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Development and nutritional evaluation of high-fiber multigrain bars supplemented with apple peel powder

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Apple peel, a byproduct of the food industry, is high in fiber, polyphenols and minerals making it a potentially appealing component of bakery products. It is rich in flavonoids and polyphenols, exhibiting strong antioxidants, and anti-diabetic, anti-hypertensive and anti-inflammatory properties. This research aimed to develop high-fiber bars using waste peel with multigrain flour to improve nutritional profile without compromising taste. The strategy was simple to create, be affordable, environmentally friendly and enhance the nutritional value of the product. Powdered apple peel was added to multigrain flour to make high-fiber multigrain bars. A total of five treatments were prepared T_1, T_2, T_3, T_4 with different concentrations of apple peel powder (10%, 20%, 30%, 40%) while T_0 was a control group. High-fiber multigrain bars were formulated, and the product was subjected to different analyses such as proximate analysis, antioxidant analysis, total flavonoid content), physicochemical, total phenolic content (TPC), and texture analysis at 21 days of storage with 7 days of interval. All the data was statistically analyzed with the factorial design. Chemical analysis revealed that T_4 was the best treatment because the moisture (14.31-17.51%), protein (12.99-10.39%), fat (3.22-3.02%), fiber (8.08-7.78%), ash (3.68-2.21%), NFE (55.86-59.79%), TPC (95.85-93.08 mg GAE/g), TFC (68.03-64.17ug CE/g), pH (4.71-3.90), L*(41.02-44.26), a*(8.17-5.23), b*(7.19-6.73), hardness (7.87-6.62kg), stickiness (4.90-5.08N) and firmness (1.52-1.42kg) varies with the storage at 1st to 21st day. These bars were stable at the refrigerator (4^{o}C) during storage as indicated by significant differences among treatments to moisture content. The best treatment was T_4 due to the highest score given by the panelist. The overall findings revealed that there was a significant and highly significant relation between treatment and analysis while a non-significant relation was found between treatments and days.

Keywords: Apple Peels, Fiber, Food Industry, Nutritional, Multigrain Bars.

INTRODUCTION

Apple (Mallus domestica) is one of the easily available fruits worldwide. In 2017, about 4.9 million hectares of apple trees were planted and it is widely farmed in temperate climates that produce over 83 million apples all around the world. In Pakistan, 565,000 tons of apples were produced overall in 2018–19 (Mahmood et al. 2020). Apple peel is a key component in modern product development techniques because it contains polyphenol and fiber. About 30% of the initial fruit is made up of apple byproducts like peel and pomace (Kaur et al. 2022). Apple pomace contains 54% mash, 4% seed core, 2% stem,7% seed, and 34% peel which is an acceptable source of polyphenols Apple peel contains carbohydrate 71.1% of, fat 1.1%, fiber 15.25% of (Ahmed et al. 2020). The residue of apples is desirable source of valuable bioactive compounds and can be employed as an edible ingredient in food formulation and health-related purposes (Josimuddin et al. 2022).

One of the world's most serious public health issues is heart disease. The World Health Organization estimates that yearly (cardiovascular disease) CVD mortality rate would rise to 22.2 million in 2020 from 17.5 million in 2012. Epidemiological research has definitively demonstrated a link between consuming plant-based food like fruits, legumes, and vegetables that lower the CVD risks. Polyphenols are the protecting substances that may be responsible for the advantageous benefits of plant-based meals (Vilahur et al. 2015). According to research, long-term used of apple peel may reduce illness. Apple peel (AP) and Apple fleshes (AF) contain polyphenolic compounds that helpful in lowering vascular endothelial function, insulin resistance, and lipid metabolism (Tian et al. 2018).

Dietary fiber has just emerged as another potential solution to this problem. It is commonly recognized that changing a person's diet alone can have a major influence patient health with an immediate impact on blood pressure as well (Nepali et al. 2022). According to estimates, diabetes mellitus (DM) directly contributed to 1.5 million deaths and high blood sugar levels up to 2.2 million in Pakistan. Apple peels contain polyphenols such as hydroxycinnamates, anthocyanins, avanols and dihydrochalcones have a role in the development of anti-hypertensive, anti-inflammatory, and antioxidant characteristics (Khan et al. 2022). Apple peel contains ursolic acid which may lower lipids in 3T3-L1 cell. Apple peel utilization may be a better source of antioxidants than flesh and it may be able to lower the cellular lipid profile. Therefore, Consumers may be allowed to eat apple peel instead of flesh which has a higher amount of promoting compounds (Ko and Ku, 2022).

Prebiotics have the potential to control intestinal microflora and improve human health. The bulk of polyphenols enter colon rather than the small intestine where they are broken down into metabolites via colon bacteria (Luo et al. 2021). Several studies on the benefits of apple prebiotics can emphasize apple pectin, apple juices. However, apple peel was found to enhance the development of Lactobacillus casei Bifidobacterium animalis, and subsp. Lactis in previous research (Wang et al. 2020). Moreover, it was shown that the apple peel phenolic extract enhanced bacterial attachment to intestine epithelial cells by comparing the impact of phenolic extract from apple peel and pulp on Lactobacillus adherence. (Volstatova et al. 2017). Apple is the most valuable fruit because it contains high pectin content and herbal medicinal elements, making them particularly helpful in the treatment of diabetes. Peels of Apple have higher levels of phenolic compounds than their actual fruit. Natural phenolic compound improves the natural gut environment and function as probiotic (Deehan et al. 2017). Fiber consumption is linked to positive health outcomes in some diseases such as obesity, diabetes, and heart disease (Bindels et al. 2015). Carotenoids are significant phytochemicals found in cereal grains that provide health benefits and reflect the quality of cereal-based goods.

Corn (Zea mays L.) is the main crop and the third after wheat and rice in Pakistan. It is mainly used in the form of intact cereals in various foods such as dextrose, corn flakes, corn starch, etc. Corn contains sugar (3.0%), protein (10%), starch (72%), oil (4.8%) fiber (5.8%) (GOP, 2017). Various parts of plants have natural compounds and phytochemicals which are non-nutritive bioactive compounds of plants. These substances have antioxidant activity and other biological characteristics make them beneficial to human health.

The world's most widely produced cereal crop is wheat (Tricum aestivum L.) which is principally utilized in milling and cooking. Low-grain and Multigrain foods are not always whole grains. Whole grain diets might have a big impact on raising the incidence of chronic disorders due to this purpose wheat flour mills are used by bakeries to make bread, cookies, biscuits, etc. Wheat is a good source of fiber but the protein in wheat has low nutritional value due to the presence of a high amount of lysine (Anjali et al. 2019). Wheat is a large source of carbohydrates, but it also provides elements essential for our body, such as protein, phytochemicals, dietary fiber, and vitamins (especially B vitamins). Dietary fiber contained in wheat may decrease the risk of chronic disease (Shewry et al. 2015). Oats (Avena sativa. L) are a multipurpose grain that can be utilized for animal feed, medicine, and food Compared to other crops like maize, wheat, rye, or barley, oats have significantly smaller global cultivation (Daryanto et al. 2016). It is one of the ancient crops known to human society, having been produced annually in various parts of the world for over 2000 years. (Sang and Chu, 2017). Oats include Fiber 33.3%, iron 25%, protein 24%, carbohydrate 51.9%, total lipid 8.1%, Vit B18.3%, Vit E 2.8% (Akdeniz et al. 2019). Oat has drawn more attention from current research and the food industry. Oats are an ancient grain that generates innovative food products including infant feed, drinks, bars, breakfast cereals in food-based sectors (Boukid et al. 2018). Oats are a good source of dietary fiber and have the highest concentration of nutritional content. Oat products have gained attention due to their favorable effect on health including reducing blood cholesterol and glucose level (Dong et al. 2014; Shen et al. 2016). Abundant concentrations of vitamin E, phenolic compounds, flavonoids, sterols, and avenanthramides are present in oats (Paudel et al. 2021).

Barley (Hordeum vulgare L) among the oldest crop, is still being cultivated around the globe. Malt is made from flakes, raw ingredients, and groats, all of which are common in human nutrition and livestock feed (Tobiasz-Salach et al. 2018). Barley contains 12.5% protein, Fat 2.3%, carbohydrate 73.5%, and fiber 17.8%. A diet high in dietary fiber from barley has been linked with colon cancer and improvement of intestinal health in vivo. It

has been proved that barely starches, polyphenolic, glucan, and polypeptides have effective mechanism against obesity (Awadelkarim et al. 2018).

Preparing a cereal bar with the presentable look and are made up of different ingredients that will complement one another, it might be challenging to find one that looks presentable and provides nutritional benefits. This research aims to increase the nutritional value and assess the overall acceptance of fruit peel multigrain bars. And to assess the quality characteristics and nutritional profile of the high-fiber multigrain bar. Additionally, multigrain Bars are not only nutritionally dense but also a great source of fiber.

MATERIALS AND METHODS

The present study was conducted in Edible Fats and Oils laboratory at, National Institute of Food Science and Technology (NIFSAT), University of Agriculture Faisalabad. In this research, high-fiber multigrain bars were developed by incorporating different concentrations of apple peel powder. The protocol followed in this study has been discussed below:

Procurement of raw materials

Corn, oats, barley, and fresh red Fuji apples were purchased from AL-Fateh departmental store in Faisalabad. Punjab.

Raw Material Preparation

All the apples were washed with clean water and their peels were removed. Apple peel powder was prepared by drying the apple peel in the dehydrator and grinding it into a fine powder then sieved it and store in an air-tight container. All raw materials were clean (Corn, oats, barley, wheat) and partially roasted one by one at 200°C and converted into respective flours by using Udy Cyclone Mill.

