APPLE POMACE POWDER AS A NATURAL FOOD INGREDIENT FOR THE DEVELOPMENT OF YOGURT

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Abstract

Apple pomace, the by-product of apple juice and cider production, is a promising source of phytochemicals and contains substantial quantities of dietary fibers, vitamins, and minerals. Incorporating apple pomace powder (APP) as a natural ingredient in yogurt presents a novel strategy to enhance the nutritional profile of a dairy product. The study examines the effects of APP addition on the physicochemical, bioactivity, sensory, and textural properties of APP-enriched yogurt—the evaluation involved including APP at different concentrations (1% and 2% w/w). The results showed that yogurts enriched with APP had enhanced antioxidant activity due to their increased polyphenol content. The investigation of the texture showed that yogurts with APP had a thicker and creamier consistency.
The sensory evaluation revealed that consumers found smaller concentrations (up to 1%) acceptable, whereas greater concentrations impacted their taste and texture preferences. The APP demonstrates potential as a natural ingredient in yogurt, providing nutritional advantages and improving functional characteristics while maintaining consumer acceptability at suitable levels.

Key words: apple pomace, natural ingredient, bioactive compounds, yogurt enhancement, consumer acceptance

Agro-industrial waste has a high amount of dietary fiber, phytochemicals, and other important elements. A significant portion of this waste is sometimes incinerated or disposed of improperly; yet, it contains numerous valuable and advantageous nutrients (Esparza I. *et al,* 2020).

Apple (*Malus domestica*) is one of the most extensively cultivated crops worldwide, with a recorded production of over 89 million tonnes in 2016 (FAO, 2018). One approximate estimate suggests that 35% of the overall apple production is allocated for cider, juices, and extracts (Malec J. *et al,* 2014). Apple pomace (AP), a cheap residual product of apple juice processing, contains an abundant concentration of pectin, antioxidants, and flavor components. Apple pomace is a promising source of phytochemicals and contains substantial amounts of carbs, dietary fibers, vitamins, and minerals (Bhushan S. *et al,* 2008). Naturally occurring antioxidants include catechins, procyanidins, caffeic acid, polyphenols, phloretin glycosides, quercetin glycosides, and chlorogenic acid (Golebiewska E. *et al,* 2022).

Approximately 25-30% of all apple products, such as juice, wine, jams, and dried goods, are derived from the skin, flesh, seeds, and stems. According to estimates, apple juice processing yields a product with a low concentration of polyphenolic chemicals and just 3-10% of the antioxidant activity found in the original fruit. The majority of polyphenol chemicals are retained in apple pomace, which is a diverse combination of peel, stem, core, seed, and soft tissue (Adil I.H. *et al,* 2007).

The composition of AP includes sugars that are not soluble, such as cellulose (127.9 g/kg dried weight), hemicellulose (7.2–43.6 g/kg dried weight), and lignin (15.3–23.5 g/kg dried weight). Additionally, AP contains simple sugars like glucose, fructose, and galactose (Cruz M.G. *et al,* 2018). Several investigations have shown that the use of AP can help prevent, reduce, and eliminate various diseases by positively affecting antioxidant status, metabolic dysfunction, gastrointestinal health, and weight loss (Skinner R.C. *et al,* 2018).

It has various potential uses, including the recovery of pectin, the preparation of jam and jelly, the manufacturing of enzymes, the production of animal feed, the production of organic acids, the production of ethanol, as a source of aroma compounds, and as a source of natural antioxidants (Szabó-Nótin B. *et al,* 2014).

Prior research has demonstrated that AP powder displayed favorable characteristics in terms of water retention capacity, solubility, swelling, and its ability to increase the viscosity of milk

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(Wang K. *et al,* 2019). Thus, AP has the ability to stabilize acidic dairy products.

Yogurt is a top-rated dairy product widely consumed worldwide. Consumers have chosen this product because of its positive effects on the intestinal environment and the body's immune system. Yogurt possesses distinctive flavor, texture, and favorable sensory attributes. Yogurt also has positive effects on our intestinal microflora (Issar K. *et al,* 2017). However, the indicated health-promoting qualities motivate food entrepreneurs to prioritize apple pomace phytochemicals in food products such as food supplements, nutraceuticals, and diets enhanced with phenolic compounds. (Ganesh K.S. *et al,* 2021). Hence, the use of sustainable agricultural practices provides the potential to mitigate environmental damage and enhance the convergence into a circular economy.

