Physicochemical and sensory assessment of apple pomace enriched muffins

Muhammad Bilal Younas*, Allah Rakha, Muhammad Sohail, Summer Rashid and Hassam Ishtiaq

*National Institute of Food Science and Technology, University of Agriculture, Faisalabad.

*Corresponding Author: bilalyunas@gmail.com

ABSTRACT
In recent years, foods are not anticipated to only satisfy hunger needs and to deliver essential nutrients to people but also to avoid nutrition-related diseases and enhance physical and mental comfort of the people. Bakery products provide best structure by which functionality can be provided to the customers in a suitable food. Apple pomace is the byproduct of apple fruit industry. Apple pomace is also a rich source of phytochemicals. In this study, apple pomace was dried at 60°C to convert into powder form. Value addition of muffins were done with two varieties of apple pomace powder (Kala Kullu, Golden) using 0%, 5%, 10% and 15% concentration. These muffins were characterized on the basis of chemical (proximate analysis, total phenolic compounds), physical (texture, color) and sensory properties. Addition of apple pomace powder (APP) of both varieties significantly increases the ash, crude fiber and phenolic content. Highest values were observed in the treatment containing 15% of apple pomace powder i.e. 3.01 and 2.76 mg/g GAE for \( T_{A3} \) and \( T_{B3} \) respectively. Hardness was also increased with the increasing level of apple pomace powder. From the sensory evaluation, the muffins containing 10% APP from Kala Kullu performed better than other variety on hedonic scale. Conclusively, apple pomace can effectively be utilized to develop functional muffins with added health benefits without compromising sensory or physicochemical attributes.

Key words: Apple pomace, muffins, Physicochemical, Sensorial

INTRODUCTION
From the last few years, nutritionist are strongly emphasizing on optimal nutrition. The main reason behind the optimization the daily nutrition diet, beside fulfill the hunger needs, food must provide essential nutrients and avoid nutritional diseases (Menrad, 2003). Consumers believes that optimization of their diets will help them to improve personnel wellbeing and reduce healthcare expenses (Milner, 2002). Diet optimization can be done by adding dietary fiber that have nutritional (anticancer, ant obesity) as well as functional properties (water holding capacity, thickening, oil holding capacity) (Thebaudin et al., 1997).

The agro-food industry generates a large quantity of waste or by-products every year (Dhillon et al., 2013). By-products of vegetables and fruit industry tends to show higher quantity of dietary fiber (O’Shea et al., 2012) and phenolic compounds (Balasundram et al., 2006). They are becoming popular among food producers and consumers because the synthetic food ingredients can induce toxicity (Palafox-Carlos et al., 2010). These by-products also possess bioactive compounds in significant quantity that can be utilized as a natural source of antimicrobial agent and replaced the synthetic preservatives (Martin et al., 2012). It is generally acknowledged that increased intake of vegetables and fruits can decrease the chances of cancer, heart disease, and stroke (Liu, 2003).

Baked products are most widely consumed food item in the world. So, they can be utilized as nutritional tool to carry the dietary fiber (Lebesi and Tzia, 2011). Muffins are a widespread breakfast or a snack food, which is sold in several bakeries. Muffins are high calorific bakery item which is much sweetened in taste. (Matos et al., 2014). Majority of bakery products are high in carbohydrate, fat and calorie, but low in fiber content (Mishra and Chandra, 2012). These characteristics made them as unhealthy choices for daily consumptions. By-products with rich source of fiber can be used in bakery products, because they are less expensive and non-caloric bulking agents which enhance the oil and water retention and improve the oxidative and emulsion stabilities (Elleuch et al., 2011).

Apple pomace is the byproduct of apple juice industry. It can be a potential food ingredient with 36.8% dietary fiber (Carson et al., 1994). Apple pomace
demonstrates to have an excellent complex of polyphenols and these polyphenols includes flavanols (catechin, epicatechin, and procyanidins), flavanols, hydroxycinnamates and dihydrochalcones (Schieber et al., 2003). Apple provide dietary fiber with ideal ratio of soluble and insoluble fiber (Gorinstein et al., 2001). The phenolic compounds can be extracted from apple pomace by means of organic solvents like acetone and methanol (Cetkovic et al., 2008). These recovered compounds can be used to improve the food stability by inhibiting the lipid peroxidation (Makris et al., 2007). Apple skin contains high proportion of health promoting phytochemicals and such as phenolic acids and flavonoids (Boyer and Liu, 2004).