Table: A treatment plan for high fiber multigrain bar supplemented with apple peel powder

Treatments	Percentage %	
	Multigrain flour %	Apple Peel Powder %
T_0	100	-
T_1	90	10
T_2	80	20
T_3	70	30
T4	60	40

T_0: control group (0% apple peel powder)
T_1: 10% apple peel powder
T_2: 20% apple peel powder
T_3: 30% apple peel powder
T_4: 40 % apple peel powder

Development of High Fiber Multigrain Bars

Multigrain bars supplemented with apple peel powder were developed using roasting all raw materials (Corn, barley, oats) one by one and then mixing them with other ingredients. Cut them into bar shapes, put them in a freezer to harden and pack them in aluminum foil for storage.

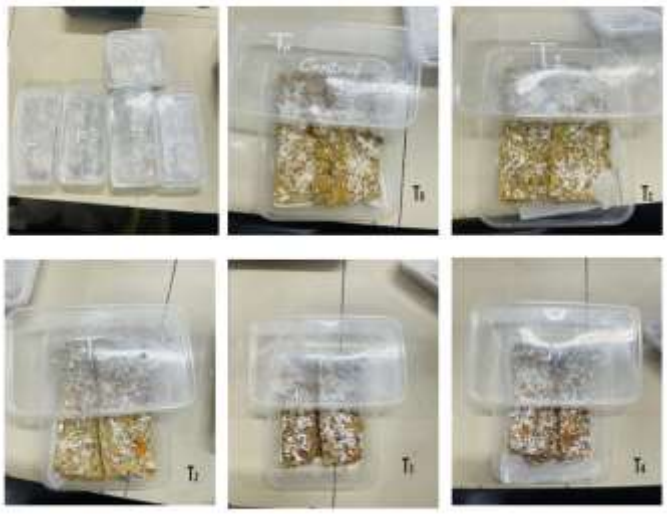

Figure 1: High-fiber Multigrain Bars supplemented with Apple peel powder

Analysis of Apple Peel Powder

Apple peel powder was evaluated for proximate analysis, mineral analysis, phytochemical analysis, and antioxidant activity.

Proximate Analysis of Apple Peel Powder

Moisture, fat, ash, protein, and fiber of apple peel powder were determined by following the protocols of AOAC (2019).

Moisture Content

Apple peel was taken, and the percentage moisture contents were determined by drying the peel in hot air oven. The apple peel powder was kept for 24 hours in a hot air oven at 105°C. After this, the sample apple peel was placed in a desiccator until it cooled down. Then the sample was weighed. Moisture percentage was determined by applying a formula.

Moisture content (%) = $\frac{\text{Initial wt. of sample (g) - Final wt. of sample (g)}}{\text{Initial wt. of sample (g)}} \times 100$

Fat Content

Determination of crude fat in apple peel powder was done using soxhlet apparatus. 5 grams of apple peel powder to extract crude fat. For this purpose, petroleum

ether was used as solvent. The concentration rate of petroleum ether was 2-3 drops per second for 3-4 hours, When the purification was complete the residue of abstraction flask and an excess amount of chemicals like hexane were evaporated at 100 °C for 30 minutes until the weight was constant.

$$\text{Fat Content (\%)} = \frac{\text{Initial wt. of sample (g) - Final wt. of sample (g)}}{\text{Initial wt. of sample (g)}} \times 100$$

Ash Content

Apple peel powder (5g) was taken in a crucible to evaluate the ash content. Charring was performed on the burner and the sample was put into the Muffle Furnace with the temperature of 550°C. When the color turned white/grey, the sample was weighed**.**

$$\text{Ash Content (\%)} = \frac{\text{Weight of residue after incineration (g)}}{\text{Initial weight of sample (g)}} \times 100$$

Fiber Content

Fiber content was determined by using a moisture and fat-free sample. Sulphuric acid (1.25%) was added in 10g of sample. Then Boling for 30 minutes, the sample was digested. After that the sample was filtered with filter paper and then washed with warn water to remove acid. The sample was placed in a beaker. 10ml of NaOH (1.25%) was taken in beaker. Distilled Water was added and boiled for 40 minutes. Again, filtered the sample and washed with hot water now the sample is alkali-free. The sample apple peel was placed in crucible and placed in over at 85°C. The residue was dried. The temperature set for drying was 130°C for two hours. The sample was weighed again and burned at 600°C, cooled, and washed again. The sample was kept in a desiccator to cool it after charring and then weighed. Fiber weight in the sample determined the weight that was lost during charring.

$$\text{Fiber (\%)} = \frac{\text{Wt. of dried sample before ashing (g) – Wt. of sample after ashing (g)}}{\text{Initial wt. of sample (g)}} \times 100$$

Protein Content

To determine nitrogen content, kjeldahl method was used. A digestion flask was taken and a 5 g sample and Sulphuric acid (30 ml) were added to it. It was boiled until the contents became clear. Then distilled water (250 ml) was used to dilute the sample in volumetric flask. After digestion 10ml of diluted sample was mixed with alkali solution (40% NaOH) and then this mixture was placed in the apparatus and then distillation was performed with steam.4% Boric acid was taken in a flask with an indicator and then distillate was mixed in it. The ammonia gas was contained in the flask at the receiving end. Then 0.1 N H_2S0_4 solution was used to perform the titration. Light pink color indicated the endpoint. The following formula was used:

$$\text{Nitrogen percentage} = \frac{\text{Vol of 0.1 N } H_2SO_4 \text{ used} \times 0.0014 \times \text{Total Dilution Volume}}{\text{Wt. of the sample} \times \text{Volume of diluted sample taken}} \times 100$$

$$\text{Protein percentage} = \text{Nitrogen Percentage} \times 6.25$$

Nitrogen free extract (NFE)

Following expression was used to assess NFE content as described in AOAC (2019).

NFE=100- (Moisture%+ Ash %+ Crude Pats+ Crude Fiber %+ Crude Protein)

Mineral Analysis

The calcium, iron, and zinc of Apple peel powder were evaluated by following the protocols described by AOAC (2019). For this purpose, wet-digested the materials so taking 2g sample of apple peel powder and 7ml HNO_3 and 3ml $HCLO_4$ in beaker now mix all chemicals and keep on hot plate until it turns into a colorless or golden-brown color. It took 30 minutes then it cooled down. When a 2ml solution was left, then increase the volume with distilled water to make 100ml solution. Then filtered it on filter paper and stored it in a bottle. An atomic absorption spectrophotometer was utilized to determine the percentage of iron and zinc in apple peel powder while calcium content was determined via flame photometer then calculation was done.

Phytochemical Analysis

Phytochemical analysis of apple peel powder was done by the method described as total flavonoid content and total phenolic content by Sadaf *et al*. (2022).

Total Phenolic Content

Folin-Ciocalteu (FC) assay was utilized to determine the TPC of apple peel powder.500µl of Folin-Ciocalteu (FC) reagents were taken and 100µl of sample extract was assorted in it. Then 6 ml of distilled water was taken into a test tube and the whole dilution was poured in it. All the things were shaken quickly and the 2 ml of 15% sodium carbonate was added. Distilled water was added to make a volume 10 ml. This dilution was kept in the dark for 2 hours. UV-visible spectrophotometer was used and absorbance reading was taken at 750nm. Results were expressed as mg of Gallic acid equivalent (GAE)/100g of dried extract.

$$\mathbf{T = C \times V/M}$$

were,

T= total contents of phenolic compound in mg GAE/g plant extract.

C= the concentration of Gallic acid calculated from calibration curve in mg/ml.

V= the volume of extract in ml.

M= the weight of apple peel powder

Total Flavonoid Content (TFC)

The TFC of apple peel powder was determined by using met Aliquot. The standard solution was mixed with 1.24ml of water and after that 4 % to 5% of 75 micro liter of sodium nitrite ($NaNO_2$) was added. After that solution was kept for 6mints and then 10% of 160 micro litter of Aluminum chloride ($AlCl_3$) solution was added to make 2.5ml volume of water solution, 0.6ml of sodium hydroxide (NaOH) solution was also added. After all that the absorption was read out at 520 nanometers. Result was displayed in terms of mg rutin equivalent per 100g of apple peel powder.

TFC=C×(V/m)

Antioxidant activity

The antioxidant activity of apple peel powder was examined by using the DPPH followed by Preti *et al*. (2021).

DPPH radical scavenging assay

The DPPH of apple peel powder was determined. 3ml of DPPH radical solution in methanol was combined with 3ml of diluted sample in methanol. The ultimate DPPH radical concentration was 1.0×10*M. Then the reaction mixtures were agitated violently and incubated for 30 minutes in the dark. Thereafter, the absorbance was calculated at 517nm by using a spectrophotometer.

$$AA\% = \frac{A_o - A_1}{A_o} \times 100$$

Analysis of product

High fiber multigrain bars were investigated by using following analysis.

Proximate Analysis

Moisture, fat, ash, protein, and fiber was analyzed by following AACC (2017) the above-mentioned protocol.

Phytochemical Analysis

TPC and TFC of bars were determined by following Kaur et al. (2022) the above protocols.

Physico-chemical Analysis of Bars

Physicochemical chemical analysis of high fiber bars was measured by following the method given below.

Color Analysis

Color analysis was done by following Nakov *et al*. (2020) by utilizing colorimeter. The surface color, a*(specifies red and green color variation), L*(denotes lightness value) and b* (denotes yellow and blue color) of bars was accessed with the help of color meter. A clear petri dish was taken and a sample was mounted in it. The light was passed directly through the samples and the indices of color parameters L*, a* and b* was calculated.

