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Research Article

Physical and Rheological Studies of Biscuits Developed with Different Replacement Levels of Pumpkin (*Cucurbita maxima*) Peel, Flesh, and Seed Powders

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Several studies have been found in the literature about the phytochemistry, nutritional profiles, and pharmacological potential of pumpkin and pumpkin-based food products but a very few data have been found about the impact of the addition of pumpkin powders on physical and rheological behaviors of bakery products. The present research work was conducted to investigate that powder of which part of pumpkin and in what percentage could prove the most acceptable to develop good quality biscuits with optimum rheological and physical characteristics, which will be very useful to utilize pumpkin waste streams with effective and efficient mechanism for benefit of mankind in terms of development of new variety of bakery items. Peel, flesh, and seeds of pumpkin were utilized in the form of dried powder at 0, 5, 10, and 15% replacement levels to develop biscuits. Farinographic studies revealed that water absorption and dough development time were significantly increased to $65.69 \pm 0.60\%$ and 5.80 ± 0.012 min, respectively, at 15% pumpkin peel powder replacement, whereas dough stability was significantly decreased for 15% replacement level of pumpkin peel, flesh, and seed powders. Mixing tolerance index was significantly increased by these replacements. Mixographic studies revealed that mixing time of control dough was 3.55 ± 0.029 min, which was significantly decreased to 3.03 ± 0.015, 2.94 ± 0.023, and 3.23 ± 0.017 min for 15% replacement level of pumpkin peel, flesh, and seed powders, respectively. Similarly, peak height values were significantly decreased as replacement levels of pumpkin powders were increased up to 15%. Width and spread factor were significantly decreased, whereas thickness was significantly increased by these replacements. These replacements of pumpkin powders with white flour did not pose negative impact on rheological behavior of composite flours, which ultimately resulted in the development of improved quality biscuits.

1. Introduction

Pumpkin is a gourd-like fruit native of tropical and subtropical regions, well known for its excellent nutritional profile. Pumpkin belongs to the genus *Cucurbita* and family *Cucurbitaceae* with three economically common species, namely, *Cucurbita maxima*, *Cucurbita pepo,* and *Cucurbita moschata*, with major producers in the world including United States, China, Russia, and India. Most common natural phytochemicals present in sufficient quantities in pumpkin are carotenoids, phenolics, vitamins, minerals, polysaccharides, pectins, fibers, tocopherols, phytosterols, essential oils, proteins, peptides, and amino acids [1]. Production of pumpkin has been recorded 22.90 million tons in 2019 with leading producers China, United States, India, and Russia. Natural pigments present in pumpkin are responsible for appearance, colors, and flavors of food products developed with pumpkin incorporation. Nutritional value of developed foods is also improved by the addition of pumpkin. Pumpkin is considered a versatile food due to its nutraceutical and functional food properties [2]. *Cucurbitaceae* family is one of the largest families belonging to the kingdom *plantae* and pumpkin is one of the important vegetables belonging to this family known for its medicinal and functional properties. Pumpkins are grown and consumed worldwide in tropical and subtropical regions [3]. As a valuable nutrient source, pumpkin is used in a variety of foods by humans; it is also a food of animals. The edible portion of pumpkin (pulp) is cooked as a vegetable and also incorporated into different foods such as bakery products, pies, jams, and soups. Pumpkin powders and flakes are used in sauces and soups as coloring agent, thickening agent, and flavoring agent [4].

Conversion of agricultural wastes into valuable food products is an area of interest of industrialists. Pumpkin wastes are composed of peel and seed byproducts, which are loaded with beneficial nutrients. Pumpkin peels are extraordinary sources of polysaccharides, pectin, and carotenoids while pumpkin seeds are equipped with bioactive compounds. Pumpkin wastes are capable of providing health benefits directly or through production of valuable nutritional food products [5]. Byproducts of seeds in pumpkin include peel, flesh, seed cake, and seed coat; these parts instead of wasting can be utilized to develop feed and food products, which could play a health-promoting role due to their nutritional values [6]. Pumpkin (*Cucurbita maxima*) peel, flesh, and seeds were dried to obtain fine quality powders, and further analyses revealed that all three fractions of pumpkin were well equipped containing comparable amounts of phytochemicals responsible for health promoting activities [7]. For the development of nutraceuticals and value-added food products, incorporation of pumpkin has gained great interest due to its antidiabetic and anticarcinogenic activities. Pumpkin fruit could be consumed as a source of different bioactives promoting human health [8]. As pumpkin seeds are excellent source of nutrients, these are known as nutritional powerhouses. Pumpkin seeds have no side effects on human health, so they can be consumed on a regular basis [9]. Pumpkin seed proteins are investigated to contain reasonably well balance of amino acids especially higher levels of lysine [10].

Pumpkins are classified among the highly perishable agricultural commodities [11]. Instead of fresh pumpkin, pumpkin flour due to its sweet taste, pleasant flavor, orange to yellow color, and increased shelf life is a good option to be used in bakery products. As pumpkins are good source of pectin, carotene, fiber, minerals, and vitamins, pumpkin flour can be used in a range of food products [12]. Different studies incorporated pumpkin powder in different bakery products to check the change in chemical composition of bakery products. El-Demery [13] replaced wheat flour with pumpkin flour to prepare bread. Pongjanta et al. [14] replaced pumpkin powder to prepare cakes and cookies. Kulkarni and Joshi [15] prepared biscuits in which pumpkin powder replaced white flour. Giami et al. [16] supplemented wheat flour with fluted pumpkin seed flour to develop cookies.

A composite flour technology is one of the potential food application methods in which different bakery products, such as cookies and bread, can be prepared [17]. Bakery products prepared from cereal flour are widely used and liked in the world and these products are a good carrier to incorporate nutritional ingredients from other flours of oilseed crops and legumes. Use of fluted pumpkin flour in bread preparation has gained considerable importance in the past [18]. Instead of bread, cookies are considered as better vehicle to supplement with other flours due to their ready to eat nature, prolonged shelf life, and consumption by all groups of people [19]. Rheological behavior of dough is important during dough mixing and development in machine, which ultimately affects the quality of bakery products. During preparation of biscuits, dough is an intermediate, short time product between ingredients and final product. For development of a suitable bakery product with appropriate physical and sensory characters, proper dough development is crucial. Any inconsistency in dough will lead to failure in developing products with good quality parameters [20]. Manley [21] reported that final quality of biscuits is dependent on dough consistency.