Addition of apple pomace in flour for bread preparation changes the loaf volume and softness of the bread. Bread with apple pomace enriched color was dark brown as compared to the control sample prepared without apple pomace incorporation (Gupta, 2006). Sensory assessment established that the muffins prepared by using fifty percent of the wheat bran replaced with powdered apple pomace were considerably very desirable as compared to the control bran muffins (Wang and Thomas, 1989). Increased supplementation of apple fiber results in enhanced water absorption capacity of food (Moazzezi et al., 2012). Incorporation of apple pomace in cake resulted in higher antioxidant activity of the cake (Sudha, et al. (2007).

Thus the proposed study is aimed to value addition of muffins with two varieties of apple pomace and investigate the physio-chemical and sensory characteristics of value added muffins.

**MATERIAL AND METHODS**

**Preparation of apple pomace powder**

Apples were washed and cut into small pieces. Juice was extracted from by using juicer machine, then left material after juice extraction is called as apple pomace. It include seeds, skin peel etc. these were subjected to drying process. Both pomaces were placed into cabinet dryer. Temperature was set at 60°C. After seven to eight hours, pomace was in dried form. Which is then crushed by crushing machine into small granules to obtain in powder form.

**Proximate composition of raw materials**

White flour and apple pomace were assessed for proximate composition i.e. moisture, crude protein, crude fat, crude fiber and ash content according to their respective methods as given in AACC 2000.

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**Determination of total phenolic content of raw materials**

Total phenolic content was measured with the help of Folin-Ciocalteu method as described by (Ashoush and Gadallah, 2011). Aliquots of 0.5 ml of the extract were added to 0.5 ml of the Folin-Ciocalteu reagent, followed by the addition of an aqueous 7.5% solution of sodium bicarbonate. The mixture was stirred and allowed to stand for 30 minutes. The absorbance was measured at 765nm by using spectrophotometer. A blank sample of water and reagent for a reference. The results were expressed milligram of gallic acids equivalent per gram powder (mg GAE/ g powder).

\[
C = cx \frac{V}{m}
\]

C= total phenolic content in mg/g

V= concentration of galic acid curve from the calibration curve

m= weight of the sample

**Preparation of muffins**

Muffins were prepared with batter containing 0%, 5%, 10%, 15% apple pomace powder of both varieties as substituting levels of wheat flour. Recipe of the muffin was wheat flour 150g, oil 100g, sugar 100g, eggs 100g, milk 50 mL., milk cream 25 mL, baking powder 9 g. In process, First of all, creaming of vegetable oil and sugar was done. Then eggs were added and mixed well till foamy mass and then all the remaining ingredients were added and at last flour (with baking powder) was added and homogenous mixture was formed. Then this homogenous mixture was put in the pans, which were lined the internal surface with paper. The pans were placed in the oven at 200±5°C until baked properly for about 20-25. The tooth pick was inserted in the center of the muffin to test proper baking. The clean tooth pick showed proper baking. After completion of baking, the pans were taken out of the oven and muffins were cooled in pans for 30 min and then taken out. For apple pomace enriched muffins, apple pomace and white flour blend was prepared by incorporating apple pomace of different percentages 5, 10, and 15 on flour basis. Rest of the procedure is same as above.

**Characterization of muffins**

**Proximate composition**
Muffins were assessed for proximate composition i.e. moisture, crude protein, crude fat, crude fiber and ash content according to their respective methods as given in AACC 2000.

**Total phenolic content**

The total phenolic contents in muffins were determined by Folin-Ciocalteu method as described by Ashoush and Gadallah, (2011).

**Texture analysis**

Textural analysis of muffins were carried out by using texture analyzer according to model of Piga et al. (2005). The instrumental texture measurements of the muffin samples were made with a Texture Analyzer (Stable Microsystems, Godalming, UK) provided with Texture expert software. A single compression test was performed with a 75 mm diameter flat-ended cylindrical probe (P/75). Once a trigger force of 1000g had been achieved, the compression platen proceeded to move down onto the spread and a rapid rise in force was observed. During this stage the sample was deformed under the applied force but there was no apparent breakdown of the product. As the compression distance increased, small peaks were seen on the graph profile, indicating a compressive failure of the sample. This stage ended abruptly when the test completed and is indicated by a large decrease in force. The greater the distance occurs, the greater is the ability to withstand compression without sample breakage. The parameters obtained from the curves were hardness. Values were the mean of at least three replicates for each formulation.

**Color**

The color of muffins was determined with the help of hand held tristimulus color meter II (Mod, NeuhausNote, Colorimeter, ColorTest II serial no. 95808, Germany) according to the method of Lara et al. (2010).