Chroma (C+) = [(a*) 2 + (b*) 2] ½ Hue angle (h) = tan (b*/a*)

Texture Analysis

Prepared High-fiber multigrain bars were analyzed by following Munir *et al*. (2016) to check hardness, springiness, and gumminess using a texture analyzer. A compression test was used with a weight of 2 kg load. Displacement speed was kept at 56mm/min and hardness, and firmness was calculated by applying force (kg) versus time (sec) with the disk probe (34 mm in diameter). Hardness as well as firmness were measured by applying maximum force.

pH Analysis

The pH of bars was evaluated by official protocols illustrated by AOAC (2019)**.** Test sample was adjusted to a temperature of 25^{o}C.The temperature of the test sample was same as the temperature of buffer solution that was used for standardization. Rinsed and blotted electrodes and then immersed electrodes in sample and pH was read by letting the meter stabilize for 1 minute. Rinsed and bottled electrodes were repeated on a fresh portion of test sample.PH values were determined on each test sample. Reading in close agreement indicated that test sample was homogeneous.

Sensory Evaluation

A total of four treatments and control (high fiber multigrain bars) were assessed by a panel of judges for various sensory characteristics via a 9-point hedonic scale system that ranged from dislike extremely (score 1) to like extremely (score 9). Sensory evaluation was done by an appropriate panel of trained judges from the National Institute of Food Science and Technology, University of Agriculture Faisalabad (UAF), by implementing (Meilgaard et al. 2007).

Storage Study

The stability of bars was checked on the 0^{th,} 7th, 14th, 21st day of the storage periods by following the method to investigate all parameters of analysis that were discussed above.

Statistical Analysis

All parameters were measured precisely after 21st-day trials. Data was assessed statistically by utilizing statistix 8.1 software. For statistical analysis, this indicated the level of significance variance of treatments and days while the mean comparison among all treatments for different parameters was determined by applying the Tuckey test via software statistix 8.1, two-way ANOVA under factorial design at $p<0.05$ significance level was used (Montgomery, 2017).

Analysis of raw material

Analysis of apple peel powder

Proximate analysis of raw material was done to determine the moisture, ash, fiber, protein, fat and NFE.

The results are according to which the moisture content (45.02±0.95), fat (9.08±0.86), fiber (2.69±0.34), ash (3.15±0.27), protein (7.86±0.40), NFE (31.57± 0.73).These findings were correlate with the result of Kaur et al. (2022) in which moisture was 47.95%, the fiber content was 1.82%ash content was 3.15%the protein was 6.68% the content of fat was 8.94%.

Minerals are naturally found inorganic nutrients with significance chemical structure. mineral analysis of apple peel powder was done and according to table 3.2. means values of minerals. The mineral content was assessed to examine the level of zinc, iron and calcium in apple peel powder. The results revealed that the level of calcium, iron and zinc was 12.64 mg/100g, 23.16mg/100g and 0.86mg/100g respectively. These results were similar with the result of Ahmad et al.(2022) that illustrated the calcium, iron and zinc of apple peel was ranging from 11.23-15.54mg/100g, 20.49-29.95mg/100g and 0.57-0.98/100mg.

Phytochemicals are bioactive compounds found in fruits, vegetables and other foods. They provide several health benefits along with scavenging activities. Table.3 demonstrates that apple peel powder contains 216±2.27 mg GAE/g total phenolic content (TPC), 29.14±1.42 mg CE/g total flavonoid content (TFC) and 8.63±0.32%, 2,2-diphenyl-1-picrylhydrazyl (DPPH). These results are in similar with the findings of Zielińska and Turemko (2020) that explained the TPC,TFC and DPPH of apple peel was ranging from 180-250 mg GAE/g, 20.61-30.91 mg CE/g and 7.12-9.45% respectively.

Table 1: Means value of proximate analysis of apple peel powder

Parameters	Means ± SD (%)
Moisture	45.02±0.95
Fat	9.08±0.86
Protein	7.29±0.74
Fiber	2.69±0.34
Ash	3.15±0.27
Nitrogen Free Extract	31.57±0.73

Table 2: Mean value of mineral analysis(mg/100g) of apple peel powder

Minerals	Values
Calcium	12.64±1.25
Iron	23.16±1.47
Zinc	0.86±0.09

Table 3: Mean value of antioxidant analysis of apple peel powder

Variables	Values
TPC (mg GAE/g)	216±4.27
TFC (mg CE/g)	29.14±1.42
DPPH (%)	8.63±0.32

Analysis of product

Proximate analysis

Proximate analysis of high-fiber multigrain bars was done to evaluate the moisture, ash, protein, fat, fiber and nitrogen-free extract (NFE).

Moisture analysis

The percentage of water present in food products is called moisture content. It is the percentage ratio of evaporated moisture to the total weight of the sample. It is a very important parameter to determine the quality and self-life of perishable food products. The moisture content of developed high fiber multigrain bars was determined. The results indicated that the difference in moisture content of bars among treatments was highly significant ($P<0.01$). Similarly, the effect of storage days on the developed products was also highly significant whereas the interaction between treatments and days was non-significant ($P>0.05$).

Table 5 . presented the mean for the moisture content of multigrain bars with the interval of one week on day 1st,7th ,14th and 21st.The mean comparison of treatments in table 3.5. demonstrated that the moisture content was decreased ranging from 27.05-15.85% with increase in the concentration of apple peel powder. This may occur as the peel contains high amounts of fiber and low water activity. Among all treatment T_0 showed the highest (25.56±0.83) % while T_4 lowest (14.31±0.47) % moisture content at 1st day. Higher moisture content in T_0 might be attributed to the water absorption capacity of multigrain flour (MF). The results of the present study were similar to the finding of Henríquez *et al*. (2020) in which the moisture content decreased with different concentrations of apple peel powder added to cereal muffins ranging from 22.5-17.9% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the moisture content was measured at different regular intervals from the 1st to the 21st day. The mean value of moisture content of bars with storage days increased ranging from 19.33-22.33%. It was determined that the moisture content increased during storage due to the process of condensation in refrigerator, as indicated in table 3.4. According to Szydłowska *et al*. (2022) food items moisture content can fluctuate slightly due to changes in atmospheric humidity. The increased air humidity in the product leads to elevated moisture content and changes in product bulk. Therefore, there was a highly significant relationship between storage and moisture content. While the interaction of days and treatment was non-significant. The result of this study was correlated with the Aslam *et al*. (2023) determined that the storage stability of fig fruit bars. The bars were stored at 0 to 90 days in the refrigerator(4-5°C). The moisture content decreased with an increase in the amount of fig added to wheat flour. This research concluded that the moisture

content of bars typically increased by 20-30% with increased storage trials.

Ash Content

Ash content refers to the inorganic residue that remains after the incineration of organic matter and comprises minerals in the food sample. This process is a quantitative evaluation of ash content in food products. The results indicated that the difference in ash content of bars among treatments was highly significant ($P<0.01$). Similarly, the effect of storage days on the developed products was also highly significant whereas the interaction between treatments and days was non-significant ($P>0.05$).

Table 3. presented the mean for the ash content of multigrain bars with the interval of one week on days 1st,7th ,14th and 21st.The mean comparison of treatments in table 3.5. demonstrated that the ash content was decreased ranging from 4.38-2.94% with an increase in the amount of apple peel powder. This may occur as the peel contains a lower amount of minerals while higher amount of fiber. Among all treatments T_0 showed highest (4.78±0.64) % while T_4 lowest (3.68±0.49) % ash content on 1st day. Higher ash content in T_0 could be related to the high amount of minerals present in multigrain flour (MF). The results of the present study were similar to the finding of Ismail et al. (2018) in which the ash content decreased with different concentrations of pomegranate peel added in cookies ranging from 2.60 to 0.74% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the ash content was measured at different regular intervals from 1st to the 21st day. The mean value of ash content of bars with storage days decreased ranging from 4.18-2.86%. It was determined that the ash content depends upon the mineral content. The ash content decreased with an increase in moisture content in bars during storage. Therefore, there was a highly significant relationship between storage and ash content. While the interaction of days and treatment was non-significant. The result of this study was correlated with Munir et al. (2019) determined that the storage stability of snack bars by using apricot peel and spinach. The bars were stored for 0 to 3 months. The ash content decreased with an increase in the amount of apricot peel and spinach. This research concluded that the ash content of bars typically decreased (3.05±0.05) % to (2.90±0.10) % with increased storage period.

Table 4: Impact of treatment and storage days on the moisture of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	25.56±0.83	26.55±0.98	27.53±0.62	28.52±0.73	27.05^{a}
T1	20.76±0.68	21.71±0.92	22.70±0.74	23.69±0.77	22.22^{b}
T2	18.92±0.22	19.91±0.65	20.89±1.01	21.71±0.71	20.40^{c}
T3	17.08±0.56	18.07±0.25	19.06±0.62	20.04±0.65	18.57^{d}
T4	14.31 ±0.47	15.30 ±0.15	16.29 ± 0.53	17.51±0.76	15.85^{e}
Mean	19.33^{d}	20.31^{b}	21.29^{c}	22.33^{a}	

T_0: 100% Multigrain flour, T_1: 10% Apple peel powder + 90 % multigrain flour, T_2: 20 % Apple peel powder +80 % multigrain flour, T_3: 30 % Apple peel powder + 70 % multigrain flour, T_4: 40 % Apple peel powder+ 80 % multigrain flour

Table 5: Impact of treatment and storage days on ash of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	4.78±0.64	4.67±0.78	4.33±0.21	3.74±0.41	4.38^{a}
T1	4.61±0.61	4.49±0.16	3.84±0.42	3.13±0.16	4.02^{ab}
T2	3.99±0.21	3.69±0.23	3.32±0.27	2.77±0.09	3.42^{bc}
T3	3.85±0.39	3.42±0.38	3.22±0.35	2.53±0.07	3.26^{cd}
T4	3.68 ±0.19	3.12 ±0.17	2.83 ± 0.11	2.12±0.23	2.94^{d}
Mean	4.18^{a}	3.94^{ab}	3.51^{b}	2.86^{c}	