Pumpkin peel, pulp, and seeds may contribute in economics of the pumpkin crop by its increased use and provided health benefits. One of the possible uses of pumpkin is in snacks and breakfast cereal products, which are gaining importance in this modern and busy lifestyle in emerging countries, due to their ready to eat nature, ease in preparation, and conveniences [22]. Conversion of pumpkin waste streams into useful powders and utilization of these pumpkin parts powders to develop acceptable bakery products with minimum quality deterioration is very necessary. Pumpkin parts powders may be used to relieve economic burden due to the consumption of wheat flour by substituting wheat flour at different replacement levels. Process efficiency and product quality of bakery items can be altered to the required standards by the addition of pumpkin parts powders in composite flours.

Need is to utilize peel and seeds of pumpkin, which are discarded as waste material during common cooking and processing of pumpkin. Pumpkin peel, flesh, and seeds can be separated and dried to prepare flours. This research work was carried out to utilize all three parts (peel, flesh, and seeds) of pumpkin in the form of powder at different replacement levels to check suitability of the replacement level and to examine rheological properties of pumpkin peel, flesh, and seed powder's composite flours with wheat flour. Study of physical characteristics of developed biscuits was also part of this study.

2. Materials and Methods

2.1. Preparation of Pumpkin Peel, Flesh, and Seed Powders. Fresh pumpkins were collected from local market of District Sargodha, Pakistan, washed with running water, cleaned, separated into peel, flesh, and seeds with the help of a knife and then dried at 60°C in hot air oven (BIOBASE HAS-T105 China), until constant moisture content was achieved. After complete drying, pumpkin peel, flesh, and seeds were grounded with the help of grinder (NIMA NM-8300 Japan), to obtain fine powders. These powders were separately packed in air tight polythene pouch bags and kept at room temperature. Graphical overview of pumpkin peel, flesh, and seed powder preparation is presented in Figure 1.

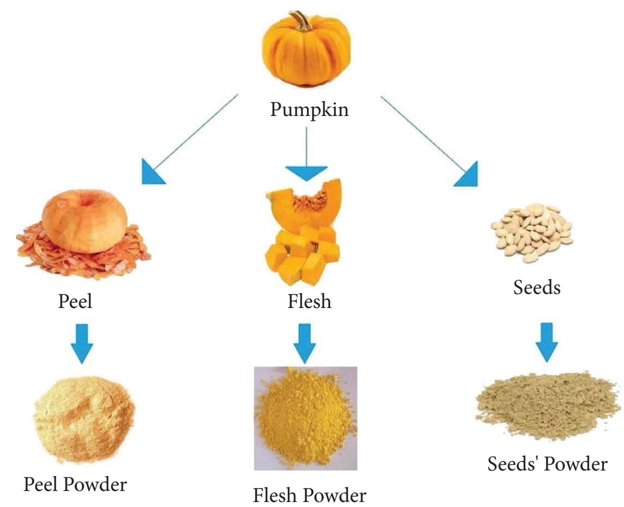

Figure 1: Graphical overview of pumpkin peel, flesh, and seed powders preparation.

2.2. Preparation of Composite Flours. Wheat flour (straight grade flour) and ingredients used in biscuit development were obtained from the local market of District Sargodha, Pakistan. Pumpkin peel, flesh, and seed powders were replaced with wheat flour each at 5, 10, and 15% level to obtain 9 different types of composite flours. Control in this study was taken as 100% wheat flour, which was used to prepare control treatment, i.e., biscuits with 100% wheat flour.

2.3. Rheological Properties of Composite Flours

2.3.1. Farinographic Studies. The composite flours mixing characteristics were studied by following the method number 54–21 of AACC [23]. Water absorption percentage (WA), dough development time (DDT), dough stability (DS), and mixing tolerance index (MTI) of the composite flours containing different proportions of pumpkin peel, flesh, and seed powders with white flour were examined by using farinograph Brabender (Model No. 8124 Brabender OHG Germany).

2.3.2. Mixographic Studies. The rheological behavior of composite flours containing different proportion of pumpkin peel, flesh, and seeds powders with white flour was examined by using mixograph according to the details given in method number 54–40 of AACC [23].

2.4. Preparation of Biscuits. Biscuits were prepared according to the method described by Kulkarni and Joshi [15], with some modifications. After mixing of ingredients, baking was done at 160°C for 15 minutes and then cooled at room temperature, and biscuits were packed in air tight polythene pouch bags. These were kept at room temperature (25°C) for further analysis. Detailed flow diagram of preparation of biscuits is given in Figure 2.

2.5. Physical Characters of Biscuits. Physical parameters such as width, thickness, and spread factor of prepared biscuits were studied during normal shelf-life time (6 months) of airtight packed biscuits. There was no effect of storage duration on physical characteristics of the biscuits was observed.

2.5.1. Width. Standard method given in AACC [23] was adapted to measure the width of control biscuits and biscuits prepared with different composite flours containing different proportions of pumpkin peel, flesh, and seed powders. Six biscuits were placed horizontally edge to edge and width was measured with the help of scale. The width was again measured after rotating each biscuit at an angle of 90° and average value of width was calculated.

2.5.2. Thickness. Thickness of sample biscuits was calculated through the method illustrated in AACC [23]. Six biscuits of each treatment were placed above one another and reading was noted in mm. Then, six biscuits were restacked in random orders and thickness was noted again and average value was calculated. Figure 3 shows the measurement of width and thickness of biscuits.

2.5.3. Spread Factor. Spread factor was measured as a ratio between the average value of width and average value of thickness of the biscuits as described in the method given in AACC [23].

2.5.4. Statistical Analysis of Data. All analyses were performed in triplicate to get triplicate determinations and results were expressed as the means ± standard deviations.