**Calorific value**

Calorific values of the bars were determined by using Oxygen Bomb Calorimeter (IKA-WERKE, C2000 Basic) as described by Krishna and Ranjhan (1981). Sample of muffin (0.5g) was taken in to the metallic decomposition vial. The vial was unscrewed and fastened by a cotton thread onto the middle of the ignition wire with a loop before loading the sample. Then the screw cap was tightened. The decomposition vial was guided into the filler head to the open measuring cell cover until it was in place. The start button was pushed and the measuring cell cover was closed. The sample within the vial was burnt through electric spark. Heat produced was noted by the C5040 CalWin software of computer (IKA-Werke, Germany) and displayed in the form of a graph denoting the temperature against time. It gave number of calories per 1 gram of a sample.

**Sensory evaluation**

Sensory characteristics of muffins were carried out by the method reported by Meilgaard et al. (2007). Sensory evaluation was done by using hedonic scale by sensory panel consisting of 3 judges. Muffins were evaluated against different attributes i.e. color, flavor, grain size, texture, uniformity, thickness of the wall, size and overall acceptability.

**Statistical analysis**

The obtained data will be subjected to statistical analysis to determine the level of significance (Steel et al. 1997).

**RESULTS AND DISCUSSION**

**Proximate composition of raw material**

From the table (1), Wheat flour exhibited 10.04±0.15% of moisture content which is evident from the findings of Ktenioudayki et al. (2013) and Kohajdova et al. (2012). According to Kohajdova et al. (2013), wheat flour had moisture content 12.7%, while Kohajdova et al. (2012) interpreted that wheat flour exhibited 10.7%. As for the apple pomace powder, the assessed moisture content were 7.82±0.20% (Variety A) and 6.55±0.10% (Variety B). These results are supported by the findings of Reis et al. (2014) who reported that apple pomace have moisture content 7.9%. These findings are also aligned with Gazalli et al. (2013) who stated that apple pomace have moisture content up to 9.75%.

It is evident from table (1), the crude protein of wheat flour is 9.53%. The protein content of the flour is in line with the assessed protein content by Kohajdova et al. (2012). Who reported that wheat flour possess 11.32% of crude protein content. The protein content of two variety of apple pomace were 4.53±0.37% and 3.43±0.03% respectively. These results are logged in table (1). These results of apple pomace protein are supported by Ghazalli et al. (2013) who found that apple pomace exhibits 5.11% of protein contents.

Results relating fat contents of apple pomace powder are presented in table (1). The determined fat contents of apple pomace of variety A and Variety B were 2.75±0.09% and 3.04±0.10% respectively. These results are supported by Reis et al. (2014) who...
interpreted that apple pomace contains 2.3%. Determined fat content of wheat flour was 1.56±0.10%, which is aligned with the findings of Kohajdova et al. (2012) indicates that fat content in flour is 1.3%.

In this study, the fiber content of wheat flour was quantified as 0.68% and displayed in table (1). This result is supported by Gunathilake et al. (2009) who interpreted that dietary fiber in wheat flour is 0.5%. Crude fiber content in apple pomace powder were measured as 12.01±0.11% and 10.63±0.39% for variety A & B respectively. The data is given in table (1). These findings are comparable to the results of Moazzezi et al. (2012) who interpreted that crude fiber of apple pomace is 10.5%. The assessed value of ash contents in flour are shown in table (1). It is evident from table that flour were 0.56±0.12% and are in line with the findings of Kohajdova et al. (2012) who states that crude ash content in flour is 0.4%. Whereas ash contents in apple pomace are presented in table (1), presented as 1.66±0.104 for variety A and 1.88±0.135 for variety B. These findings are supported with the findings of Reis et al. (2014) and Ktenioudaki et al. (2013) who found the ash content in apple pomace is 1.1% and 1.7% respectively. It is apparent from the table (1) that variety A of apple pomace has 71.22±0.45 NFE% whereas the NFE value for variety is B 74.47±0.50%. As for wheat flour, it contains 77.68±0.09% like presented in table (1).

**Determination of total phenolic contents of raw material**

Total phenolic contents of flour were 1.71±0.06 mg/g. Apple pomace of variety A had 6.11±0.15 mg/g of total phenolic contents whereas variety B showed 4.93±0.39 mg/g of total phenolic contents. These results are supported by the findings of Sudha et al. (2007) and Cetkovic et al. (2008) who reported that apple pomace contains 10.16 and 8.67 mg/g respectively.