The objective of this study was to examine the possibility of apple pomace powder (APP) as a natural component in yogurt. The physicochemical, phytochemical, and color aspects of the yogurt, along with its textural and sensory evaluations, were assessed to demonstrate the enhanced value of the product itself.

MATERIAL AND METHOD

The University of Life Sciences' Rediu Iași Research Station provided 200 L of cow's milk. In order to obtain the APP, the fruits were washed and squeezed using a fruit juices. Following this process, the apple core was then dried at a controlled temperature of +42ºC in the oven. The resulting by-product was ground into a fine, ready-to-use powder using a grinder (Blender Nutribullet Original).

The following chemicals were obtained from Sigma Aldrich Steinheim (Darmstadt, Germany): Hexane, acetone, ethanol, methanol, Folin-Ciocalteu reagent, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 6-hydroxy2,5,7,8 tetramethylchromane-2-carboxylic acid (Trolox), sodium hydroxide, sodium nitrite, Gallic acid, aluminum chloride solution, and sodium carbonate. All the other substances utilized in the studies were of analytical quality.

Extraction of biological active compounds from APP. The ultrasound-assisted extraction technique, as outlined by Gavril (Ratu) R.N. *et al* (2024), was employed to extract the bioactive constituents from APP with slight adjustments. 1.0 g of APP was combined with 10 mL of a solvent combination consisting of 3 parts n-hexane to 1-part acetone, or 70% ethanol (used for extracting polyphenols and flavonoids). The mixture was then subjected to ultrasonic treatment using an Elmasonic S 180 H ultrasound bath from Elma, Germany. The treatment lasted for 35 minutes at a temperature of 30°C and a frequency of 37 kHz. The obtained extract was thereafter retrieved and subjected to centrifugation at a speed of 6500 rpm and a temperature of 10°C for 10 minutes. Subsequently, the APP supernatant was analyzed for the overall content of carotenoids, flavonoids, and polyphenols.

The determination of carotenoids, phenolic compounds and antioxidant activity of APP extract.

Total carotenoid content. The carotenoid concentration was quantified using the spectrophotometric techniques described by Mihalcea L. *et al* (2018). The absorbance at 450 nm for the total carotenoid concentration of the extract was measured using a UV–VIS spectrophotometer, namely the Analytik Jena - Specord 210 Plus model from Germany. The results were expressed in milligrams per 100 grams of dry weight (d.w.).

Total flavonoid content. The Horincar G. *et al.* (2019) method was employed to quantify the total flavonoid concentration of the APP extract, with certain adjustments. The absorbance of the resultant mixture was promptly measured at a wavelength of 510 nm. The total flavonoid content was calculated in milligrams of catechin equivalents (EC) per gram, using the equation derived from the standard catechin calibration curve ($y = 2.8919x + 0.006$ with $R^2 = 0.9968$).

Total polyphenolic content. The Folin-Ciocâlteu colorimetric method was employed to quantify the total polyphenol concentration. According to Horincar G. *et al* (2019), absorbance measurement was taken at a specific wavelength of 765 nm. The polyphenolic component content was quantified as milligrams of Gallic acid equivalents (GAE) per gram of dry weight (dw), using an equation derived from the standard Gallic acid calibration curve ($y = 1.6991x - 0.0256$ with $R^2 = 0.9837$).

Antioxidant activity (DPPH). The antioxidant activity was measured using the DPPH technique, and the results were reported as µmol of Trolox equivalents per gram of dry weight (µmol TE/g d.w.) (Castro-Vargas H.I. *et al,* 2010). The calibration curve employed Trolox as the standard, with a linear equation of $y = 0.45x + 0.0075$ and a coefficient of determination (R^2) of 0.993. The samples were produced by combining 0.10 mL of each extract with 3.90 mL of a 0.1 M DPPH solution. The solutions were thereafter incubated at ambient temperature in the absence of light for 30 minutes before measuring the absorbance (Af) at a wavelength of 515 nm. For the blank (A0), the 3.9 mL solution of DPPH along with 0.10 mL of pure methanol was prepared. Additionally, the percentage of inhibition was computed. The inhibition percentage can be calculated using the formula: $(A0 - Af) / A0 \times 100$.