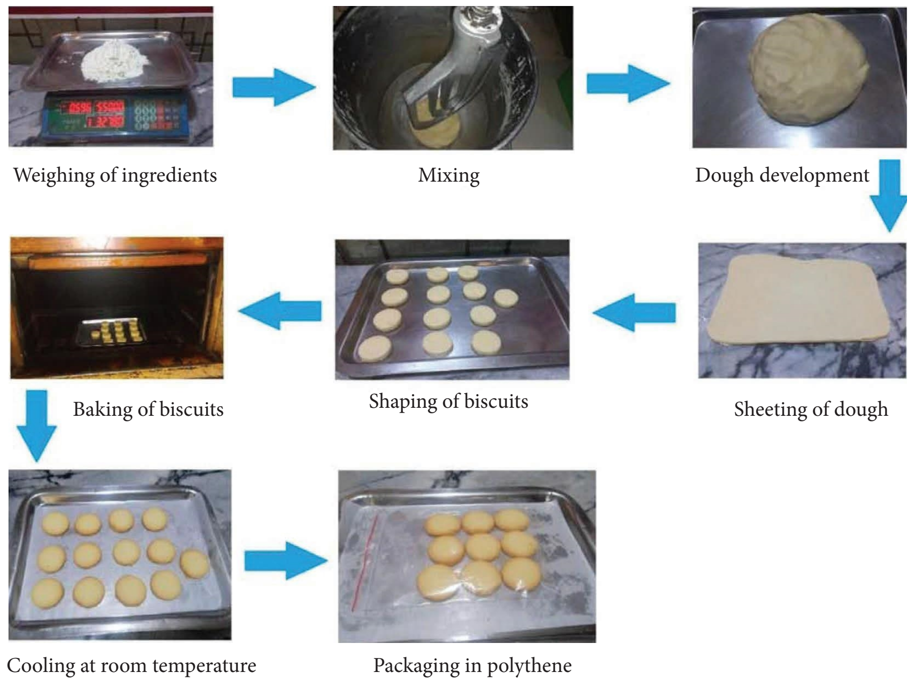

Figure 2: Flow diagram of preparation of biscuits.

Figure 3: Measurement of width and thickness of developed biscuits.

The statistical analysis was done using one-way and two-way ANOVA, and Duncan's multiple-range test was used to differentiate between the mean values by following the procedures provided by Steel et al. [24].

3. Results and Discussion

3.1. Farinographic Studies

3.1.1. Water Absorption Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. From the results given in Table 1, it can be seen that control dough having 100% lesser wheat flour (WA) was recorded ($60.06 \pm 0.05\%$) and highest WA ($65.69 \pm 0.60\%$) was recorded in biscuits having 15% pumpkin peel powder. Replacement of pumpkin peel powder up to 15% increased the WA of dough significantly up to $65.69 \pm 0.60\%$; similarly, replacement of pumpkin seed powder, up to 15%, also increased the WA of dough significantly up to $63.78 \pm 0.46\%$, while less significant increase in WA ($61.94 \pm 0.59\%$) was observed when pumpkin flesh powder was replaced up to 15%. Lesser WA by replacement of pumpkin flesh powder than peel and seed powder replacement might be due to lesser fiber and protein contents in pumpkin flesh powder.

The quantity of water added is considered to be very important for distribution of dough materials, their hydration, and the gluten protein network. Water absorption is defined as quantity of water needed by specific weight of flour for development of dough of specific consistency [25]. It has been reported that increase in protein percentage and improvement in gluten quality in flour result in increased WA [26]. Some other factors like damaging of starch during milling are also responsible for changes in water absorption. Kent [27] has reported that stronger flours from hard wheat are able to absorb and retain higher amounts of water as compared to weaker flours from soft wheat.

Similar results to our study were obtained when Imran et al. [28] conducted study on rheological properties of pumpkin wheat composite flour and observed an increase in WA with increase in the replacement level of pumpkin flour. In 100% wheat flour, WA was found 55.33%, 5% replacement of pumpkin powder with wheat flour gave

Table 1: Water absorption (%) of biscuits with different replacement levels of pumpkin peel, flesh, and seeds powders.

Replacement level of pumpkin powders	*Means (±SE) of water absorption (%)*				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
100%	60.06 ± 0.05f	—	—	—	—
5%	—	61.31 ± 0.09def	60.42 ± 0.26f	60.98 ± 0.54ef	60.90 ± 0.22C
10%	—	63.51 ± 0.25bc	61.25 ± 0.55def	62.35 ± 0.55cd	62.37 ± 0.40B
15%	—	65.69 ± 0.60a	61.94 ± 0.59de	63.78 ± 0.46b	63.81 ± 0.61A
Overall means	—	63.50 ± 0.66A	61.20 ± 0.33C	62.37 ± 0.48B	

Mean values in a row or column having the same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

increased value of WA (56.33%), further 10% replacement level gave value of WA 57.17% and 15% replacement level of pumpkin powder with wheat flour gave maximum WA (57.50%). Similar results were also obtained by Malomo et al. [29]. Turksoy and Ozkaya [30] used pumpkin pomace powder in two different wheat varieties flour to develop cookies and a progressive increase in WA was observed. Minarovičová et al. [31] studied effect of pumpkin (*Cucurbita moschata*) powder incorporation at different levels on rheological properties of dough prepared for pasta. A significant increase in WA of dough was observed at 5% replacement level of pumpkin flour as WA of control dough having 100% wheat flour was 45.2% and it increased to 56.2% at 5% replacement level of pumpkin flour. WA at 7.5% and 10% replacement level of pumpkin flour was 56.2% and 56.3%, respectively. Apostol et al. [32] incorporated defatted pumpkin seeds powder at different levels in wheat flour and observed a nonsignificant decrease in WA of the dough. Control dough with 100% wheat flour gave value of WA 60% whereas 5, 10, and 15% replacement level dough values of WA were 59.5, 59.1, and 58.5%, respectively. Similar effects of flours from different cereals have been reported on rheological characteristics of wheat flour dough and a significant increase is found in water absorption with increase in non-wheat flours having more fibers [33].