**Chemical analysis of muffins**

**Proximate composition of muffins**

The results in Table (2) represents the proximate analysis regarding apple pomace enriched muffins. It is evident that there is insignificant difference amongst all the treatments. It was determined that Tₐ exhibited the highest moisture content in among all the treatments which is 16.08±1.05%. While, Tₐ₁, Tₐ₂ and Tₐ₃ has moisture content of 15.62±0.67%, 15.32±0.63% and 15.10±0.47% respectively. Sample prepared with variety B showed 15.39±0.52%, 15.23±0.66% and 14.89±0.49% for Tₐ₁, Tₐ₂ and Tₐ₃ correspondingly. These results are also in agreement with the research of Shearer et al. (2004), according to them muffins contained 17% of moisture.

From table (2) corresponding protein content in muffins, Tₐ has highest protein content 10.13±0.98% whereas Tₐ₁ exhibited the maximum value with 9.57±0.15% amongst muffins containing apple pomace powder. According to mean value table, Tₐ₁, Tₐ₂ and Tₐ₃ has crude protein content 9.57±0.15%, 8.36±1.03% and 7.013±0.81% respectively. While Samples prepared with variety B showed protein content 8.82±0.51%, 7.61±1.02% and 6.38±0.50% for Tₐ₁, Tₐ₂ and Tₐ₃. Hence, protein content was decreased as the apple pomace content increased in the food product. These findings are supported with the results of Rupasinghe et al. (2008) and Reis et al. (2014). Reis et al. (2014) interpreted that bakery products containing apple pomace exhibited 12% protein content, while according to Rupasinghe et al. (2008), protein content in muffins are upto 8%.

As for crude fiber, Tₐ₃ exhibited the highest fiber among the treatments, explaining that the crude fiber increases with the addition of apple pomace. Tₐ₃ had the crude fiber content 0.75±0.12%. Treatments Tₐ₁, Tₐ₂, Tₐ₃ had crude fiber content of 1.57±0.39%, 2.45±0.41% and 3.13±0.42% respectively. Sample prepared with variety B showed 1.160±0.22%, 2.20±0.39% and 2.94±0.18% for Tₐ₁. These results are aligned with the research of Rupasinghe et al. (2008), who found that apple skin powder enriched muffins had crude dietary fiber content up to 5.8%. For crude fat content in muffins, table (2) showed that Tₐ has greatest the crude fat content which is 21.92±1.09%. Whereas Tₐ₁, Tₐ₂ and Tₐ₃ has crude fat content of 20.12±1.006, 19.8±0.99% and 19.59±0.98% respectively. Sample prepared with variety B showed 20.30±1.01%, 19.91±0.99% and 19.70±0.98% for Tₐ₁, Tₐ₂ and Tₐ₃ accordingly. These results are supported with the findings of Rupasinghe et al. (2008). According to them, muffins prepared with apple skin powder had 26% of crude fat content. From table (2), It was found that muffin containing 15% apple pomace of variety B showed the maximum ash content 1.69±0.28%. Treatment without apple pomace possessed crude ash content 0.93±0.16%. Whereas Tₐ₁, Tₐ₂ and Tₐ₃ had crude ash content of 1.12±0.20%, 1.35±0.12% and 1.56±0.30% respectively. Sample prepared with variety B showed 1.26±0.15%, 1.43±0.10% and 1.69±0.28% for Tₐ₁, Tₐ₂ and Tₐ₃. Therefore, ash content increases as the apple pomace
content increase in the food product. Results are allied with the research of Reis et al. (2014) who stated that apple pomace enriched bakery products have 3% ash content.

**Total phenolic content**

It was observed from graph (Figure 1) that T₃ exhibited the highest phenolic contents which explains that the addition of apple pomace significantly increase the phenolic content in muffins. As shown in graph regarding phenolic content in muffins, controlled sample displayed 1.62±0.38 mg/g. total phenolic content. Sample containing apple pomace of variety A shows 2.01±0.23 mg/g., 2.61±0.24 mg/g. and 3.01±0.25 mg/g for T₁, T₂ and T₃ accordingly. Whereas sample containing apple pomace of variety B exhibited 1.80±0.15 mg/g., 2.38±0.06 mg/g. and 2.76±0.28 mg/g. for T₁, T₂ and T₃ respectively. These results were supported with the findings of Sudha et al. (2007) who found that cake containing 25% of apple pomace exhibited 3.15 mg/g of apple pomace.