Crude Protein

Protein has a significant role in the functional and nutritive qualities of any food product or food commodity. Table 8. illustrates the analysis of variance for the protein content of different treatments of high fiber multigrain bars prepared by various concentrations of apple peel powder and multigrain flour. The protein content of developed high fiber multigrain bars was determined. The results indicated that the difference in protein content of bars among treatments was highly significant (P<0.01). Similarly, the effect of storage days on the developed products was also highly significant whereas the interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is presented in Table 6. explained that the protein content was decreased ranging from 16.47-11.69% with the increase in concentration of apple peel powder. This may occur as the peel contains a lower amount of protein while higher amount of fiber. Among all treatment T_0 showed the highest (17.90±0.36) while T_4 lowest (12.99±0.20) protein content on 1st day. Higher protein content in T_0 might be attributed to the high amount of protein present in multigrain flour (MF). The results of the present study were similar to the finding of Bertagnolli *et al*. (2014) in which the protein content decreased with different concentrations of guava peel flour added in cookies ranging from 14.23 to 10.48% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the protein content was measured at different regular intervals from 1st to 21st day. The mean value of protein content of bars with storage days decreased ranging from 15.41-12.53%. The protein content in bars decreases during storage due to oxidation of amino acids in food products and air humidity in refrigerators which can result in degradation. The protein content also decreased with an increase in water activity and microbial activity in bars during storage. Therefore, there was a highly significant relationship between storage and protein content. While the interaction of days and treatment was non-significant. The result of this study was correlated with the findings of Siregar *et al*. (2021) determined the storage stability of snack bars by adding different flours. The bars were stored at different temperatures (0-5°C). This research concluded that the protein content of bars typically decreased (2.99±0.05) % to (1.90±0.10) % with increased storage trials.

Fiber Content

Crude fiber is the quantitative evaluation of fiber present in food products. The fiber content of developed high fiber multigrain bars was determined. The results indicated that the difference in fiber content of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was significant (p<0.05) while the interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments in table 7. explicated that the fiber content was increased ranging from 1.29-7.93% with increase in concentration of apple peel powder. This may occur as the peel contain higher amount of fiber and ratio of apple peel powder was increased with treatments. Among all treatments, T_0 showed lowest (1.43±0.03) % while T_4 highest (8.08±0.63) % fiber content at 1st day. Lower fiber content in T_0 might be attributed to the lower amount of fiber present in multigrain flour (MF). The results of the present study were similar to the finding Henríquez *et al*. (2020) in which the fiber content increased with different concentrations of apple peel powder added to cereal muffin ranging from 2.09 to 9.72% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the fiber content was measured at different regular intervals from 1st to 21st day. The mean value of fiber content of bars with storage days decreased ranging from 4.66-4.34%. It was determined that the fiber content decreased during storage due to the degradation of food which changed the structural properties of bars. Therefore, there was a highly significant relationship between storage and fiber content. While the interaction of days and treatment was non-significant. The result of this study was correlated with the Sharma *et al*. (2021) that determined the storage stability of cereal bars by adding different fruit peels. The maximum fiber was found in T_5 due to the presence of the high amount of peel while the lower amount of fiber content in the control treatment. The fiber content decreased significantly during 30 days of storage periods. In this research findings concluded that the fiber content of bars typically decreased from 1.13% to 1.10% with increased storage trials.

Table 6: Impact of treatment and storage days on crude protein of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	17.90±0.36	16.96±0.65	16.12±0.29	14.87±0.57	16.47[a]
T1	17.03±0.66	16.12±0.27	15.08±0.56	14.05±0.48	15.57[b]
T2	14.88±0.57	13.83±0.53	13.78±0.10	12.21±0.18	13.68[c]
T3	14.25±0.47	13.12±0.27	12.12±0.09	11.16±0.43	12.66[d]
T4	12.99±0.20	12.21±0.47	11.16 ± 0.43	10.39±0.19	11.69[e]
Mean	**15.41[a]**	**14.45[b]**	**13.66[c]**	**12.53[d]**	

Table 7: Impact of treatment and storage days on the crude fiber of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	1.43±0.03	1.35±0.07	1.26±0.03	1.15±0.07	1.29^{e}
T1	2.99±0.17	2.80±0.19	2.71±0.27	2.61±0.09	2.78^{d}
T2	4.71±0.11	4.59±0.20	4.46±021	4.35±0.19	4.53^{c}
T3	6.11±0.38	6.01±0.44	5.90±0.40	5.79±0.30	5.95^{b}
T4	8.08 ±0.63	7.99 ±0.65	7.86 ± 0.57	7.78±0.51	7.93^{a}
Mean	4.66^{a}	4.55^{ab}	4.44^{ab}	4.34^{b}	

Another study was like the finding of Jahanzeb *et al*. (2016) determined that the cereal bar by adding guava pulp. According to the means, the fiber content was higher in T_3 (4.84%) while the lowest fiber content was shown in control group (1.36%). When stored at 0 to 30 days, the fiber content of control decreased from 1.36-0.36% while the T_3 reduced from 4.84% to 3.73% respectively during storage of 30 days. However, the same trend was observed in all other treatments during storage periods.

Crude Fat

Crude fat is rough estimation to measure fat in food products which is the major source of calories. The fat content of developed high fiber multigrain bars was determined. The results indicated that the difference in fat content of bars among treatments was highly significant ($P<0.01$). The effect of storage days on the developed products was significant ($p<0.05$) while the interaction between treatments and storage days was non-significant ($P>0.05$).

The mean comparison of treatments in table 8. reveals that the fat content was decreased ranging from 3.81-3.13% with an increase in concentration of apple peel powder. This happened because the level of fat content in bars was reduced by adding apple peel powder. Among all treatments T_0 showed highest (3.90±0.22) % while T_4 lowest (3.22 ±0.19) % fat content at 1st day. Higher fat content in T_0 might be attributed to the higher amount of fat present in multigrain flour (MF). The results of the present study were similar to the finding Henríquez et al. (2020) in which the fat content decreased with different concentrations of apple peel powder added to cereal muffin ranging from 9.72 to 2.09% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the fat content was measured at different regular intervals from 1st to 21st day. The mean value of fat content of bars in table.8 . with storage days decreased ranging from 3.49-3.29%. It was determined that the fat content decreased during storage due to lipid oxidation which causes a free radical reaction between fatty acids and oxygen and leads to a rancid product. Therefore, there was a highly significant relationship between storage and fat content. While the interaction of days and treatment was non-significant. The result of this study was correlated with the Sousa et al. (2019) determined that the storage stability of snack bars by adding a different maize byproduct, corn bran(CB). The maximum fat was displayed in T_0 of fat (5.48%) due to the present of high amount of maize byproduct while T_5 (2.63%) had lowest fat content due to the present of corn bran. The fat content decreased significantly during 30 days of storage periods. In this research, findings concluded that the fat content of bars typically decreased from 5.45 to 2.10% with increased storage trials.

Table 8: Impact of treatment and storage days on crude fat of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	3.90±0.22	3.85±0.15	3.79±0.09	3.69±0.19	3.81^{a}
T1	3.59±0.20	3.54±0.01	3.47±0.19	3.39±0.13	3.49^{b}
T2	3.44±0.29	3.39±0.17	3.32±0.13	3.23±0.18	3.34^{bc}
T3	3.32±0.16	3.27±0.09	3.20±0.15	3.11±0.07	3.23^{c}
T4	3.22±0.19	3.17 ±0.13	3.10 ± 0.03	3.02±0.16	3.13^{c}
Mean	3.49^{a}	3.45^{ab}	3.38^{ab}	3.29^{b}	

Nitrogen Free Extract (NFE)

The nitrogen free extract is calculated by subtracting the original sample from the sum of the weights of moisture, fat, protein, ash and fiber to estimate the number of water-soluble polysaccharides. The NFE content of developed high fiber multigrain bars was determined. The results indicated that the difference in the NFE content of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is in Table 9. described that the NFE content was increased ranging from 46.21-57.58% with the increase in the concentration of apple peel powder. This happened because the level of moisture content and fiber content increased in bars while the other parameters of proximate decreased. Among all treatments T_0 showed the lowest (44.72±1.46) % while T_4 highest (55.86 ±1.85) % NFE content on 1st day. The higher NFE value in T_4 might be attributed due to higher amount of carbohydrates present in multigrain flour and peel powder. Secondly, the use of brown sugar and honey in bars are also high in carbohydrates which may cause to increased NFE value. The results of the present study were similar to the Farouk Abdel-salam *et al*.(2022) in which the NFE content increased with different concentrations of apple flour, banana flour and carrot flour added to high-energy protein bars ranging from 61.27±0.18% to 64.13±0.91% respectively.

The bars were stored in a refrigerator (4°C) for storage study and the NFE content was measured at different regular intervals from 1st to 21st day. The mean value of NFE content of bars is in Table 4.15. with storage days increased ranging from 51.25-55.16%. NFE content increased during storage due to an increase in air humidity and increased water activity of the bar which leads to increased moisture content. The level of carbohydrates was also increased which caused the NFE value of bars to increase. Therefore, there was a highly significant relationship between storage and NFE content. While the interaction of days and treatment was non-significant. These results were correlated with the finding of Abdel-Hameed *et al*. (2023) described that the NFE value of papaya by-product in cupcakes increased with an increase in concentration of papaya by product.

These results were also similar to the finding of Mahmood *et al*. (2020) explained that the NFE value of snack bars developed from apricot and carrot showed an increasing trend. When stored the snack bar at 90 days. In this research, the highest NFE value was observed in treatment T_3 (66.7%) while lower observed in treatment T_0(44.92%).