Yogurt manufacturing. The yogurt manufacturing process using APP starts with the initial stage of receiving the raw materials and ingredients, which include cow's milk, lactic cultures, and auxiliary materials. Once the milk has been filtered, it undergoes a low-pasteurization procedure at a temperature of 65 °C for 20 minutes. The milk was subjected to a process of concentration at a temperature of 90–91 °C for 14 seconds. Afterward, the milk was chilled while the temperature was observed and kept at 43 °C. Following the prior dosing and preparation, the subsequent step in the technological process involved the inoculation of milk with lactic starter cultures. The concentration of lactic starter cultures per batch was also measured (mg/batch). Subsequently, the technical technique advanced by incorporating the bioactive component and closely monitoring its concentration at levels of 1% YAPP1 and 2% YAPP2 per batch. The yogurt was dispensed into PET glasses with a volume of 250 mL, and then sealed by thermo-welding at a temperature of 227 °C. The thermostating technique entails the controlled maintenance of yogurt-filled glasses at certain temperatures for a specific duration. During this step, the time and temperature of the thermostat were observed and recorded in the following manner: 360 minutes at 43 °C; 90 minutes at 20 °C; 60 minutes at 15 °C; and 360 minutes at 6 °C. Subsequently, the yogurt was stored at a temperature range of 2–4 °C for further analyses.

The samples were analyzed for moisture content, total protein, fat, ash, and pH following the methods specified by the Association of Official Analytical Chemists (AOAC, 2010).

Texture analysis. The texture of the yogurt samples was analyzed by Texture Profile Analysis method (TPA), applied with a Brookfield CT3 Texture Analyzer. The testing parameters were as follows: the diameter of the cylinder probe was 35 mm, the test speed was 1.0 mm/s, the penetration distance was 25 mm, and the surface trigger force was 10 g. The Exponent software estimated the following parameters: Cohesiveness, Elasticity, Firmness, Gumminess, Chewiness, Resilience. Five measurements were conducted for each sample, and the texture parameters were computed using TexturePro CT v1.5 software developed by Brookfield Engineering Labs. Inc.

Color analysis. The measurement of color was conducted using a colorimeter (Konica Minolta Chroma Meter CR-410, Osaka, Japan). Three yogurt samples were used to fill the cuvette. The CIELab parameters L∗, a∗, and b* were provided, together with the hue angle Hue angle = 180 + arctan(b*/a*) for quadrant II (-a*, +b*)), ΔE= total color difference ($\sqrt{L*^2+a*^2+b*^2}$) and Chroma ($\sqrt{(a^*)^2+(b^*)^2}$). The value of L* (lightness) ranges from 0 (representing black) to 100 (representing white). The coordinate a* represents the color spectrum from red (positive) to green (negative), while the coordinate b* represents the color spectrum from yellow (positive) to blue (negative) (McGuire R.G., 1992).

Sensorial analysis. The sensory evaluation of yogurt, both with and without APP, was conducted by a group of 20 panelists who were not trained in sensory evaluation. These panelists were habitual consumers of yogurt (consuming it more than once a month) and were between the ages of 18 and 41. The group consisted of 9 males and 11 females, who were recruited randomly. The participants were notified about the study's primary goal and the essential protocols for managing personal data. Panelists were instructed to assess the enriched yogurts on a 9-point hedonic scale, rating several aspects such as appearance, color, odor, flavor, consistency, taste, aftertaste, and overall acceptability. The scale ranged from 1 (very dislike) to 9 (highly like). The sensory evaluation area was kept in an appropriately air-conditioned environment, with the temperature in the booths controlled at around 25 ºC. The samples were exhibited in a randomized sequence. Panelists were instructed to cleanse their mouths meticulously with water following each sample assessment.