**Physical analysis of muffins**

**Color**

Color is one of the important indicators of consumer acceptance towards the product. It is a major concern in assessing consumer's perception, quality aspects and acceptability of a food product. The traits analyzed included L*, a* and b* values where L* depicts brightness, a* shows greenish to reddish tonality, whilst b* indicates bluish to yellowish color. Mean squares regarding L* value of color as logged table (3) interprets that corresponding attribute of color have significantly affected among all treatments. Means relating L* values of Muffins as shown in table (3) has revealed that T₃ and T₁ showed the maximum L* color values. T₃ exhibited 52.10±0.53 L* value, whereas mean value of color obtained of T₁, T₂ and T₃ were 49.26±0.09, 45.33±0.30 and 39.98±0.43. While T₁, T₂ and T₃ of variety B showed the L* value 51.68±0.21, 48.72±0.27 and 45.03±0.59.

It is evident from table (3) that a* value changed significantly. According to mean table (3) about a* value, it is recognized sample containing 15% of apple pomace powder of variety A displayed maximum value which is 8.10±0.05. From the mean table, it is known that T₃ showed the a* value of 5.61±1.25. T₁, T₂ and T₃ from variety A displayed 6.42±0.22, 7.00±0.33 and 8.10±0.25 respectively. Variety B muffins showed 6.03±0.50, 6.79±0.23 and 7.59±0.30 a* value for T₁, T₂ and T₃ respectively. Controlled sample showed b* mean value of 37.49±1.565 which is highest as displayed in mean table (3). Mean table (3) corresponding b* value about all the treatments, explains that there is significant relationship between all the treatments. T₁, T₂ and T₃ showed mean value 36.58±0.10, 33.33±0.46 and 29.10±1.44 respectively. It was found that in T₁, T₂ and T₃, from variety B the mean values were 36.12±0.71, 34.09±0.71 and 33.67±0.22. It is concluded that b* values significantly decreases with the increase in apple pomace in products.

**Texture of muffins**

In baking industry, the products having a specific shape and definite texture determine the acceptance or rejection of the product by the consumers. Any significant deviation from the acceptable textural range of the product is considered as decline in the product quality. In case of muffins, the most important parameter for texture is hardness. Texture analysis was performed with texture analyzer (TA-XT2, Plus, Stable Microsystems, Surrey, UK). Texture of product shows its quality. The while mean value of texture analysis were presented in table (4). Mean table displays that there was significant variation amongst the trials. From the mean table, sample with 15% of apple pomace powder of variety B showed maximum force of hardmess which is 0.67±0.02 Kg force. As shown in mean table, controlled sample showed 0.34±0.01 Kg force of hardness. Whereas sample prepared with apple pomace of variety A shows 0.40±0.02 Kg force, 0.49±0.06 Kg force and 0.62±0.02 Kg force for T₁, T₂ and T₃ respectively. While, muffins prepared with apple pomace variety B showed 0.44±0.03 Kg force, 0.56±0.01 Kg force and 0.67±0.02 Kg force for T₁, T₂ and T₃. These results pointed out that hardness of muffins increases as the percentage on apple pomace increase. These results are supported with the research of Sudha et al. (2007), who established that the hardness of cake was increased as the apple pomace percentage was increased in cake.

**Caloric values of muffins**

Results corresponding from mean table it was acknowledged that there is no significant relationship amongst the treatments. As from the mean table (4), it was found that the controlled sample showed 4633.0±11.150 caloric/gram which is highest between all the treatments. As for sample containing apple pomace powder of variety A showed 4598.0±10.26 cal/g, 4557.0±14.42 cal/g and 4534.0±12.31 cal/g for
Table 1. Mean Percentages of proximate composition

<table>
<thead>
<tr>
<th></th>
<th>Variety A (Kala Kullu)</th>
<th>Variety B (Golden)</th>
<th>Wheat Flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content</td>
<td>7.82±0.20</td>
<td>6.55±0.10</td>
<td>10.04±0.15</td>
</tr>
<tr>
<td>Protein</td>
<td>4.53±0.37</td>
<td>3.43±0.03</td>
<td>9.53±0.37</td>
</tr>
<tr>
<td>Ash</td>
<td>1.66±0.10</td>
<td>1.88±0.13</td>
<td>0.56±0.12</td>
</tr>
<tr>
<td>Fat</td>
<td>2.75±0.09</td>
<td>3.04±0.10</td>
<td>1.56±0.10</td>
</tr>
<tr>
<td>Fiber</td>
<td>12.01±0.11</td>
<td>10.63±0.39</td>
<td>0.63±0.06</td>
</tr>
<tr>
<td>NFE</td>
<td>71.22±0.45</td>
<td>74.47±0.50</td>
<td>77.68±0.09</td>
</tr>
</tbody>
</table>

