

Research Article



Rheological and Qualitative Assessment of Wheat-Pea Composite Flour and its Utilization in Biscuits

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Abstract | The present study aimed to develop composite flour by substituting wheat flour with pea flour at different levels and to check its suitability in biscuits through its rheological and qualitative study. Results indicated rheological parameters including water absorption, dough development time, dough stability, gluten content and falling no. values differed significantly ($p < 0.01$) among all the treatments of composite flour. Wet and dry gluten content decreased from $22.16 \pm 1.58\%$ (T_0) to $16.43 \pm 1.32\%$ (T_3) and $7.46 \pm 0.47\%$ (T_0) to $5.03 \pm 0.38\%$ (T_3) respectively. With increasing percent of pea flour in biscuits, moisture, carbohydrates and caloric value decreased from (1.84% - 1.33%), (62.87% - 54.57%), (525.64 Kcal /100 g to 502.84 Kcal /100 g) respectively while ash, fat, fiber, protein, iron, zinc, magnesium and manganese contents increased significantly ($p < 0.01$). There was a non-significant ($p > 0.05$) effect on the color, flavor, taste and texture of biscuits. So, it is concluded that replacement of wheat flour with pea flour up to a level of 20% improved the nutritional potential of biscuits without affecting the consumer acceptability score.

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Keywords | Pea, Composite Flour, Rheology, Biscuits, Composition

Introduction

Wheat is a staple food as it constitutes 60% of daily diet of a common man in Pakistan. The population of Pakistan is increasing so there is a need to share the burden of wheat by developing composite flour. Composite flour is defined as a mixture of flour from starch based-tubers, protein enriched legumes and from other cereals flour in combination with or without wheat flour. Research have been carried out on the utilization of various food items like cassava, yam, sweet potato, maize, rice, sorghum, millet, soya, chick pea, cow pea and peanuts as a substitute of wheat flour (Begum et al., 2013; Ohimain, 2014).

Composite flour utilization in development of various food products is an attractive approach to meet the global challenge of protein-calorie malnutrition. To overcome the problem of protein calorie malnutrition and to increase intake of dietary protein in to the diet, the combination of cereal-based products with legumes is of considerable importance. Pulses or legumes are an important source of dietary vegetable protein containing twice the protein content compared to cereal grains. Cereals are deficient in lysine but contain sufficient amount of sulphur containing amino acids. In contrast, legumes contain sufficient lysine but lacking sulphur containing amino acids. Therefore, to overcome the problem of protein

calorie malnutrition and to increase intake of dietary protein in to the diet, the combination of cereal based products with legumes is of considerable importance (Kadam et al., 2012).

Among the legumes, pea (*Pisum sativum*) is the second most important highly nutritious crop in terms of production. Peas are recognized as a low fat (3%), high protein (24%), carbohydrates (58%) and dietary fiber (12%) carrying food (Iqbal et al., 2006). Pea containing a significant amount of vitamin A, vitamin C, vitamin B complex, iron, calcium, copper, zinc and manganese. No significant value of anti-metabolites or toxicity has been reported in pea (Garg et al., 2015; Narayanan et al., 2015). Pea flour and pea protein exhibits different functional properties like solubility, emulsifying and foaming properties, gelling ability and water holding capacity. These functional properties are desirable in different foods to increase stability and shelf life (Ettoumi and Chibane, 2015). So, pea flour could be used in bread, bagels, crackers, cake, muffins, brownies and cookies.

Pea is an excellent source of antioxidants like carotenoids, leutin and zeaxanthin. Based on the nutrition and phytochemical contents of pea, it is utilize to treat anxiety, stress, and neurosis. Due to folate content of pea, it is recommended to pregnant women and lactating mothers. Folate supports in the fetal nervous system development (Narayanan et al., 2015). Amylose content of pea starch and fiber contents reduced starch digestibility, lowering glycaemic index and improve gastrointestinal health (Dahl et al., 2012). As reported in previous studies, nutritional constituents of pea have shown a significant reduction in the incidence of cancer, LDL cholesterol, type-2 diabetes and heart disease (Ettoumi and Chibane, 2015).

