differed non-significantly during two months (Table 8).

Gradual reduction in gross energy among the treatments might be due to replacement of flour with that of psyllium husk resulting in reduced starch and protein levels in composite blends. Similar trend was presented by Uysal et al. (2007) revealing that fiber addition regardless of source resulted decrease in caloric value of the cookies. Likewise, Bilgicli et al. (2007) indicated lower energy in the cookies by adding up of fiber.

Hardness
Means for hardness were the highest in control (178±0.47g) whereas in supplemented cookies the values decreased gradually ranging from 159±0.58 to 110±0.60g in T_1 and T_5, respectively (Table 7). Means depicted in Table 4.10 for hardness of cookies during storage explicated the highest value 148±0.26g at beginning of study that reduced subsequently during storage and the lowest value 133±0.28g was recorded at 60th day.

Significant differences in hardness were observed in treated and control cookies nevertheless with increasing level of psyllium husk the hardness decreased simultaneously. Hardness in control treatment compared to other treatments is attributed to starch content of white flour and also the binding of starch with protein during baking whilst in treated cookies flour was replaced with psyllium husk that imparts lesser amount of starch and protein eventually producing softer product. Moreover, husk from psyllium seed is potentially hydrophilic in nature thereby absorbed excessive moisture and affected the hardness. Psyllium husk is an excellent muciloid therefore bound moisture even during baking consequently imparts considerable soft texture to the cookies. Current results are comparable with the work of Uysal et al. (2007) and Toma et al. (2009) illuminated that fiber addition reduces hardness in cookies. Likewise, Piga et al. (2005) elucidated that moisture retention in cookies during storage imparts less resistance to the applied force thus softer product is attained.

References