Table 2. Proximate composition of muffins

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fiber</th>
<th>Fat</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>16.08±1.05</td>
<td>10.13±0.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.75±0.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.92±1.09</td>
<td>0.93±0.16&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tₐ1</td>
<td>15.62±0.67</td>
<td>9.57±0.15&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.57±0.39&lt;sup&gt;d&lt;/sup&gt;</td>
<td>20.12±1.00</td>
<td>1.12±0.20&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tₐ2</td>
<td>15.32±0.63</td>
<td>8.36±1.03&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.45±0.41&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>19.80±0.99</td>
<td>1.35±0.12&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tₐ3</td>
<td>15.10±0.47</td>
<td>7.01±0.81&lt;sup&gt;de&lt;/sup&gt;</td>
<td>3.13±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.59±0.98</td>
<td>1.56±0.30&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tₜ₁</td>
<td>15.39±0.52</td>
<td>8.83±0.51&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>1.160±0.22&lt;sup&gt;de&lt;/sup&gt;</td>
<td>20.30±1.01</td>
<td>1.26±0.15&lt;sup&gt;bcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tₜ₂</td>
<td>15.23±0.66</td>
<td>7.61±0.19&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>2.20±0.39&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.91±0.99</td>
<td>1.43±0.10&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
<td>Tₜ₃</td>
<td>14.89±0.49</td>
<td>6.38±0.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.94±0.18&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>19.70±0.98</td>
<td>1.69±0.28&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

** = Highly significant (p<0.01), * = Significant (p<0.05), NS = Non Significant

T₀: Sample containing 0% apple pomace; Tₐ1: Sample containing 5% apple pomace of variety A; Tₜ₁: Sample containing 5% apple pomace of variety B; Tₐ2: Sample containing 10% apple pomace of variety A; Tₜ₂: Sample containing 10% apple pomace of variety B; Tₐ3: Sample containing 15% apple pomace of variety A; Tₜ₃: Sample containing 15% apple pomace of variety B
Table 3. Color assessment in muffins

<table>
<thead>
<tr>
<th>Treatments</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>52.10±0.53a</td>
<td>5.61±1.25c</td>
<td>37.49±1.56a</td>
</tr>
<tr>
<td>Tₐ₁</td>
<td>49.26±0.09b</td>
<td>6.42±0.22cde</td>
<td>36.58±0.10a</td>
</tr>
<tr>
<td>Tₐ₂</td>
<td>45.33±0.30c</td>
<td>7.00±0.33bc</td>
<td>33.33±0.46b</td>
</tr>
<tr>
<td>Tₐ₃</td>
<td>39.98±0.43b</td>
<td>8.10±0.050a</td>
<td>29.10±1.44c</td>
</tr>
<tr>
<td>Tₐ₁</td>
<td>51.68±0.21a</td>
<td>6.02±0.50de</td>
<td>36.12±0.71a</td>
</tr>
<tr>
<td>Tₐ₂</td>
<td>48.72±0.27b</td>
<td>6.79±0.23bcd</td>
<td>34.09±0.71b</td>
</tr>
<tr>
<td>Tₐ₃</td>
<td>45.03±0.59c</td>
<td>7.58±0.30bc</td>
<td>33.67±0.22b</td>
</tr>
</tbody>
</table>

** = Highly significant (p<0.01), * = Significant (p<0.05), NS = Non Significant

Table 4. Texture and caloric assessment of muffins

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Texture (Kg Force)</th>
<th>Caloric value (cal/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>0.34±0.01c</td>
<td>4633.0±11.15</td>
</tr>
<tr>
<td>Tₐ₁</td>
<td>0.40±0.02d</td>
<td>4598.0±10.26</td>
</tr>
<tr>
<td>Tₐ₂</td>
<td>0.49±0.06c</td>
<td>4557.0±14.42</td>
</tr>
<tr>
<td>Tₐ₃</td>
<td>0.62±0.02a</td>
<td>4534.0±12.31</td>
</tr>
<tr>
<td>Tₐ₁</td>
<td>0.44±0.03d</td>
<td>4576.0±18.77</td>
</tr>
<tr>
<td>Tₐ₂</td>
<td>0.56±0.01b</td>
<td>4540.0±15.71</td>
</tr>
<tr>
<td>Tₐ₃</td>
<td>0.67±0.02a</td>
<td>4520.0±10.59</td>
</tr>
</tbody>
</table>