Now, consumers are calorie conscious and demand a healthy food that is more natural or natural-like. To satisfy the demand, protein rich food ingredients are added in to various products. Among available foods in market, bakery items are considering as a healthier vehicle for value addition or fortification (Amin et al., 2016). Cookies/ biscuits considered as a longer shelf life, convenient and economical source of nutrient for all group of people in comparison to other bakery items (Akubor, 2003; Hooda and Jood, 2005). Keeping in view the importance of cereals and legumes blended products, to share the burden of wheat and to combat protein calorie malnutrition and on

the basis of relationship of wheat and pea flour on the quality of the end product, wheat-pea composite flour at different levels were developed and its influence on the physico-chemical, mineral profile and sensory characteristics of biscuits were assessed.

Material and Methods

Procurement of raw material

Raw material, which includes wheat grains, pea, sugar, shortening, eggs, baking powder and milk were purchased from the local market of Islamabad, Pakistan. All the chemicals used in the present study were of analytical grade.

Preparation of pea flour

After drying at 40°C of fresh peas, grinding of peas were carried out using a cyclotech (Model 1093) to get uniform and finest particle. After sieving, flour was packed in a polythene bag and stored at ambient temperature for further analysis.

Preparation of composite flour

Cleaned and sieved wheat tempered at 16% moisture and then milled with Quadrumate Senior mill to get fine flour. Composite flour blends were prepared with the addition of 5%, 10% and 20% of pea flour in wheat flour and compared with the control.

Table 1: Formulation of biscuits

Ingredients	Quantity
Flour	200 g
Eggs	20 g
Sugar	80 g
Ghee / Shortenings	110 g
Milk	8 ml
Vanilla essence	2 Drops

Preparation of biscuits

Biscuits were prepared according to the method as reported in AACC (2000). The formulation are shown in Table 1. After weighing of all the ingredients in prescribed quantity, shortenings and grinded sugar put in dough mixer and mix it for 2 mints until creamy texture obtained. Beaten egg was added during mixing. Baking powder and sieved fine wheat flour, milk and essence added and then mix gently for further 1-2 minutes. After, sheeting (3-5 mm thickness) and molding of the dough, baking of biscuits were done at 180°C for 15 minutes. After cooling (35°C), packed biscuits in air tight polyethylene bags. The schematic

flow line of the biscuit is given in Figure 1. The details of the prepared treatments are given below:

- T₀ = Biscuits without pea flour (control)
- T₁ = Biscuits with 5% pea flour
- T₂ = Biscuits with 10% pea flour
- T₃ = Biscuits with 20% pea flour

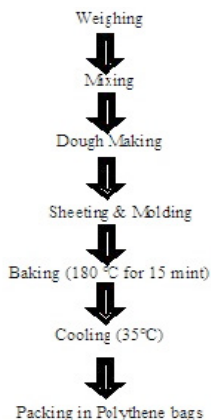


Figure 1 Schematic Flow Line of Biscuits

Figure 1: Schematic flow line of biscuits

Rheological analysis of composites flour blends

The falling number value of all the treatments was determined using the method AACC No 56-81 B (2000). According to the method, based on the moisture contents samples were weighed and to make suspension 25 mL water added into a viscometer tube and shaken for 60s. To make gel tube were suspended into a water bath at 100°C. The total time required by the plunger to drop through the gel noted as falling number value.

Wet and dry gluten contents were determined by following the method no. 38-12 as reported in AACC, 2000. 10 g of ground sample weighed and placed in glutomatic chamber for washing with 2% salt solution to remove starch. The remaining portion after washing weighed as wet gluten. Wet gluten dried in glutork for 4 min and calculated as dry gluten.

Farinographic parameters like water absorption, dough development time and dough stability were determined by using farinograph. Farinograph measures and record the resistance of dough against mixing. Based on the moisture content of flour the instrument automatically measured the weight of flour and amount of water to be added to make dough (AACC, 2000).

Physical parameters of biscuits

Biscuits diameter (cm) and thickness (cm) were de-

termined using vernier callipers, while cookies weight was determined using an electronic weighing balance. Spread ratio was expressed as diameter/thickness (McWatters et al., 2003). Spread factor was determined using the following equation:

$$\text{Spread Factor} = \text{Spread ratio of sample} / \text{Spread ratio of control sample} \times 100$$

Physico-chemical composition of biscuits

All the physic-chemical analysis including moisture, fat, protein, ash, fiber, carbohydrates were conducted by following the guidelines of AOAC (2005). Moisture was determined through hot air oven operated at 130°C for 1 hrs. Kjeldahl method was used to determine the crude protein content by multiplying the percent N with factor 6.25. Soxhlet extraction unit used to estimate the fat content using hexane as a solvent. To determine fiber content, firstly sample was neutralized, filtered followed by drying and ignition. Calculated loss in weight of sample is taken as a fiber percent. Dry ashing was done by putting in a muffle furnace at 550-600°C for 16 hrs and then weighed to calculate ash content.