Costa et al. [34] gave higher value of WA of control dough (57.67%) as compared to 30% shelled pumpkin seeds flour dough (53.47%) and 30% unshelled pumpkin seeds flour dough (54.00%). Supportive results have also been found in the research conducted by Aljahani [35], where increase in water absorption of composite flour was noticed as compared to wheat dough. Increased water absorption by addition of pumpkin powders might be due to more absorption of water by composite starches, developed by composite flours, and increased amount of fiber contents in composite flours. Peel and seeds powders of pumpkin due to the presence of more fiber and protein contents, respectively, might have raised the water absorption levels of composite flours as compared to the flour containing flesh powder.

3.1.2. Dough Development Time Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. DDT of control dough having 100% wheat flour was recorded 4.19 ± 0.030 min, which was found increasing significantly by replacement of pumpkin peel, flesh, and seed powders. Highest DDT (5.80 ± 0.012 min) was recorded in dough having 15% pumpkin peel powder. Replacement of pumpkin peel powder up to 15% increased the DDT significantly up to 5.80 ± 0.012 min; similarly, replacement of pumpkin seed powder, up to 15%, also increased the DDT significantly up to 5.17 ± 0.017 min. While less significant increase in DDT (4.77 ± 0.024 min) was observed when pumpkin flesh powder was replaced up to 15% (Table 2). Increased DDT by replacement of pumpkin peel and seeds powder might be due to more protein and fiber contents in these parts as compared to pumpkin flesh.

Dough development time is defined as the time taken by dough, which started from the addition of water till the development of maximum consistency of the dough [25]. Turksoy and Ozkaya [30] used pumpkin pomace powder in two different wheat varieties of flour to develop cookies and farinographic studies cleared that a significant increase in the DDT was observed by 25% replacement of pumpkin pomace powder. DDT increased from 3.0 min to 11.4 min for Greek-79 flour and from 2.0 min to 27.5 min for Guadalupe flour. Minarovičová et al. [31] studied the effect of pumpkin (*Cucurbita moschata*) powder incorporation at different levels on rheological properties of dough prepared for pasta. A significant increase in DDT was observed at 7.5% replacement level of pumpkin flour as DDT of control having 100% wheat flour was 2.6 min and it increased to 3.1 min at 7.55% replacement level of pumpkin flour. DDT at 5% and 10% replacement level of pumpkin flour was 2.5 min and 3.8 min, respectively. Kundu et al. [33] reported significant increase in DDT of composite flours incorporated with fiber rich pumpkin powder, during development of breads. Furthermore, they linked this increase in DDT of pumpkin powder incorporated flours with increase in total fiber contents of dough due to which disturbance in gluten network resisted timely development of dough. Davoudi et al. [36] observed significant increase in DDT of composite flours from 3.9 min (control) to 4.9 min (15% pumpkin powder).

Imran et al. [28] conducted study on rheological properties of pumpkin wheat composite flour and found nonsignificant data for DDT with different replacement levels of pumpkin flour in wheat flour. Costa et al. [34] gave higher value of DDT of control dough with 100% wheat flour (14.17 min) as compared to 30% shelled pumpkin seed flour dough (6.0 min) and 30% unshelled pumpkin seed flour dough (5.67 min). Reason behind the increase in DDT by the addition of pumpkin part powders might be the competition between the wheat and pumpkin proteins for water, which might delay the hydration process and thus DDT. Significant

Table 2: Dough development time (min) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	*Means (±SE) of dough development time (min)*				Overall means
	White flour	Peel powder	Flesh powder	Seed powder	
0% (control)	4.19 ± 0.030h	—	—	—	—
5%	—	4.68 ± 0.015e	4.30 ± 0.009g	4.52 ± 0.015f	4.50 ± 0.055C
10%	—	5.15 ± 0.003b	4.52 ± 0.015f	4.82 ± 0.015c	4.83 ± 0.091B
15%	—	5.80 ± 0.012a	4.77 ± 0.024d	5.17 ± 0.017b	5.24 ± 0.151A
Overall means	—	5.21 ± 0.163A	4.53 ± 0.067C	4.84 ± 0.093B	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

increase in DDT with replacement of pumpkin peel powder might be due to the presence of more dietary fiber in peel as compared to seeds and flesh.

3.1.3. Dough Stability Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. Mean values for DS analysis of 100% white flour biscuits and biscuits prepared with different replacement levels of pumpkin peel, flesh, and seed powders are given in Table 3. From these results, it was evident that highest DS (6.13 ± 0.044 min) was observed in control treatment having 100% white flour and this DS level was found decreasing significantly with increasing level of all three types of pumpkin powders. More significant decrease in DS (3.53 ± 0.024 min) was noticed by 15% replacement of pumpkin peel powder as compared to 15% replacement of flesh powder (4.98 ± 0.020 min) and 15% seed powder (4.31 ± 0.019 min).

Dough stability is defined as the difference in time between the time when the curve first intercepts the 500 Brabender unit line and the time when the curve leaves the 500 line [25]. DS dictates the strength of the dough by retaining maximum consistency over a long time under shear [35]. Minarovičová et al. [31] studied the effect of pumpkin (*Cucurbita moschata*) powder incorporation at different levels on rheological properties of dough prepared for pasta. A significant decrease in DS was observed with the incorporation of pumpkin powder; at 5% replacement level of pumpkin flour, DS of control having 100% wheat flour was 9.6 min, and it was decreased to 9.3 min at 5% replacement level of pumpkin flour. DS at 7.5% and 10% replacement level of pumpkin flour further decreased as values were 9.2 and 5.6 min, respectively. Costa et al. [34] observed higher value of DS of control dough (19.67 min) as compared to 30% shelled pumpkin seeds flour dough (4.67 min) and 30% unshelled pumpkin seeds flour dough (7.33 min). Ajila et al. [37] incorporated mango peel powder in wheat flour to prepare soft dough biscuits and conducted rheological studies using farinograph. DS of 100% wheat flour biscuits was 6.7 min, which was significantly decreased to 4.0 min at 10% replacement of mango peel powder from where it was clear that fruits peels cause decrease in DS due to lesser protein especially gluten contents which is in greater quantity in wheat flour. Another study conducted by Aslam et al. [38] proved that fruit peels and seeds powders improve product quality and process consistency by positively affecting the rheological properties of composite flours. They recorded DS 7.7 min in control biscuits with 100% wheat flour and it was decreased to 6.0 min with incorporation of 5% mango peel powder and 4.6 min with 15% incorporation of mango peel powder. Similarly, 5% incorporation of mango kernel powder decreased DS to 5.8 min and 15% incorporation of mango kernel powder decreased DS to 4.4 min. Bae et al. [39] witnessed significant decrease in wheat flour DS due to replacement of sweet pumpkin powder at 10 percent. This change could have been due to differences in physiochemical properties between the constituents of pumpkin powder and wheat flour.