Phytochemical Analysis

Phytochemicals are secondary plant metabolites and non-nutritive constituents of plants with potential health-promoting benefits. Phytochemicals perform different functions in our body. These compounds are very helpful in the detoxification of enzymes, immune system stimulation, hormone metabolism, and platelets aggregation reduction.Lipid modulation, antibacterial, and anti-mutagen, effects, induction of apoptosis and reduction of tumor initiation (González Mera *et al.* 2019). The analysis regarding phytochemical is given below;

Total Phenolic Content (TPC)

Phenolic chemicals are key plant constituents with redox characteristics and antioxidant action. The phenolic extract present in a food product is determined using folin-ciocalteu reagent in an alkaline environment. The TPC content of developed high fiber multigrain bars was determined. The results indicated that the difference in TPC content of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is in Table 10. described that the TPC content was increased ranging from 68.59-94.45 mg GAE/g with the increase in the concentration of apple peel powder. The maximum value was observed in T_4 (95.85±3.02) while the minimum value was noticed in T_0 (70.09±1.07) mg GAE/g at 1st day. The highest value was observed due to the 40% apple peel powder added to the bars. The peel has higher phenolic acid compounds and has higher antioxidant activity which may increase the TPC value in bars. The results were correlated with the finding of Kaur *et al*. (2022). In this research, the TPC value of the muffin increased ranging from 40.49-90.57% as the amount of apple peel powder in the wheat flour increased.

The bars were stored in a refrigerator (4°C) for storage study and the TPC content was measured at different regular intervals from 1st to 21st day. The mean value of TPC content of bars in table 4.17. with storage days decreased ranging from 79.79-77.06 mg GAE/g.TPC content decreased during storage due to exposure to air which leads to an increase the hydrolysis of food products and may oxidize the bars. Therefore, there was a highly significant relationship between storage and TPC content. While the interaction of days and treatment was non-significant. These findings were correlated with the Parekh *et al*. (2014) explained that the TPC value of mango bars decreased during storage from 0 to 6 months. This research concluded that the TPC value may decrease due to increased hydrolysis and oxidation of reducing sugar in bars during storage periods.

These results were also similar to Silva Carvalho

and Conti-Silva (2018) that developed the cereal bars by utilizing banana peel flour (BPF). The TPC value decreased from 59.91 to 40.11mg GAE/g throughout 11 months of storage and it was significantly related to storage. The findings indicate that the bioactive activities of BPF-enriched cereal bars decreased during storage study.

Table 9: Impact of treatment and storage days on NFE of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	44.72±1.46	45.10±0.98	46.54±0.72	48.51±2.00	46.21^{d}
T1	49.44±0.91	50.94±1.67	51.89±1.33	53.73±1.75	51.25^{c}
T2	52.40±1.71	53.94±1.33	54.80±1.45	56.03±1.52	54.29^{b}
T3	53.84±1.55	54.51±1.67	55.92±0.92	57.70±0.99	55.49^{b}
T4	55.86±1.85	56.59±2.05	58.08 ± 1.57	59.79±0.95	57.58^{a}
Mean	51.25^{c}	52.21^{bc}	53.24^{b}	55.16^{a}	

Table 10: Impact of treatment and storage days on TPC of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	70.09±1.07	68.90±1.09	68.26±2.06	67.131.03	68.59^{e}
T1	72.48±2.51	72.24±1.11	71.23±2.34	70.16±1.91	71.53^{d}
T2	75.27±1.15	74.14±1.14	74.14±1.28	73.08±1.12	74.14c
T3	85.25±0.67	84.08±1.07	83.91±1.27	82.83±1.25	83.52^{b}
T4	95.85±3.02	94.94±2.46	93.95±1.44	93.08±0.97	94.45^{a}
Mean	79.79^{a}	78.86^{ab}	77.08^{bc}	76.06^{c}	

Total Flavonoid Content (TFC)

These are the secondary metabolites of the flavonoids also called vitamin P. These compounds are mostly required by plants to create yellow and other pigments that play a major role in plant color. TFC method is used to measure the flavonoid extract in food products. The aluminum chloride colorimetric analysis is one of the most used techniques for determining TFC in plant extracts (Aparna and Hema, 2022). The TFC content of developed high-fiber multigrain bars was determined. The results indicated that the difference in TFC content of bars among treatments was highly significant ($P<0.01$). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant ($P>0.05$).

The mean comparison of treatments is in Table 11. described that the TFC content was increased ranging from 37.43-66.18 ug CE/g with the increase in the concentration of apple peel powder. Moreover, T_4 has highest TFC content (68.03±1.82) while T_0 has lowest phenolic content (39.28±0.52) ug CE/g 1st day. The highest value was observed due to the 40% apple peel powder added to bars. The peel has higher flavonoid compounds (catechin) and higher antioxidant activity which may increase the TFC value in bars. The findings was correlated with the Ranjha *et al*. (2020) explained that the TFC value of apple peel and pomegranate peel in the date bars increased from 29.43 to 59.54ug CE/g to as the amount of these peels powder increased.

The bars were stored in a refrigerator (4°C) for storage study and the TFC content was measured at different regular intervals from 1st to 21st day. The mean value of TFC content of bars is in table 4.19. with storage days decreased ranging from 53.66-49.79 ug CE/g.TFC content decreased during storage due to exposure of air which leads to an increase the hydrolysis of food products and may oxidize the bars. Therefore, there was a highly significant relationship between storage and TFC content. While the interaction of days and treatment was non-significant. These findings correlate with Parekh *et al*.(2014) described that the TFC value of mango bars decreased during storage from 0 to 6 months. This research concluded that the TFC value may decrease due to increased hydrolysis and oxidation of reducing sugar in bars during storage periods.

These results were also similar with Jabeen *et* al.(2021) developed that the six types of bars by using date, apricot, cheese and whey protein during storage of 0-45 days. The TFC value increased from 0.2-1.2 mg Rutin Equivalents/5g at 30 days of storage. Total flavonoid content decreased from 1.2-0.6mg Rutin Equivalents/5g 45 days. Moreover, there was a significant relationship between TFC and storage. The findings indicate that the decline in bioactivity was due to the presence of protein breakdown in bars which result in increased oxidative stress in bars.

Table 11: Impact of treatment and storage days on TFC of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	39.28±0.52	38.09±1.84	36.90±1.99	35.42±2.07	37.43^{e}
T1	46.47±1.24	45.28±1.11	44.09±0.52	42.61±1.39	44.62^{d}
T2	53.66±1.43	52.47±1.40	51.28±1.37	49.79±0.98	51.80^{c}
T3	60.84±1.67	59.66±1.59	58.48±0.72	56.99±1.52	58.99^{b}
T4	68.03±1.82	66.85 ±1.79	65.66 ± 1.75	64.17±1.71	66.18^{a}
Mean	53.66^{a}	52.48^{ab}	51.28^{b}	49.79^{c}	

Physicochemical Analysis

pH

The pH is the quantitative measure of the acidity of food products. The pH value of developed high fiber multigrain bars was determined. The results indicated that the difference in pH of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant (P>0.05).

Table 12. presented the mean for the pH value of multigrain bars with the interval of one week on day 1st,7th,14^{th,} and 21st.The mean comparison of treatments is in Table 3.12. shown that the pH value was decreased ranging from 5.16-4.24 with an increase in concentration of apple peel powder. The maximum value was observed in T_0 (5.32±0.59) while the minimum value was noticed in T_4 (4.71±0.35) on 1st day. The highest value was observed due to the incorporation of apple peel in bars which shows neutral to basic value. The findings were correlated with the results of El-Kholany et al.(2022) showed that the pH value of lemon peel bars decreased with the addition of lemon peel extract. During the storage of 30 days at 4°C temperature, the pH value decreased from 4.44 to 4.15. The control group showed the highest pH value 4.29 while the T_4 showed lowest value 4.18. The overall findings showed that there was a significant relationship between pH and treatments. The pH value of the bar declined with increasing the concentration of lemon peel.

The bars were stored in a refrigerator (4°C) for storage study and the pH value was measured at different regular intervals from 1st to 21st day. The mean value of the pH value of bars in Table with storage days decreased ranging from 4.98-4.01. The pH value decreased during storage due to microbial and enzymatic degradation of bars during the storage period. Therefore, there was a highly significant relationship between storage and the pH value. While the interaction of days and treatment was non-significant.

Other findings were closely related to Aslam et al. (2023) that developed a fruit bar by using roselle fig. There was a significant relation present between treatment and pH value. The pH value decreased with the increased concentration of fig. When the bar was stored for 90 days, the pH value showed a decreasing trend. The treatments decreased from 5.25 to 3.06 during 90 days of storage trial.

Color analysis

Color is the most vital sensory attribute in bakery food. Color influences consumers perception of a product's quality, flavor, and reliability. Various types of equipment and senses may be used to evaluate the color. The most important instrument used to assess the color is the colorimeter. The colorimeter was used to determine the color parameters of the high fiber multigrain bars from 1st to 21st days storage period. The color parameters L* indicated the lightness while a* and b* were chromaticity parameters which indicated the red-green and blue-yellow values respectively. The higher value of the L* indicates the maximum whiteness of the samples.

Table 12: Impact of treatment and storage days on pH of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	5.32±0.59	5.27±0.54	5.13±0.27	4.92±0.44	5.16^{a}
T1	5.13±0.56	5.08±0.18	4.81±0.46	4.31±0.72	4.83^{ab}
T2	4.93±0.49	4.43±0.44	4.21±0.57	3.42±0.34	4.30^{bc}
T3	4.82±0.32	4.52±0.37	4.35±0.42	3.51±0.21	4.25^{bc}
T4	4.71±0.35	4.32 ±0.21	4.01 ± 0.24	3.90±0.29	4.24^{c}
Mean	4.98^{a}	4.72^{a}	4.50^{ab}	4.01^{b}	

L*value

The L* value represented the product lightness as it proceeded from darkness to brightness. The L* value ranges from 0 to 100, indicating the light color of food products. The L* value of developed high fiber multigrain bars was determined. The results indicated that the difference in the L* value of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while interaction between treatments and storage days was non-significant (P>0.05).