The carbohydrate content was calculated according to the following expression:

$$\text{Carbohydrates (\%)} = 100 - (\text{Moisture \%} + \text{Protein \%} + \text{Fat \%} + \text{Fiber \%} + \text{Ash \%})$$

Caloric value was estimated by using the following formulae as reported by Osborne and Voogt (1998):

$$\text{Energy (Kcal/ 100 g)} = \text{g of protein} \times 4 + \text{g of fat} \times 9 + \text{g of carbohydrates} \times 4$$

Mineral profile of biscuits

The samples were burned in a muffle furnace at 550 °C for 16 hours, and the ashes were dissolved by using 6 M hydrochloric acid (Merck) and 0.1 M nitric acid. The filtered sample is further diluted with de-ionized water. Iron, zinc, manganese and magnesium were determined by atomic-absorption spectrophotometry (Perkin- Elmer Model 3300) against the standard solutions AOAC (2005). The obtained results were expressed in ppm (mg / 1000 mL).

Sensory evaluation

Biscuits prepared from different level of pea flour were subjected to sensory evaluation for color, flavor, texture, taste and aroma by a panel of 5 judges using the 9 point hedonic scale according to the method described by Meilgaard et al. (2007).

Statistical analysis

All the experiments were carried out in triplicates and results were presented as mean ± Standard deviation. Completely randomized designed were applied on all parameters followed by LSD pair-wise comparison test. All the analysis was performed using Statistix 8.1 Software (Analytical Software, Tallahassee, FL, USA) considering 95% of confidence interval.

Results and Discussion

Effect of pea flour addition on the rheological parameters of composite flour

Rheological behavior including water absorption, dough development time and dough stability studied by Farinograph are presented in Table 2. Water absorption percent varied significantly ($p < 0.01$) among all of the composite flours. With increasing proportion of pea flour into white flour, water absorption increased. This increase in water absorption capacity of dough is due to gradual increase of percent protein in all the composite flours. Due to presence of non-wheat proteins, water becomes unavailable to wheat protein for gluten development (Des Marchais et al., 2011). Dough development time and dough stability varied significantly ($p < 0.01$) with changing the level of substitution of pea in composite flour. It is depicted from the Table 1 that dough development time and dough stability inversely correlates to each other. This behavior of dough is due to decreasing the gluten protein content with increasing level of pea protein content in composite flours. With substitution of wheat gluten, dough weakens and its stability decreased. Similar results were reported by Pasha et al. (2011), Mohammad et al. (2012) and Kohajdova et al. (2013).

The results regarding the falling no of different treatments of composite flour have been shown in Figure 2. The results differed significantly ($p < 0.01$) among

all the treatments. The falling no. value was higher (430 ± 1.54) for wheat flour (T_0) and least amount of falling no. (396 ± 1.29) was observed for composite flour with 20 % pea flour (T_3). With increasing level of substitution of wheat flour with pea flour the falling no. value lowered correspondingly. Lower falling number value indicated higher α -amylase activity and less starch will be available to interact with the gluten protein which ultimately deteriorates the viscoelastic characteristics of dough. Results of the present study are in close agreement with the findings of Hassan et al. (2013) who reported that the falling no. value decreased with the addition of decorticated pigeon pea flour in biscuits.

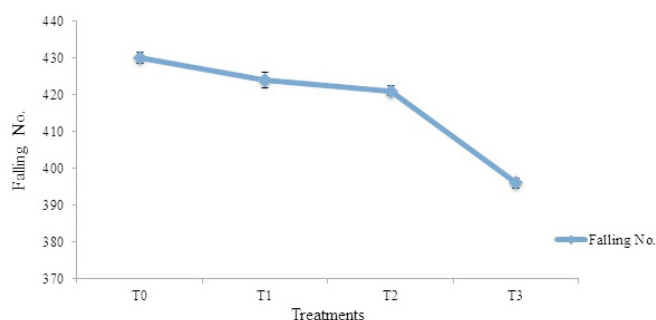


Figure 2: Effect of pea flour addition on falling No. value of composite flours

T_0 = Wheat Flour (control); T_1 = Composite Flour with 5% pea flour; T_2 = Composite Flour with 10% pea flour; T_3 = Composite Flour with 20% pea flour