Turksoy and Ozkaya [30] used pumpkin pomace powder in two different wheat varieties of flour to develop cookies and farinographic studies showed a steady increase in DS which indicates resistance of dough with replacement of pumpkin pomace powder from 10% to 25%. Apostol et al. [32] incorporated defatted pumpkin seeds powder at different levels in wheat flour and observed nonsignificant data for DS. Decrease in dough stability might be due to disturbance in protein matrix especially gluten, of wheat flour, which occurred due to incorporation of pumpkin powders.

3.1.4. Mixing Tolerance Index Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. From results given in Table 4, it was evident that MTI values significantly increased by replacing white flour with pumpkin peel, flesh, and seed powder but as the replacement level of pumpkin peel, flesh, and seed powders was increased from 5% to 10% and 15% MTI values started decreasing significantly. The highest MTI value (68.67 ± 0.15) was observed in biscuits having 5% pumpkin peel powder and lowest MTI value (28.47 ± 0.14) was found in biscuits having 15% pumpkin seeds powder.

MTI is defined as a difference in dough between the height at the peak and height 5 min later [40]. DS is an indirect indicator of the MTI of the composite dough thus higher the DS means higher the MTI of the dough [35]. Minarovičová et al. [31] studied effect of pumpkin (*Cucurbita moschata*) powder incorporation at different levels on rheological properties of dough prepared for pasta. A significant decrease in MTI of dough was observed with increase in the replacement level of pumpkin flour, at 5% replacement level of pumpkin flour MTI was 105 BU, at 10% replacement level of pumpkin flour MTI was decreased significantly to 60 BU and at 15% replacement level of pumpkin flour MTI was further decreased to 30.3 BU. MTI

Table 3: Dough stability (min) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	Means (±SE) of dough stability (min)				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	6.13 ± 0.044a	—	—	—	—
5%	—	5.08 ± 0.015d	5.75 ± 0.029b	5.32 ± 0.017c	5.38 ± 0.099A
10%	—	4.28 ± 0.015g	5.33 ± 0.015c	4.81 ± 0.007f	4.80 ± 0.152B
15%	—	3.53 ± 0.024h	4.98 ± 0.020e	4.31 ± 0.019g	4.28 ± 0.210C
Overall means	—	4.30 ± 0.223C	5.35 ± 0.111A	4.81 ± 0.145B	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

Table 4: Mixing tolerance index (BU) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	Means (±SE) of mixing tolerance index (BU)				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	30.33 ± 0.12 h	—	—	—	—
5%	—	68.67 ± 0.15a	60.45 ± 0.20b	40.77 ± 0.18f	56.63 ± 4.14A
10%	—	60.52 ± 0.24b	50.32 ± 0.22d	36.82 ± 0.11g	49.22 ± 3.43B
15%	—	52.27 ± 0.18c	41.57 ± 0.23e	28.47 ± 0.14i	40.77 ± 3.44C
Overall means	—	60.48 ± 2.37A	50.78 ± 2.73B	35.35 ± 1.81C	

Mean values in a row or column having the same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

of control dough having 100% wheat flour was 61 BU. Bae et al. [39] noticed significant increase in weakness (BU) of composite flours dough as a result of increased levels of sweet pumpkin powder for bread development. In another study, Kundu et al. [33] reported decrease in MTI of flours having pumpkin powders. Also, the consistency of dough was maintained for longer time because of competition of water between starch and fiber of pumpkin that implies that the dough is more stable and has more resistance against mechanical mixing. MTI is the difference in BU from the top of the curve at the peak to the top of the curve measured at 5 min after the peak is reached. Flours which have good tolerance to mixing have low MTI and MTI; the stronger is the flour. Results indicate that with increasing concentration of pumpkin powder in the formulation, there was significant decrease in MTI.

Similar results were obtained when Imran et al. [28] conducted a study on rheological properties of pumpkin wheat composite flour and observed decrease in MTI, with increase in the replacement level of pumpkin flour. Costa et al. [34] gave higher value of MTI of 30% shelled pumpkin seeds flour dough (56.67 BU) as compared to control dough having 100% wheat flour (30 BU) and 30% unshelled pumpkin seeds flour dough (23.33 BU). Higher MTI of 30% shelled pumpkin seeds flour dough might be due to its higher fiber levels and higher lipids level in 30% unshelled pumpkin seeds flour dough led to its low MTI. Ajila et al. [37] incorporated mango peel powder in wheat flour to prepare soft dough biscuits and conducted rheological studies using farinograph. An increase in MTI of dough was observed by addition of mango peel powder. Due to the presence of more fiber levels in pumpkin peel powder, greater MTI was noticed in pumpkin peel powder biscuits and presence of more fat content in pumpkin seeds, lesser values of MTI were noticed in pumpkin seed powder biscuits.

3.2. Mixographic Studies

3.2.1. Mixing Time Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. From the results given in Table 5, it was evident that highest mixing time (3.55 ± 0.029 min) was observed in control treatment having 100% white flour and this mixing time was found decreasing significantly with increasing level of all three types of pumpkin powders. Lowest mixing time 2.94 ± 0.023 min was noticed when 15% pumpkin flesh powder was replaced by wheat flour while 15% pumpkin peel powder and 15% pumpkin seeds powder replacement gave values of mixing time 3.03 ± 0.015 and 3.23 ± 0.017 min, respectively. This decrease in mixing time of composite flours might be due to decreased level of gluten contents as compared to control dough with 100% wheat flour.