Table 13. presented the mean for the L* value of multigrain bars with the interval of one week on day 1st,7th,14th and 21st. The mean comparison of treatments is in Table 13. demonstrated that the L* value was increased ranging from 35.71-42.64 with an increase in the concentration of apple peel powder. This may occur due to the darker color of apple peel. Among all treatment, T_0 showed the lowest (34.64±0.92) while T_4 highest (41.02±0.57) L* value at 1st day. The higher L* value in T_4 might be attributed to the darker to luminous color present in apple peel powder. The results were similar to the findings of Nakov et al. (2020) revealed that the L* value increased from most luminous(59%) to the darker color (75%) by adding apple peel powder. This was caused by the presence of apple peel powder in the food industry product, which had a darkening effect.

The bars were stored in a refrigerator (4°C) for storage study and the L* value was measured at different regular intervals from 1st to 21st day. The mean value of the L* value of bars is in table 4.23. revealed that with the storage days increased L* value of bars ranging from 37.97-40.49. The L* value increased during storage due to the maillard reaction occurring in bars which changed reducing sugar into non-reducing sugar which leads to the change the color of bars into a brown shade. Therefore, there was a highly significant relationship between storage and the L* value. While the interaction of days and treatment was non-significant. These findings were also correlated with Mridula et al. (2013) which developed omega-3 rich energy bar by supplementation of flaxseed. During storage stability from 0 to 90 days at the refrigerator, the L* value of bar increased from 41.27-61.81 which represented the darker color of bars.

These results were also similar to the Lucas et al.(2020) revealed that the used of (2 to 6) % of spirulina added to developed snack bars. There were significant relations present between treatment and L* value. When the bar was stored at 30 days, the L* value showed in increasing trend. The L* value of treatment increased throughout the storage period.

a*value

The a* number represents the red-to-green color of food products. The color intensity indicated by the a* value has no numerical limits. The a* value of developed high fiber multigrain bars was determined. The results indicated that the difference in a* value of bars among treatments was highly significant (p≤0.01). The effect of storage days on the developed products was also highly significant while interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is in Table 3.14. shown that the a* value was increased ranging from 4.18-6.65 with an increase in the concentration of apple peel powder. This may occur as the peel contains darker red color. Among all treatments, T_4 showed highest (8.17±0.17) while T_0 lowest (5.34±0.46) a* value at 1st day. Lower a* value in T_0 might be attributed to the darker to yellowish color present in multigrain flour (MF). The results were similar to the study of Nakov et al.(2020) revealed that by adding apple peel powder the a* value increased 3.63-8.91and showed a change from green to magenta color. This happened due to the presence of apple peel powder that incorporate in the food industry product which showed to change the color of bars.

The bars were stored in a refrigerator (4°C) for storage study and the a* value was measured at different regular intervals from 1st to 21st day. The mean value of the a* value of bars in table 4.14. with storage, days decreased ranging from 6.62 to 4.25. The a* value decreased during storage due to Millard reaction occur in bars which changed reducing sugar into non-reducing sugar that leads to the change the color of bars into a darker green shade. Therefore, there was a highly significant relationship between storage and the a* value. While the interaction of days and treatment was non-significant. These findings were also correlated with Mridula et al. (2013) developed that omega-3 rich energy bar by supplementation of flaxseed. During storage stability from 0 to 90 days at the refrigerator, the a* value of bar decreased from 5.23-2.72 which represented the darker color of bars.

These results were also similar to the Lucas et al.(2020) revealed that the used of (2 to 6) % of spirulina added to developed snack bars. There were significant relations present between treatment and a* value. When the bar was stored at 30 days, the a* value showed in decreasing trend. The a*value of treatment decreased throughout the storage period.

b*value

The b* value denotes the blue-to-yellow color component of food products. A positive b* number represents that the color of food material is yellow, whereas a negative b* value shows that the color of food materials is blue. The *b value of developed high fiber multigrain bars was determined. The results indicated

that the difference in b* value of bars among treatments was significant (p≤0.05). The effect of storage days on the developed products was highly significant (p≤0.01) while interaction between treatments and storage days was non-significant (P>0.05).

Table 15. presented the mean for the b* value of multigrain bars with the interval of one week on day 1st,7th ,14th and 21th.The mean comparison of treatments is in Table 15. shown that the b* value was increased ranging from 6.31-6.99 with an increase in concentration of apple peel powder. This may occur as the peel contains darker color. Among all treatments T_0 showed lowest (6.63±0.73) while T_4 highest (7.19±0.79) b* value on 1st day. Higher b* value in T_4 might be attributed to the darker to yellowish color present in apple peel powder. The results were similar to the study of Nakov et al.(2020) revealed that by adding apple peel powder the b* value increased 5.49-6.21 and showed the change from blue to yellowish color.

The bars were stored in a refrigerator (4°C) for storage study and the b* value was measured at different regular intervals from 1st to 21st day. The mean value of the b* value of bars in table 15. with storage days decreased ranging from 6.89 to 6.00. The b* value decreased during storage due to degradation of color changed in bars from greenish to a darker yellowish shade. Therefore, there was a highly significant relationship between storage and the b* value. While the interaction of days and treatment was non-significant. These findings were also correlated with Mridula et al. (2013) which developed omega-3 rich energy bar by supplementation of flaxseed. During storage stability from 0 to 90 days at the refrigerator, the b* value of the bar decreased from 6.85-5.23 which represented the darker color of the bars.

These results were also similar to the Lucas et al.(2020) revealed that the use of (2 to 6) % of spirulina added to developed snack bars. There were significant relations present between treatment and b* value. When the bar was stored at 30 days, the b* value showed in decreasing trend. The b* value of treatment decreased throughout the storage period.

Table 13: Impact of treatment and storage days L* of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	34.64±0.92	35.20±0.54	36.00±0.14	36.99±0.66	**35.71^{e}**
T1	37.09±0.57	37.21±0.60	38.26±0.67	39.04±0.59	**37.89^{d}**
T2	37.98±0.60	38.06 ±0.66	39.04 ± 0.58	40.12±0.77	**38.80^{c}**
T3	39.15±0.60	40.41±0.92	41.10±1.17	42.08±0.67	**40.68^{b}**
T4	41.02±0.57	42.19±0.78	43.08±0.28	44.26±0.69	**42.64^{a}**
Mean	**37.97^{c}**	**38.61^{c}**	**39.49^{b}**	**40.49^{a}**	

Table 14: Impact of treatment and storage days a* of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	5.34±0.46	4.71±0.27	3.48±0.20	3.16±0.19	**4.18^{d}**
T1	5.98±0.34	5.00±0.24	4.20±0.46	3.23±0.28	**4.60^{c}**
T2	6.57±0.56	5.40±0.31	4.98±0.16	3.14±0.17	**5.44^{b}**
T3	7.06±0.39	6.08 ±0.48	5.21 ± 0.30	4.84±0.16	**5.79^{b}**
T4	8.17±0.17	6.99±0.39	6.20±0.27	5.23±0.30	**6.65^{a}**
Mean	**6.62^{a}**	**5.63^{b}**	**4.81^{c}**	**4.25^{d}**	

Table 15: Impact of treatment and storage days b* of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	6.63±0.73	6.33±0.70	5.89±0.65	5.43±0.60	**6.31^{ab}**
T1	6.74±0.72	6.53±0.19	6.21±0.28	5.77±0.50	**6.45^{ab}**
T2	6.91±0.76	6.71±0.73	6.23±0.69	5.94±0.65	**6.44^{ab}**
T3	7.01±0.77	6.83 ±0.75	6.43 ± 0.71	6.14±0.88	**6.07^{b}**
T4	7.19±0.79	7.15±0.40	6.90±0.62	6.73±0.74	**6.99^{a}**
Mean	**6.89^{a}**	**6.71^{a}**	**6.33^{ab}**	**6.00^{b}**	

Texture analysis

Hardness

The strength of a material to endure the deformation

is called the hardness. It is tested by a standard test method that measures the resistance of the surface to puncture. The hardness value of developed high-fiber multigrain bars was determined. The results indicated that the difference in the hardness of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant (P>0.05).

Table 6. presented the mean for the hardness value of multigrain bars with the interval of one week on day 1st,7th ,14th and 21st.The mean comparison of treatments is in Table 16. shown that the hardness value decreased ranging from 7.19-7.51 kg with an increase in the concentration of apple peel powder. Among all treatments, T_0 showed lowest (7.53±0.68) kg while T_4 highest (7.87±0.38) kg hardness value on 1st day. The higher hardness value in T_4 might be attributed to the increased fortification of apple peel powder. The results were similar to the study of Munir et al.(2016) in which the fruit bar showed increase in hardness level with the addition of fruit seeds. The control group showed the minimum value of bar 10.59 kg while the maximum value of 15.48 kg was observed T_5 of the bar.

The bars were stored in a refrigerator (4°C) for storage study and the hardness value was measured at different regular intervals from 1st to 21st day. The mean value of the hardness value of the bars in table 4.29. illustrated storage days decreased ranging from 7.72 to 6.48 kg. The hardness value decreased during storage due to air humidity, the moisture content increased and also increased water activity of bars. Therefore, there was a highly significant relationship between storage and the hardness value. While the interaction of days and treatment was non-significant. These findings were closely related to Jabeen et al. (2021) developed that an energy bar by using date, apricot, cheese and whey protein. There were significant relations present between treatment and hardness value. The hardness decreased with the increase in the concentration of ingredients. When the bar was stored for 45 days, the hardness level showed in decreasing trend. The treatments decreased from 0.5 to 0.2(kg) at 45 days of storage periods.