Wet and dry gluten content of all the treatments of composite flours are graphically presented in Figure 3. Wet and dry gluten contents varied significantly ($p < 0.01$) among all the treatments. Wet gluten contents are within the range of 22.16 ± 1.58 % (T_0) to 16.43 ± 1.32 % (T_3) while dry gluten contents showed a decreasing trend from 7.46 ± 0.47 % (T_0) to 5.03 ± 0.38 % (T_3). With substitution of wheat flour in dough, gluten content decreased which greatly influenced the functional properties of dough. Similar trend of decreasing gluten contents were also reported by Dhingra and Jood (2004) and Hassan et al. (2013).

Table 2: Farinographic parameters (water absorption, dough development time and dough stability) of all the composite flour

Parameter	Treatment			
	T0	T1	T2	T3
Water Absorption (%)	58.50 ± 1.34d	59.30 ± 1.11c	60.06 ± 1.02b	61.10 ± 0.59a
Dough Development Time (min)	2.30 ± 0.12d	2.90 ± 0.05c	3.20 ± 0.43b	3.80 ± 0.05a
Dough Stability (min)	6.50 ± 0.42a	5.70 ± 0.89b	4.10 ± 0.65c	3.10 ± 0.13d

Values are expressed as mean ± standard deviation. Different letters in a row represents a significant ($p < 0.01$) difference among treatments; T_0 = Wheat Flour (control); T_1 = Composite Flour with 5% pea flour; T_2 = Composite Flour with 10% pea flour; T_3 = Composite Flour with 20% pea flour

Table 3: Physical parameters of all the wheat-pea composite flour biscuits

Parameter	Treatment			
	T0	T1	T2	T3
Thickness (cm)	20.26 ± 0.25a	18.33 ± 0.30b	17.33 ± 0.30c	15.53 ± 0.50d
Diameter (cm)	8.46 ± 0.57c	8.55 ± 0.5b	8.60 ± 0.11b	8.71 ± 0.15a
Spread Factor	100 ± 0.76d	112 ± 0.74c	117 ± 0.82b	133 ± 1.73a
Spread Ratio	0.42 ± 0.06d	0.47 ± 0.01c	0.49 ± 0.55b	0.56 ± 0.01a
Weight (g)	8.39 ± 0.53a	8.16 ± 0.02a	8.30 ± 0.1a	8.45 ± 0.02a

Values are expressed as mean ± standard deviation. Different letters in a row represents a significant ($p < 0.01$) difference among treatments.

Table 4: Physico-chemical analysis of all the wheat-pea composite flour biscuits

Parameter	Treatments			
	T0	T1	T2	T3
Moisture (%)	1.84 ± 0.02a	1.66 ± 0.06b	1.65 ± 0.03b	1.33 ± 0.13c
Fat (%)	27.40 ± 1.32d	27.62 ± 1.77c	28.12 ± 2.11b	28.16 ± 3.22a
Protein (%)	6.89 ± 0.42 d	7.35 ± 0.45c	7.58 ± 1.72b	7.78 ± 1.42a
Ash (%)	0.30 ± 0.02d	0.40 ± 0.01c	0.64 ± 0.03b	0.77 ± 0.32a
Fiber (%)	0.70 ± 0.01d	1.59 ± 0.31c	3.60 ± 0.11b	7.39 ± 1.04a
Carbohydrates (%)	62.87 ± 2.50a	60.65 ± 3.44b	58.41 ± 2.66c	54.57 ± 3.00d
Energy (Kcal/100g)	525.64 ± 2.46a	520.58 ± 3.41b	517.04 ± 3.04c	502.84 ± 2.73d

Values are expressed as mean ± standard deviation. Different letters in a row represents a significant ($p < 0.01$) difference among treatments.

Effect of pea flour on the physical parameter of biscuits

Statistical analysis results revealed the significant ($p < 0.01$) effect of pea addition on the physical characteristics of the biscuits. The treatment mean values are graphically presented in Table 3. There was a significant decrease in the thickness of biscuits from 20.26 ± 0.25 (T₀) to 15.53 ± 0.50 (T₃) while diameter increased from 8.46 ± 0.57 (T₀) to 8.71 ± 0.15 (T₃). With increasing level of pea contents, weight also increased but statistically this increase was non-significant ($p > 0.05$). Both spread ratio and spread factor value increased with increased percent of pea flour (T₀ to T₃) from 0.42 ± 0.06 - 0.56 ± 0.01 and 100 ± 0.76 - 133 ± 1.73 respectively. Addition of non-wheat protein exhibits hydrophilic properties and had higher water absorption property and swelling index due to these properties, diameter, spread ratio and spread factor of the biscuits dough expands while weight reduced slightly. The results regarding the physical attributes of biscuits are in agreement with the work of Noor-Aziah et al. (2012); Grah et al. (2014); Igabul et al. (2015); Youssef (2015).