In baking industry, mixing time is one of the important factors associated with cost of production of developed bakery goods. Decreased mixing time, with same quality of dough, is highly appreciated by the researchers and composite flours containing pumpkin part powders provided reduction in mixing time for dough development. Longer mixing times are required for dough with increased gluten network, which requires more time to develop, while in composite flours gluten levels are decreased due to which mixing time and dough development time were found decreased.

Similar results for mixing time were obtained by An and Lee [41], when they studied mixographic characteristics of pan bread prepared by the addition of cranberry powder. Similar results were also obtained when Imran et al. [28]

Table 5: Mixing time (min) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	Means (±SE) of mixing time (min)				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	3.55 ± 0.029a	—	—	—	—
5%	—	3.39 ± 0.023c	3.38 ± 0.017c	3.48 ± 0.015b	3.42 ± 0.017A
10%	—	3.20 ± 0.012d	3.20 ± 0.029d	3.38 ± 0.015c	3.26 ± 0.031B
15%	—	3.03 ± 0.015e	2.94 ± 0.023f	3.23 ± 0.017d	3.07 ± 0.045C
Overall means	—	3.21 ± 0.054B	3.17 ± 0.066C	3.36 ± 0.036A	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

conducted study on rheological properties of pumpkin wheat composite flour and observed decrease in mixing time with increase in the replacement level of pumpkin flour. In 100% wheat flour dough mixing time was found 3.67 min, 5% replacement of pumpkin powder with wheat flour gave decreased value of mixing time (3.50 min), further 10% replacement level resulted in decreased mixing time of 2.83 min and 15% replacement level of pumpkin powder with wheat flour gave minimum value of mixing time (2.77 min). Supportive results were found when Song et al. [42] studied quality characteristics of pan bread with the addition of Korean whole wheat flour. Nonsignificant data for mixing time was obtained when Lee et al. [43] studied physicochemical properties of rice flour sponge cake containing different levels of pumpkin flour. Results depicted by Hussain et al., [44] were also suitable to endorse the results of the present study. The decrease in mixing time of composite flours containing pumpkin powders might be due to the decreased level of gluten contents in in composite flours as compared to control.

3.2.2. Peak Height Analysis of Added Pumpkin Peel, Flesh, and Seed Powder Flours. Control dough having 100% wheat flour exhibited the highest value of peak height 57.40 ± 0.21 BU, and as the replacement level of pumpkin peel, flesh, and seed powders was increased, values of peak height started decreasing significantly and maximum decrease was observed in the case of pumpkin peel powder where 15% replacement gave value of peak height 51.18 ± 0.14 BU and minimum decrease was noticed in case of pumpkin flesh powder where value was found 54.53 ± 0.23 BU (Table 6).

Similar results for peak height were obtained by An and Lee [41] when they studied mixographic characteristics of pan bread prepared by addition of cranberry powder. Results were very similar to our study when Imran et al. [28] conducted studies on rheological properties of pumpkin wheat composite flour and observed a significant decrease in peak height of the dough, with increase in the replacement level of pumpkin flour. In 100% wheat flour peak height was found 59.30 BU, 5% replacement of pumpkin powder with wheat flour gave increased value of peak height (58.00 BU), further 10% replacement level gave further decreased value of peak height 57.00 BU, and 15% replacement level of pumpkin powder with wheat flour gave minimum value of peak height (55.50 BU). These results were also similar with the findings of Malomo et al. [29]. Supportive results were also found when Song et al. [42] studied quality characteristics of pan bread with the addition of Korean whole wheat flour. Nonsignificant data for peak height was obtained when Lee et al. [43] studied physicochemical properties of rice flour sponge cake containing different levels of pumpkin flour. Studies conducted by Tufail et al. [45] provided the similar results endorsing the decrease in peak height by addition of cell wall of different cereal brands. The reduction in peak height of composite flours as compared to control dough might be related to the lower total starch contents, lower swelling rates, and higher fiber and protein contents due to substitution of pumpkin powders [46].

3.3. Physical Characters of Biscuits

3.3.1. Width of Added Pumpkin Peel, Flesh, and Seed Powder Biscuits. From results summarized in Table 7, it was clear that highest values for the width of biscuits (42.89 ± 1.45 mm) was obtained with 100% white flour dough and replacement of white flour with pumpkin peel, flesh, and seed powders resulted a decrease in width of biscuits and this decrease was significant by increasing the level of replacement from 5 to 15%. Significant decrease in width (33.03 ± 0.31 mm) was noticed when 15% pumpkin flesh powder was replaced with white flour, while 15% peel and 15% seeds powders replacement gave values of width 34.06 ± 1.19 mm and 37.66 ± 0.74 mm, respectively. Pumpkin flesh powder replacement caused more decrease in width which might be due to lesser water absorption by this composite flour dough. On the other hand, the addition of pumpkin seed powder resulted in lesser reduction in width of biscuits and values were found close to the control, which is clear indication that replacement of wheat flour with pumpkin seeds powder might be the more suitable to produce good quality biscuits with desirable physical characteristics. Pumpkin parts powders due to the presence of functional ingredients can also increase the nutritional values of the developed food products [47].

Pumpkin seed oil press cake flour was used as a substitute of wheat flour at different replacement levels to evaluate the quality of developed biscuits and decrease in width and diameter of biscuits was noticed by Jukic et al. [46]. Supportive results to our study were obtained when Van Toan and Thuy [48] produced high quality pumpkin flour and developed biscuits with its different proportions. They observed a decrease in width of biscuits as the replacement level of pumpkin flour was increased. Similar

Table 6: Peak height (BU) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	*Means (±SE) of peak height (BU)*				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	57.40 ± 0.21a	—	—	—	—
5%	—	54.27 ± 0.15c	56.73 ± 0.17a	55.61 ± 0.22b	55.54 ± 0.37A
10%	—	52.94 ± 0.60d	55.38 ± 0.25b	54.23 ± 0.23c	54.19 ± 0.40B
15%	—	51.18 ± 0.14e	54.53 ± 0.23c	53.34 ± 0.20d	53.02 ± 0.50C
Overall means	—	52.80 ± 0.48C	55.55 ± 0.34A	54.39 ± 0.35B	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

Table 7: Width (mm) of biscuits with different replacement levels of pumpkin peel, flesh, and seed powders.