Stickness

Stickiness is defined as the ability to stick like glue and the property to adhering any substance that can hold things together in a usual way by surface adhesion that prevents separation. The stickiness value of developed high fiber multigrain bars was determined. The results indicated that the difference in stickness of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is in Table 17. shown that the stickness value was increasing ranging from 3.79-4.97 kg with an increase in the concentration of apple peel powder. Among all treatments T_0 showed lowest (3.75±0.09) kg while T_4 highest (4.90±0.10) kg stickiness value at 1st day. The higher stickness value in T_4 might be attributed due to the increased sugar and carbohydrate content of apple peel powder. The results were similar to the study of Munir et al. (2016) in which the fruit bar showed a increased in stickness level with the addition of fruit seeds. The control group showed minimum value of bar while the maximum value was observed T_5 of the bar.

The bars were stored in a refrigerator (4°C) for storage study and the stickiness value was measured at different regular intervals from 1st to 21st day. The mean value of the stickiness value of bars in table 4.17. revealed that the storage days decreased ranging from 4.93 to 4.29 kg. The stickness value decreased during storage due to a decrease in hardness and cohesiveness of the bars. Therefore, there was a highly significant relationship between storage and the stickness value. While the interaction of days and treatment was non-significant. These results were also related to Aggarwal et al. (2022) that developed a ready-to-eat fruit bar by using kinnow juice derived from low-quality kinnow. Kinnow bars were shelf-stable for up to 4 months at ambient temperature and 6 months under refrigeration, respectively, with a significant (p<0.05) difference in physicochemical stability. The stickiness level decreased with the storage at the refrigerator (4^0C). T_5 was lower stickiness (kg) ranging from 8.32-5.79 during storage trials.

Firmness

Cohesiveness or firmness is the ratio of the compression of the product. The firmness value of developed high fiber multigrain bars was determined. The results indicated that the difference in firmness of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is in Table 3.18. shown that the firmness value was increasing ranging from 0.78-1.48 kg with an increase in the concentration of apple peel powder. Among all treatments, T_0 showed lowest (0.82±0.19) kg while T_4 highest (1.52±0.27) kg firmness value on 1st day. The higher firmness value in T_4 might be attributed to an increase in apple peel powder. The results were similar with the study of Munir et al.(2016) in which the fruit bar showed a change in firmness level with the addition of fruit seeds. The control group showed minimum value of bar while the maximum value was observed T_4 of the bar.

The bars were stored in a refrigerator (4°C) for

storage study and the firmness value was measured at different regular intervals from 1st to 21st day. The mean value of the firmness value of bars in Table 4.18. With storage days decreased ranging from 1.26-1.16 kg. The firmness decreased during storage due to a decrease in the hardness and stickiness of the bars. Therefore, there was a highly significant relationship between storage and firmness value. While the interaction of days and treatment was non-significant. These findings were closely related to Jabeen et al. (2021) developed an energy bar by using date, apricot, cheese and whey protein. There was a significant relation present between treatment and firmness value. The firmness value decreased with the increase in the concentration of ingredients. When the bar was stored for 45 days, the firmness level showed a decreasing trend. The treatment decreased from 1.42- 0.12(kg) at 45 days of storage periods.

Table 16: Impact of treatment and storage days hardness of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	7.53±0.68	7.46±0.13	7.38±0.12	6.38±0.11	7.19^{c}
T1	7.66±0.17	7.59±0.19	6.23±0.14	6.47±0.13	7.34^{b}
T2	7.73±0.19	7.56±0.17	7.48±0.16	6.39±0.27	7.29^{bc}
T3	7.78±0.22	7.71±0.19	7.62±0.18	6.52±0.17	7.41^{ab}
T4	7.87±0.38	7.81±0.21	7.42 ± 0.19	6.62±0.18	7.51^{a}
Mean	7.72^{a}	7.64^{ab}	7.55^{b}	6.48^{c}	

Table 17: Impact of treatment and storage days stickiness of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	3.75±0.09	3.78±0.13	3.80±0.17	3.84±0.19	3.79^{d}
T1	3.81±0.05	3.83±0.21	3.86±0.06	3.89±0.33	3.85^{d}
T2	4.40±0.23	4.42±0.08	4.46±0.35	4.49±0.39	4.45^{c}
T3	4.60±0.31	4.62±0.37	4.65±0.43	4.69±0.74	4.64^{b}
T4	4.90±0.10	4.92±0.35	4.95 ± 0.17	5.08±0.28	4.97^{a}
Mean	4.93^{a}	4.35^{ab}	4.32^{b}	4.29^{b}	

Table 18: Impact of treatment and storage days firmness of bars

Treatment	Day 1	Day 7	Day 14	Day 21	Mean
T0	0.82±0.19	0.81±0.15	0.78±0.13	0.73±0.07	0.78^{e}
T1	1.20±0.15	1.18±0.21	1.15±0.17	1.10±0.25	1.15^{d}
T2	1.35±0.33	1.32±0.19	1.29±0.23	1.24±0.27	1.29^{c}
T3	1.44±0.35	1.41±0.25	1.38±0.29	1.34±0.21	1.39^{b}
T4	1.52±0.27	1.49±0.33	1.47±0.47	1.42±0.23	1.48^{a}
Mean	1.26^{a}	1.24^{b}	1.21^{c}	1.16^{d}	

Sensory Analysis

The sensory analysis of high fiber multigrain bars was conducted to determine the consumer's perception about the product's acceptance or rejection. Sensory panelists rated the bars on a 9-point hedonic scale for sensory characteristics. The bars were evaluated for the five parameters including color, aroma, texture, taste and overall acceptability. These parameters were also evaluated during the storage at one-week intervals including 1st, 7th, 14th and 21st days. The following parameters were evaluated.

Aroma

Aroma is the term used to describe the distinctive smell or scent that a product emits. It is the aromatic impression that a product emits and that the sense of smell can pick up on. The aroma value of developed high fiber multigrain bars was determined. The results indicated that the difference in the aroma of bars among treatments was highly significant (P<0.01). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant (P>0.05).

The mean comparison of treatments is presented in Figure 2. shown that the aroma value was decreased with an irregular trend ranging from 5.17-6.81 with an increase in the concentration of apple peel powder. Among all treatments, T_2 showed the lowest 6.2 while T_4 highest 8.1 aroma value at 1st day. The higher aroma value in T_4 might be attributed to the increased content of apple peel powder. The bars were stored in a refrigerator (4°C) for storage study and the aroma value was measured at different regular intervals from the 1st to 21st day. The mean value of the aroma value of bars in Figure 1. With storage days decreased ranging from 6.81-5.20. Therefore, there was a highly significant

relationship between storage and aroma value. While the interaction of days and treatment was non-significant. Similar results were reported by Bansal *et al*. (2022) that demonstrated nutrition bars and determined its organoleptic characteristics. A storage study of 90 days was carried out and results showed that sensory attributes decreased range from (7.65-4.76) as the days proceed. Patil *et al.* (2022) developed millet bars and carried out its sensory evaluation and similar scores of sensory analyses were obtained the values from (9.43-6.23).

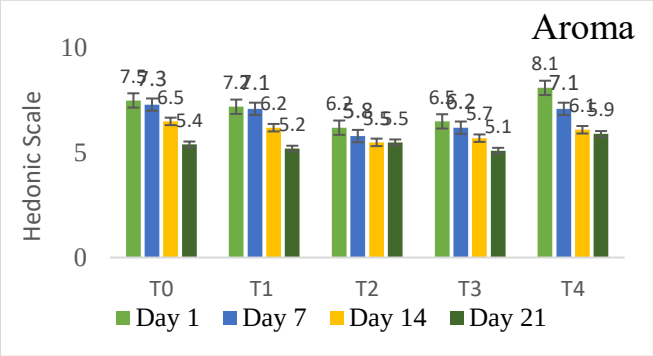

Figure 2: Impact of treatment and storage days on aroma of bars

Texture

Texture describes the physical characteristics of food product that can be felt or seen. The texture of the bars was determined and was also assessed during the storage. The analysis of variance for the texture value is in Table demonstrate different treatments of high fiber multigrain bars prepared by different concentrations of apple peel powder and multigrain flour. The texture value of developed high fiber multigrain bars was determined. The results indicated that the difference in texture of bars among treatments was highly significant ($P<0.01$). The effect of storage days on the developed products was also highly significant while the interaction between treatments and storage days was non-significant ($P>0.05$).

The mean comparison of treatments is in Figure 3 shown that the texture value was increased ranging from (6.32-7.05) with treatment due to rise the concentration of apple peel powder. Among all treatments T_1 showed lowest 6.4 while T_4 highest 7.6 texture value on 1st day. Therefore, there was a highly significant relationship between storage and aroma value. The higher texture value in T_4 might be attributed due to the increased content of apple peel powder. The inclusion of brown sugar and a larger amount of pectin present in the peel increases the texture of the bar. The bars were stored in a refrigerator (4°C) for storage study and the texture value was measured at different regular intervals from the 1st to 21st day. The mean value of the texture value of the bars is in Figure 3.2. with storage days decreased ranging from (7.15-6.29). Therefore, there was a highly significant relationship between storage and texture value. While the interaction of days and treatment was non-significant since their values remained constant. Similar results were reported by Bisen Jawaharlal Nehru Krishi Vishwavidyalaya *et al*. (2020) that developed 12 different types of bars by using papaya peel and guava pulp. Storage study of 0-100 days was carried out and results showed that sensory attributes of texture ranging from 8.75-7.70 decreased as the days proceed.