** = Highly significant (p<0.01), * = Significant (p<0.05), NS = Non Significant

T₀: Sample containing 0% apple pomace; Tₐ₁: Sample containing 5% apple pomace of variety A; Tₐ₁: Sample containing 5% apple pomace of variety B; Tₐ₂: Sample containing 10% apple pomace of variety A; Tₐ₂: Sample containing 10% apple pomace of variety B; Tₐ₃: Sample containing 15% apple pomace of variety A; Tₐ₃: Sample containing 15% apple pomace of variety B
Table 5. Sensory evaluation of muffins

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Color</th>
<th>Flavor</th>
<th>Texture</th>
<th>Thickness of wall</th>
<th>Uniformity</th>
<th>Grain size</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_o$</td>
<td>8.67±0.57a</td>
<td>7.17±0.76ab</td>
<td>8±1.00a</td>
<td>7.67±0.57a</td>
<td>7.67±0.57a</td>
<td>8.00±0.10a</td>
<td>8.00±0.10a</td>
</tr>
<tr>
<td>$T_{A1}$</td>
<td>8.00±0.10ab</td>
<td>7.67±0.57a</td>
<td>7.67±0.57ab</td>
<td>7.33±0.57a</td>
<td>7.67±0.57a</td>
<td>7.67±0.57ab</td>
<td>7.67±0.57abc</td>
</tr>
<tr>
<td>$T_{A2}$</td>
<td>7.33±1.15bc</td>
<td>6.67±1.52abc</td>
<td>6.67±0.57bc</td>
<td>6.67±0.57</td>
<td>6.84±1.04ab</td>
<td>7.33±0.57ab</td>
<td>7.33±0.57abc</td>
</tr>
<tr>
<td>$T_{A3}$</td>
<td>6.33±1.15cd</td>
<td>5.33±0.57c</td>
<td>5.83±0.76c</td>
<td>6.16±1.04</td>
<td>6.33±1.15abc</td>
<td>6.17±0.76c</td>
<td>6.83±0.76bcd</td>
</tr>
<tr>
<td>$T_{B1}$</td>
<td>7.00±0.50bcd</td>
<td>6.67±0.28abc</td>
<td>6.33±0.57c</td>
<td>6.83±0.76</td>
<td>5.5±1.00bc</td>
<td>6.67±0.57bc</td>
<td>6.67±0.57cd</td>
</tr>
<tr>
<td>$T_{B2}$</td>
<td>6.83±0.28bcd</td>
<td>6.33±0.57abc</td>
<td>6.17±0.28c</td>
<td>6.5±0.50</td>
<td>5.67±0.76bc</td>
<td>6.17±1.04c</td>
<td>6.17±0.76d</td>
</tr>
<tr>
<td>$T_{B3}$</td>
<td>6.00±0.10d</td>
<td>6.17±0.28bc</td>
<td>5.67±0.28c</td>
<td>6±0.50</td>
<td>4.83±1.25c</td>
<td>6.00±0.10c</td>
<td>6.00±0.10d</td>
</tr>
</tbody>
</table>

** = Highly significant ($p<0.01$), * = Significant ($p<0.05$), NS = Non Significant

$T_o$: Sample containing 0% apple pomace; $T_{A1}$: Sample containing 5% apple pomace of variety A; $T_{B1}$: Sample containing 5% apple pomace of variety B; $T_{A2}$: Sample containing 10% apple pomace of variety A; $T_{B2}$: Sample containing 10% apple pomace of variety B; $T_{A3}$: Sample containing 15% apple pomace of variety A; $T_{B3}$: Sample containing 15% apple pomace of variety B

![Total Phenolic Content (mg GAE/g)](image)

**Figure 1. Total Phenolic content of muffins as affected by different level of apple pomeace**

$T_{A1}$, $T_{A2}$ and $T_{A3}$. While $T_{B1}$, $T_{B2}$ and $T_{B3}$ showed 4576.0±18.77 cal/g, 4540.0±15.71 cal/g and 4520.0±10.599 cal/g. Therefore, there was a decreasing trend was observed in calorific values of the samples as the apple pomace powder addition was increased.

**Sensory Evaluation**

**Color**

Color of any product is the first perception received by consumer for selection of that product. From mean table (5), it was found that maximum points were
given to \( T_0 \) 8.67±0.57 and \( T_{A1} \) 8.±0.100 as compared to \( T_{A2}, T_{A3}, T_{B1}, T_{B2} \) and \( T_{B3} \) 7.33±1.15, 6.33±1.15, 7.00±0.50, 6.83±0.28 and 6.00±0.1 respectively. Mean values indicates that lightness of muffins was decreased with increased concentration of apple pomace. These results are also inconformity with the Sudha \ et al. (2007) who stated that the grain size of the cake significantly decrease with apple pomace incorporation.