Replacement level of pumpkin powders	*Mean (±SE) of width (mm)*				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	42.89 ± 1.45a	—	—	—	—
5%	—	39.36 ± 1.62cd	38.46 ± 0.69de	41.07 ± 1.39b	39.63 ± 1.23A
10%	—	37.06 ± 0.86f	35.04 ± 2.26g	39.95 ± 2.23c	37.35 ± 1.78B
15%	—	34.06 ± 1.19gh	33.03 ± 0.31h	37.66 ± 0.74ef	34.92 ± 0.75C
Overall means	—	36.82 ± 1.22B	35.51 ± 1.09C	39.56 ± 1.45A	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

results to our study were obtained when Turksoy and Ozkaya [30] used pumpkin pomace powder in two different wheat varieties flour to develop cookies. When they used the flour of wheat variety Greek-79 flour and the replaced pumpkin pomace powder at 0, 10, 15, 20, and 25% level width (mm) of cookies was 81.79, 69.57, 65.87, 63.84, and 62.76, respectively, which indicates a significant decrease in width of cookies by increasing the level of pumpkin pomace powder. Gurung et al. [49] studied effect of replacement of pumpkin puree with wheat flour on physical characteristics of biscuits and a nonsignificant decrease in diameter (mm) of biscuits was observed as values of control, biscuits with 10, 20, 30, and 40% replacement level of pumpkin puree were found 48, 46, 45, 44, and 41 mm, respectively. Similar results were also given by Dhiman et al. [50]. Three different types of pumpkin powders were used up to 15% replacement level to develop biscuits and similar results for width and volume of biscuits were observed by Mehmoud and Mehder [51]. They explained the reason behind the changes in physical parameters of biscuits as difference in chemical composition of composite flours, especially difference in protein and fiber contents. The decrease in width of biscuits developed from composite flours was probably due to dilution of gluten contents which was present in greater amount in control biscuits having 100% wheat flour. One more factor responsible for this decrease in width of biscuits might be the greater water absorption resulting in increase in dough viscosity, which has been found increasing with increasing the replacement levels of pumpkin parts powders.

3.3.2. Thickness of Added Pumpkin Peel, Flesh, and Seed Powder Biscuits. Thickness of control biscuits prepared with 100% white flour was 7.61 ± 0.35 mm and composite flours containing 15% each pumpkin peel, flesh, and seeds powders caused significant increase in thickness of biscuits with values 8.15 ± 0.07 mm, 8.08 ± 0.35 mm, and 7.89 ± 0.29 mm, respectively (Table 8). Thickness of biscuits, which is also called as height, is a quality parameter and optimum values are always desirable by manufacturers. Pumpkin parts powders especially seeds powders replacement gave rise to the biscuits with thickness close to the control biscuits, that means pumpkin seeds powder could prove a good alternate of wheat flour to manufacture improved quality bakery products with desirable physical parameters.

Van Toan and Thuy [48] produced high quality pumpkin flour and developed biscuits with its different proportions. They observed a significant decrease in thickness of biscuits as replacement level of pumpkin flour was increased. Similar results were obtained when Turksoy and Ozkaya [30] used pumpkin pomace powder in two different wheat varieties flour to develop cookies. Results supporting to our research work were obtained when Dhiman et al. [50] prepared cookies and addition of the pumpkin seed powder caused a nonsignificant decrease in thickness of cookies as values of thickness (cm) of control, 10, 20, and 30% pumpkin seed powder cookies were 1.102, 1.092, 1.062, and 1.042, respectively. Gurung et al. [49] studied effect of replacement of pumpkin puree with wheat flour on physical characteristics of biscuits and a nonsignificant decrease in thickness (mm) of biscuits was observed as values of control, biscuits with 10, 20, 30, and 40% replacement level of pumpkin puree were found 7.70, 7.48, 6.93, 6.62, and 6.56 mm, respectively. According to Mehmoud et al. [51] the changes in chemical contents especially protein and fiber amounts were the factors responsible for changes in physical parameters of the developed biscuits with different replacement levels of different types of pumpkin powders. The increase in thickness of biscuits developed from composite flours was probably

Table 8: Thickness (mm) of biscuits with different replacement levels of pumpkin peel, flesh, and seeds powders.

Replacement level of pumpkin powders	Mean (±SE) of thickness (mm)				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	7.61 ± 0.35bc	—	—	—	—
5%	—	7.48 ± 0.27c	7.86 ± 0.15ab	7.36 ± 0.15c	7.57 ± 0.19B
10%	—	8.07 ± 0.64a	7.99 ± 0.21a	7.61 ± 0.32bc	7.89 ± 0.39A
15%	—	8.15 ± 0.07a	8.08 ± 0.35a	7.89 ± 0.29ab	8.04 ± 0.24A
Overall means	—	7.90 ± 0.33A	7.98 ± 0.24A	7.62 ± 0.57BC	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

due to dilution of gluten contents due to the addition of pumpkin peel, flesh, and seeds powders, which was present in greater amount in control biscuits having 100% wheat flour. Increased water absorption by composite flours with increased levels of pumpkin fractions powders, may result in increased viscosity of dough, which ultimately trigger the increase in thickness of the biscuits reducing its volume spread.

3.3.3. Spread Factor of Added Pumpkin Peel, Flesh, and Seed Powder Biscuits. A significant decrease in spread factor of biscuits prepared with composite flours containing pumpkin peel, flesh, and seeds powders was noticed as spread factor of control biscuits having 100% wheat flour was 5.64 ± 0.25. Replacement level of 5% of each pumpkin peel, flesh, and seeds powders gave significantly decreased values of spread factor 5.26 ± 0.21, 4.89 ± 0.12 and 5.59 ± 0.02, respectively. These values of spread factor were further decreased significantly to 4.18 ± 0.01, 4.09 ± 0.18 and 4.77 ± 0.21, when 15% pumpkin peel, flesh, and seeds powders were replaced, respectively (Table 9). The higher the spread factor of the biscuits the more desirable it is. Control biscuits have higher spread factor and biscuits with replacement of pumpkin seeds powders gave values of spread factor very close to the control, which means that addition of pumpkin seeds powders can produce good quality biscuits, while greater reduction in spread factor of biscuits due to the addition of pumpkin peel and flesh powder was due to increased fiber and decreased gluten contents of composite flours.