Effect of pea flour on the physico-chemical composition of biscuits

The mean values for physico-chemical profile of wheat-

pea composite flour blended biscuits have been given in the Table 4. Statistical analysis of different treatments indicated that moisture, fat, protein, ash, fiber, carbohydrates and caloric values varied significantly ($p < 0.01$) from each other. Moisture content plays a pivotal role to determine the shelf stability of the end product. It is depicted from the Table 4, moisture content decreased significantly ($p < 0.01$) with increasing level of substitution of white flour with pea flour. Highest treatment mean for moisture content was found in T₀ (control) while values of T₁ (biscuits with 5% pea flour) and T₂ (biscuits with 10% pea flour) were statistically at par from each other.

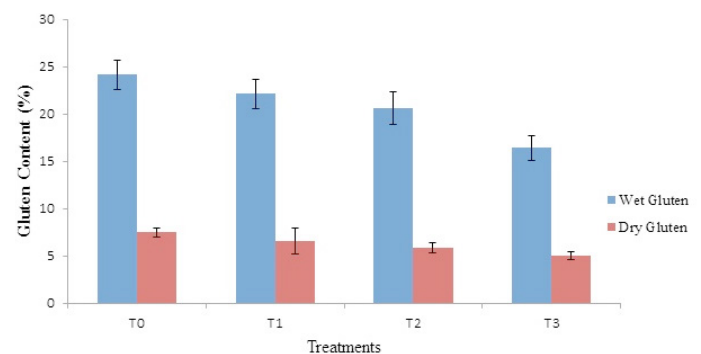


Figure 3: Effect of pea flour addition on wet and dry gluten contents of composite flours

T₀ = Wheat Flour (control); T₁ = Composite Flour with 5% pea flour; T₂ = Composite Flour with 10% pea flour; T₃ = Composite Flour with 20% pea flour

Results reported that fat and protein content increased significantly ($p < 0.01$) with increasing level of substitution of white flour with pea flour. The mean value for fat contents of all treatments was in the range of 27.40 % to 28.16 % while the range for protein contents was 6.89-7.78%. This increase in fat and protein content of biscuits might be due to higher fat and protein content of pea as compared to white flour. Highest treatment mean of protein content (7.78%) was observed in pea flour biscuits containing 20% pea flour (T_3). However, lowest mean (6.89%) was observed in biscuits without pea flour (T_0). The change in protein and fat content was in conformity with the findings of Okpala and Okoli (2011) and Thongram et al. (2016).

Ash and fiber contents significantly ($p < 0.01$) influenced due to increasing proportion of pea flour. Highest mean value (0.77%) of the ash content is of biscuits with 20% of pea flour (T_3). Moreover the lowest ash (0.30%) content was calculated in biscuits without pea flour (T_0). The range of fiber contents in the present study is from (0.70%-7.39%). Highest fiber content was observed in treatment having 20% pea flour (7.39%). This significant increase in fiber content is due to increasing substitution of pea flour in biscuits. These results are in line with the work of Amin et al. (2016).

Carbohydrates contents decreased significantly ($p < 0.01$) from T_0 (62.87 %) to T_3 (54.57 %). This decrease was due to increasing the level of fiber and protein content with increased level of substitution of white flour with pea flour. The results regarding the caloric value showed that there was a significant decrease from T_0 (525.64 Kcal /100 g) to T_3 (502.84 Kcal /100 g). These results are in agreement with the findings of Noor-Aziah et al. (2012).