Saleh Kourany *et al.* (2017) developed fruit bars by using guava and mango pulp. The mean value of texture increased from 7.01–8.10 due to the increased concentration of fruit pulp. The finding concluded that the panelists have given the best score to overall T_4.

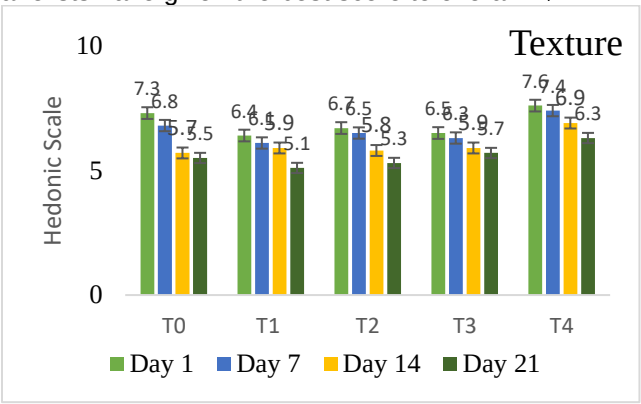

Figure 3: Impact of treatment and storage days on texture of bars

Color

Color is the most crucial sensory attribute in developing effective and appealing products for consumer. The color of the bars was determined and was also assessed during the storage.

The mean comparison of treatments is in figure 4 shown that the texture value was increased ranging from (6.68-7.82) with treatment due to rise the concentration of apple peel powder. In figure 3.3. the color value was increased range T_0 from 6.3 to 7.1 with treatment due to rise the concentration of apple peel powder at day first. The higher texture value in T_4 might be attributed due to the increased content of apple peel powder. The bars were stored in a refrigerator (4°C) for storage study and the texture value was measured at different regular intervals from the 1st to 21st day.

The decreasing trend of acceptability of color with storage days is also reported by Mir and Nath (2019) developed a helical form of plain mango bar with a combination of mango coconut bar and mango soya protein bars. These three types of bars were developed with different concentrations of mango peel or pulp rang from (8.55-5.43). These were stored for 90 days. During storage, their color and texture were greatly affected and there was significant relation with decreasing trend. Patil

(2022) developed millet bars and carried out its sensory evaluation color rang from (9.34-6.53) with treatment concentration of bars increased due to addition of millet in bars.

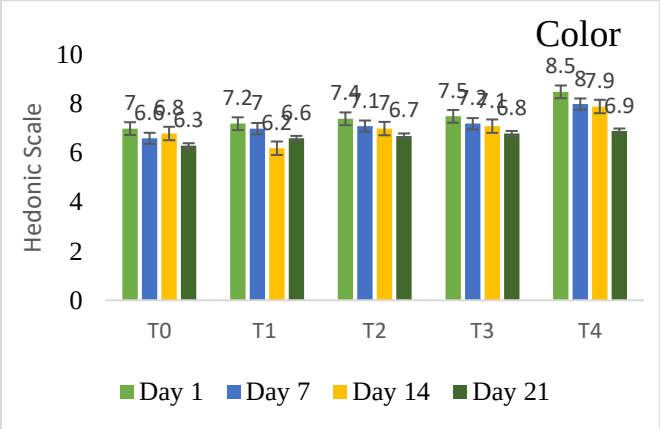

Figure 4: Impact of treatment and storage days on color of bars

Taste

Taste is the ability to perceive flavors and feel the effects of food and drink on the taste buds. It is the sense that enables us to distinguish between and savor many flavors, including sweet, sour, bitter and salty. The taste of the bars was determined and was also assessed during the storage.

The mean comparison of treatments is Figure 5 shown that the taste value was increased ranging from 6.72-7.07 with an increase in the concentration of apple peel powder. Among all treatments, T_2 showed the lowest 6.2 while T_4 highest 7.90 aroma value on the 1st day. The higher aroma value in T_4 might be attributed due to the increased content of apple peel powder. The bars were stored in a refrigerator (4°C) for storage study and the aroma value was measured at different regular intervals from the 1st to 21st day. The mean value of the aroma value of bars in table 3.3. with storage days decreased ranging from 7.70-6.09. In Figure 3.4. the impact of treatment and storage days on taste of bars was in decline trend. The taste scores of the bar were high on 1st day and this trend declined as the days proceed. As the days preceded the taste acceptability decreased with storage. These results were similar with the findings of Bansal *et al*. (2022) developed nutrition bars by adding fruit peel. This research concluded that the increased in taste ranging from (6.54-8.56) by adding fruit peel while the storage study of 90 days was carried out and results showed that sensory attributes decreased as the days proceed. Similar results were reported by Bisen Jawaharlal Nehru Krishi Vishwavidyalaya *et al*. (2020) that developed 12 different types of bars by using papaya peel and guava pulp. Storage study of 0-100 days was carried out and results showed that sensory attributes of taste ranging from 8.75-7.70 decreased as the days proceed.

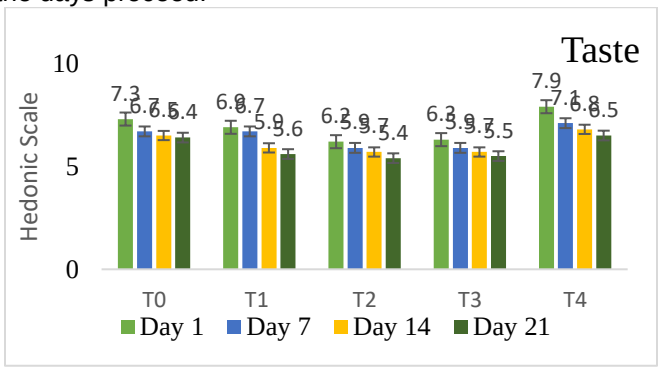

Figure 5: Impact of treatment and storage days on taste of bars

Overall acceptability

The extent to which a product, service, or experience meets to the expectations and satisfies the needs of its intended audience or customers is known to as overall acceptability. The overall acceptability of the bars was determined and was also assessed during the storage.

The mean comparison of treatments is in Figure 6 shown that the overall acceptability value decreased ranging from 7.02-6.90 with an increase in concentration of apple peel powder. Among all treatments, T_2 showed the lowest 6.9 while T_4 highest 7.9 overall acceptability at 1st day. The higher aroma value in T_4 might be attributed to the increased concentration of apple peel powder. During storage in refrigerator (4°C) for storage study, the overall acceptability value was measured at different regular intervals from the 1st to 21st day. The mean value of the aroma value of bars in table 3.41. with storage days decreased ranging from 7.02-6.55. In Figure 6 the impact of treatment and storage days on the overall acceptability of bars was in decline trend. The overall acceptability of the bars was high on the 1st day and this trend declined as the days proceeded. As the days preceded the overall acceptability of bars decreased. Overall acceptability scores of T_0 decreased from 7.8 to 6.7 similarly, T_4 decreased from 7.9 to 6.5. The decreasing trend of acceptability of overall acceptability with storage days is also reported by Mir and Nath (2019) developed a helical form of plain mango bar, a combination of mango coconut bar and mango soy protein bars. These three types of bars were developed with different concentrations of mango peel or pulp. These were stored for 90 days in the refrigerator. During storage, the overall acceptability and texture were greatly affected and there was a significant relation with a decreasing trend during storage while there was an increasing trend observed with treatments ranging from 7.80-8.60. These results were similar with the findings of Bansal et al. (2022) developed nutrition bars by using fruit peel and determined their organoleptic

characteristics. A storage study of 90 days was carried out and results showed that sensory attributes decreased as the days proceeded.

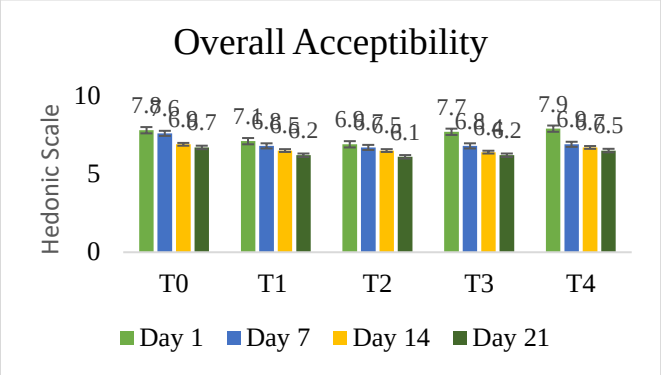

Figure 6: Impact of treatment and storage days on overall acceptability of bars

CONCLUSIONS

High fiber multigrain apple peel waste utilization is a good and alternative way to enhance the nutritional properties of bakery products and to provide a healthy alternative that can be used as snack food. Multigrain products with the addition of apple peel powder are becoming more prominent as essential aspects of dietary patterns and a great way to get more nutritious whole-grain food. Locally available grains like wheat, oats, barley and corn with the supplementation of apple peel waste provide health benefits with increased health profile. It was concluded that T_4 was the best treatment development with multigrain and 40% apple peel powder with nutritionally superior and can provide acceptable sensory parameters.

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Supplementary materials

This article's supplementary material/support can be found online and downloaded from Google Scholar, Science Direct, and Publon.

Author contributions

Kainat designed the Research Layout and conducted the research and Miss Uswah Ramzan helped with statistics and the remaining authors contributed to proofreading and the final review

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Institutional Review Board Statement

The University of Agriculture, Institute of Human Nutrition and Dietetics, Faisalabad Bioethical Committee approved the study.

Informed Consent Statement

Not applicable.

Data Availability Statement

All of the data is included in the article/Supplementary Material.

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Conflict of interest

The authors declare no conflict of interest.

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