**Flavor**

From the mean table (5), Controlled sample scored 7.17±0.76 whereas \( T_{A1}, T_{A2} \) and \( T_{A3} \) obtained 7.67±0.57, 6.67±1.52 and 5.33±0.57. Whereas, \( T_{B1}, T_{B2} \) and \( T_{B3} \) obtained 6.67±0.28, 6.33±0.57 and 6.17±0.28. So, \( T_{A1} \) gained the maximum points between all treatments regarding flavor characteristic.

**Texture**

Textural attributes of muffins specified with moistness, tenderness as well as softness. Mean values were presented in tables (5). According to mean table, \( T_0 \) and \( T_{A1} \) got maximum scores (8±1.00 and 7.67±0.57 respectively) and as compared to, \( T_{A2}, T_{A3}, T_{B1}, T_{B2} \) and \( T_{B3} \) got 6.67±0.57, 5.83±0.76, 6.33±0.57, 6.17±0.28 and 5.67±0.28 respectively. Results of texture evaluation by sensory panel supported by Sudha \ et al. (2007). According to them texture points was decreased as the concentration of APP in cake was increased.

**Thickness of the wall**

Results corresponding from the mean table (5), \( T_0 \) and \( T_{A1} \) showed the highest 7.67±0.57 and 7.33±0.57 respectively. Whereas \( T_{B2} \) showed the lowest value 6±0.50. The mean values for thickness are 7.33±0.57, 6.67±0.57, 6.16±1.04, 6.83±0.76, 6.5±0.50 and 6±0.50 for \( T_{A1}, T_{A2}, T_{A3}, T_{B1}, T_{B2} \) and \( T_{B3} \) respectively.

**Uniformity**

From the table (5), the highest point was given to the \( T_0 \) and \( T_{A1} \) which is 7.67±0.57. Uniformity of \( T_{A1}, T_{A2} \) and \( T_{A3} \) is 7.67±0.57, 6.84±1.04 and 6.33±1.15, while \( T_{B1}, T_{B2} \) and \( T_{B3} \) gained 5.5±1.00, 5.67±0.76 and 4.83±1.25 points.

**Grain size**

From the mean table (5), \( T_0 \) gained maximum score with 8.00±0.10. While, \( T_{A1}, T_{A2}, T_{A3}, T_{B1}, T_{B2} \) and \( T_{B3} \) obtained 7.67±0.57, 7.33±0.57, 6.17±0.76, 6.67±0.57, 6.17±1.04 and 6.00±0.10 respectively from the evaluation panel. Mean table shows that grain size muffins was reduced with increased concentration of apple pomace. These results are also in lined with the Sudha \ et al. (2007) who stated that the grain size of the cake was decreased with apple pomace incorporation.

**Overall acceptability**

Keeping in view all parameters, Muffin containing no apple pomace and containing pomace 5% \( T_{A1} \) got maximum points (8.0±0.100 and 7.67±0.57, respectively) as compared to other treated muffins as displayed in mean table (5). \( T_0 \) gained 8.00±0.10 score while \( T_{A1}, T_{A2}, T_{A3}, T_{B1}, T_{B2} \) and \( T_{B3} \) obtained 7.67±0.57, 7.33±0.57, 6.83±0.76, 6.67±0.57, 6.17±0.76 and 6.00±0.10 respectively from the judges. These findings are supported by Sudha \ et al. (2007), who interpreted that overall quality has inverse relation with concentration of apple pomace.

**Conclusion**

In this study, pomace of two apple varieties (Kala Kullu and Golden) was used to develop functional muffins. Difference levels of apple pomace were used (5, 10 and 15%). Developed muffins were analyzed for their antioxidant, physicochemical and sensorial attributes. It is inferred from results that supplementation of apple pomace powder up to 10% in muffin did not induce any adverse effect on aforementioned parameters. Addition of APP significantly enhanced the antioxidant potential of muffin. In color analysis, \( L^*\), \( a^*\) and \( b^*\) value were significantly varied among all treatments. Muffins with apple pomace (10%) performed better on hedonic scale as compared to others. Thus, apple pomace is the potential contender to be utilized to enhance the nutritional as well as sensory profile of the bakery food items.

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