Effect of pea flour on the mineral profile of biscuits
The treatment mean values of all the wheat pea composite flour blended biscuits are presented in Figure 4. All the analyzed minerals including iron, zinc, magnesium and manganese changed significantly ($p < 0.01$). Fe contents are within the range of 11.54 ± 0.01 ppm to 14.82 ± 0.02 ppm. Highest mean value of Fe (14.82 ± 0.02 ppm) was observed in biscuits containing 20% pea flour (T_3) while least content was found in biscuits without pea flour (T_0). Zinc, magnesium and manganese content varied from 216.42 ± 1.68 ppm to 307.09 ± 3.05 ppm, 100.69 ± 2.85 ppm

to 190.75 ± 0.65 ppm and 3.15 ± 0.02 ppm to 3.44 ± 0.00 ppm respectively. As the mineral contents are directly related to the ash content, it increase in minerals (Fe, Zn, Mg and Mn) might be due to higher percentage of ash contents in a biscuits containing 20 % pea flour as compared to the other treatments. These results are in conformity with the work of Dahl et al. (2012), who reported that pea is also a significant source of different minerals including iron, zinc, calcium, potassium and magnesium.

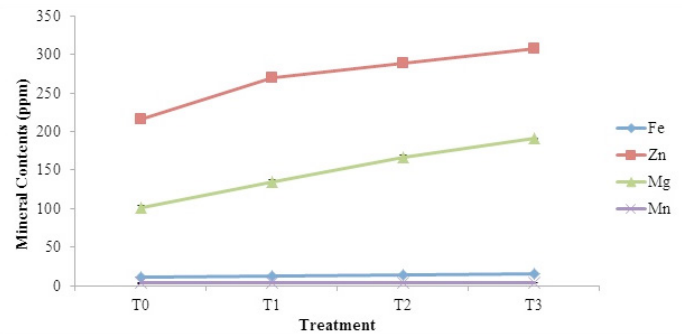


Figure 4: Effect of pea flour addition on mineral contents of wheat-pea composite flour biscuits
 T_0 = Biscuits without pea flour; T_1 = Biscuits with 5% pea flour; T_2 = Biscuits with 10 % pea flour; T_3 = Biscuits with 20 % pea flour

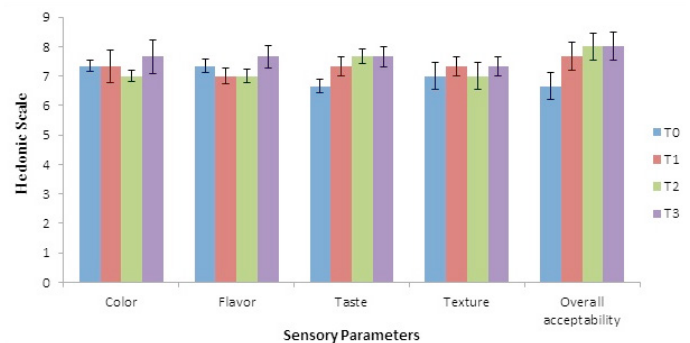


Figure 5: Effect of pea flour addition on sensory parameters of wheat-pea composite flour biscuits
 T_0 = Biscuits without pea flour; T_1 = Biscuits with 5% pea flour; T_2 = Biscuits with 10 % pea flour; T_3 = Biscuits with 20 % pea flour

Effect of pea flour on the sensory evaluation of biscuits

The mean values of sensory parameters (color, flavor, taste, texture and overall acceptability) of all treatments have been given in Figure 5. Statistical data revealed that there were a non-significant ($p > 0.05$) effect of the addition of pea flour on the color, flavor, texture, taste and overall acceptability of biscuits. It is depicted from the results that addition of protein rich pea flour did not influenced on all the sensorial attributes. In terms of color, flavor, taste, texture and overall acceptability, highest treatment means was observed in biscuits containing 20 % pea flour (T_3). Based on color, T_0 and T_1 gained the same sensory score (7.33)

while in terms of taste and overall acceptability T_0 got a least score (6.66). The results of the present study are in line with the findings of Taiwo (2006) and Ashaye et al. (2015) who reported that addition of cassava and pigeon pea flour in the development of biscuits by replacing the white flour up to 30% did not influenced the consumer acceptability score.

Conclusion

From the present research it is concluded that composite flour having varying degree of wheat-pea could improve the nutritional status of baked products but it negatively affects the bread making process and quality of bread. However, it could be used in the development of biscuits.

Authors' Contributions

Aqsa Qayyum, Masooma Munir: Research planned and executed.

Saeeda Raza, Nouman Rashid: Provided the research design and drafted the paper.

Mussarat Gillani, Amer Mumtaz, Saima Kanwal: They have participated in research analysis.

Naeem Safdar, Zarmina Gillani: Analyzed the data statistically and final reviewed of the manuscript.

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