Turksoy and Ozkaya [30] used pumpkin pomace powder in cookies prepared from two different wheat varieties. When they used flour of wheat variety Greek-79 flour and replaced by pumpkin pomace powder at 0, 10, 15, 20, and 25% level spread ratio of cookies was 9.14, 5.98, 5.57, 5.37, and 5.19, respectively which indicates a significant decrease in spread ratio of cookies by increasing the level of pumpkin pomace powder. Gurung et al. [49] studied effect of replacement of pumpkin puree with wheat flour on physical characteristics of biscuits and a nonsignificant difference in spread ratio of biscuits was observed as values of control, biscuits with 10, 20, 30, and 40% replacement level of pumpkin puree were found 6.23, 6.15, 6.49, 6.64, and 6.25, respectively. Dhiman et al. [50] reported that addition of pumpkin seeds powder caused a nonsignificant decrease in spread ratio of cookies as values of spread ratio of control, 10%, 20%, and 30% pumpkin seeds powder cookies were 0.331, 0.328, 0.321, and 0.313, respectively. As spread factor is a ratio between width and thickness of biscuits and as the thickness was decreased in composite flours as a result spread factor was also decreased. A recent study by Hussain et al. [52] has summarized the different utilization patterns of pumpkin, which included pumpkin powders, extracts, isolates, and pumpkin-based novel and functional food products. Development and consumption of such nutritional foods could promote health of mass populations.

4. Novelty behind the Research

Several studies have proven that pumpkin is an excellent fruit with respect to its health promoting potential, which is due to remarkable phytochemistry of pumpkin and food products developed by incorporation of pumpkin are always nutritious with enhanced amounts of phytochemicals. Consumption of pumpkin directly or in the form of developed products has been increased tremendously as awareness among the people has been grown about the use of pharma foods. A wide range of pharmacological properties have also been found associated with pumpkin. Previous studies on pumpkin have proven that not only pulp but peel and seeds of pumpkin also have benefitable nutritional profiles so, instead of discarding each fraction of pumpkin should be utilized to develop good quality functional and pharma foods [53, 54]. While reviewing the literature about the nutritional profiles of pumpkin and developed food products from pumpkins, so many data are present but there are only few research studies about the effect of the addition of pumpkin powders on the rheology and physical characteristics of the developed bakery products, as process efficiency and product quality are the bench marks for the development of bakery products. If developed bakery products are nutritious and provide required amount of nutrients but their physical characteristics are not up to the mark, it is always difficult to market these products with maximum attraction of the consumers. So, the idea behind this research work was to evaluate pumpkin fractions powders replacement with white flour to judge that, which powder and in what percentage of replacement was most suitable in terms of rheological behavior and physical characteristics of bakery products.

Table 9: Spread factor of biscuits with different replacement levels of pumpkin peel, flesh, and seeds powders.

Replacement level of pumpkin powders	Mean (±SE) of spread factor				Overall means
	White flour	Peel powder	Flesh powder	Seeds powder	
0% (control)	5.64 ± 0.25a	—	—	—	—
5%	—	5.26 ± 0.21c	4.89 ± 0.12d	5.59 ± 0.02b	5.25 ± 0.12A
10%	—	4.59 ± 0.22e	4.39 ± 0.05f	5.25 ± 0.16c	4.74 ± 0.14B
15%	—	4.18 ± 0.01g	4.09 ± 0.18g	4.77 ± 0.21d	4.35 ± 0.13C
Overall means	—	4.68 ± 0.15B	4.46 ± 0.12C	5.20 ± 0.13A	

Mean values in a row or column having same letter are nonsignificant ($P > 0.05$). Small letters compare interaction means and capital letters compare overall means.

5. Conclusion

Pumpkin peel, flesh, and seeds were separated, dried into powders, and utilized in biscuits. In fresh form, pumpkin parts (peel, flesh, and seeds) were perishable due to greater moisture contents and drying into powders resulted their increased shelf life and convenience in use. Preparation of composite flours from using pumpkin peel, flesh, and seeds powders as replacement of wheat flour maintained rheological properties of dough in limits, resulting in good quality biscuits. Up to 15% replacement of these powders produced good quality biscuits without any significant adverse effects on physical characters of biscuits. This technique will not only help to manage pumpkin waste materials (peel and seeds) produced as a result of processing but also to produce a new range of acceptable nutritious bakery products by using them.

6. Recommendations

The addition of pumpkin powder to wheat flour brought some significant changes in the dough mixing behavior as measured by farinograph and these farinographic characteristics of flour supplemented with pumpkin powder indicate that pumpkin powder supplemented flour can be used for making good quality biscuits. Cultivation of underutilized nutritious crops like pumpkin can be promoted. Innovative processing technologies can be implemented to minimize the waste production during development of food products. Waste streams of pumpkins can be converted into powders, extracts, and functional ingredients to develop functional food products. A wide range of food products including beverages, bakery products, snacks, extruded products, soups, sausages, and confectionary, can be developed from powders of peel, flesh, and seeds of pumpkin. Need of time is to develop and implement processes and techniques, which can provide optimum parameters of food quality through proper interaction among food components during mixing, dough development, baking, and storage of baked items.

Data Availability

The data presented in this article are available upon request from the corresponding author.

Consent

Not applicable.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Authors' Contributions

Ashiq Hussain wrote the original draft. Tusneem Kausar conceptualized the study. Jawed Aslam performed validation. Muhammad Yousaf Quddoos performed visualization. Atif Ali performed data curation. Samina Kausar performed software utilization. Mehwish Zerlasht performed experiments. Ayesha Rafique performed data analysis. Saima Noreen provided language and grammatical support. Khansa Iftikhar provided resources. Muhammad Waheed Iqbal performed project administration. Muhammad Shoaib performed investigations. Mohammed Y. Refai wrote, reviewed, and edited the manuscript. Faisal Aqlan performed the methodology. Sameh A. Korma provided funding acquisition.

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