Statistical Analysis. The experiments were replicated three times unless otherwise specified. The data are presented as the average value ±the standard deviation. The statistical study was conducted using Minitab 17 software. The statistical significance was established with a p-value of less than 0.05. The data were examined using a one-way analysis of variance (ANOVA) followed by a Tukey test.

RESULTS AND DISCUSSIONS

Fruit juice processing firms produce a significant quantity of industrial waste, such as apple pomace. The phytochemical composition and antioxidant capacity of the apple pomace extract were assessed and the findings are presented in *table 1*.

Table 1 shows that APP extract had a high carotenoid content of 15.25±0.22 mg/100g d.w. DPPH radical scavaging activity was 18.78±0.09 µmol TE/g d.w. Our results were lower compared to another study, that reported a total polyphenol content of 52.36 ± 1.22 mg GAE/g and a total flavonoid content of 8.40 ± 0.13 mg CE mg/g (Ahmed M.A. *et al.* 2022) after the conventional extraction of APP bioactives with ethyl acetate and stirred at 20°C for 3 hours.

Table 1

Phytochemical content of the APP extract

Parameters	*Sample APP*
Total carotenoids (mg/100g d.w.)	15.25±0.22
Total flavonoids (mg CE/g d.w.)	2.71±0.04
Total polyphenols (mg GAE/g d.w.)	8.40±0.26
DPPH (µmol TE/g d.w.)	18.78±0.09
Inhibition (DPPH) %	83.34 ±0.28

The phytochemical composition of the apple pomace extract varies because of differences in the phytochemical variability of raw materials, raw material fractions, extraction procedures, and environment. The extracts from the apple pomace appear to be remarkable due to their bioactive potential and antioxidant activity.

The samples' phytochemical composition and antioxidant activity are displayed in *table 2*. The food products obtained were examined for their overall phytochemical composition.

Table 2

Phytochemical profile of the control and APP-supplemented yogurts

Parameters	*Type of* Yogurt		
	YC	YAPP1	YAPP2
Total carotenoids (mg/100g d.w.)	-	17.32±0.28[b]	29.19±0.50[a]
Total flavonoids (mg CE/g d.w.)	1.18±0.12[c]	3.88±0.10[b]	8.23±0.08[a]
Total polyphenols (mg GAE/g d.w.)	1.73±0.14[c]	5.10±0.22[b]	10.17±0.27[a]
DPPH (µmol TE/g d.w.)	16.89±0.25[c]	35.24±0.27[b]	47.02±0.32[a]
Inhibition (%)	27.20±0.29[c]	41.12±0.17[b]	52.03±0.19[a]

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

The inclusion of APP in the yogurt products resulted in a dose-dependent increase in phytochemicals (carotenoids, flavonoids, polyphenols) and the ability to scavenge free radicals, as compared to the control group ($p < 0.05$). The addition of increasing concentrations of RFP, ranging from 1 to 2%, resulted in a proportional rise in the levels of carotenoids, flavonoids, and polyphenols in the supplemented yogurts, demonstrating a dose-dependent effect. The scavenging of free radicals by antioxidant activity is directly correlated with the presence of phenolic and flavonoid components in specific food systems. A notable increase in antioxidant activity was seen when the quantities of APP steadily increased. The obtained yogurts highlighted the satisfactory content in phytochemicals. These findings are consistent with those of Ahmed M.A. *et al.* (2022), who found that yogurt containing apple pomace (1 to 2%) increased polyphenols (3.67 to 3.99 mg GAE/g), flavonoids (1.24 to 1.35 CE mg/g), and antioxidant activity (61.80 to 63.85%).

Table 3

Chemical composition of the control and APP-supplemented yogurts

Parameters	*Type of Yogurt*		
	YC	YAPP1	YAPP2
Water (%)	85.30±0.05[a]	83.71±0.02[b]	83.11±0.03[b]
Dry mattter (%)	14.70±0.07[b]	16.29±0.03[a]	16.89±0.02[a]
Fat (%)	4.43±0.04[a]	4.66±0.03[a]	5.07±0.03[b]
Carbohydrate (%)	5.22±0.06[a]	3.29±0.06[b]	1.99±0.05[c]
Protein (%)	4.53±0.04[b]	4.92±0.04[b]	5.12±0.03[a]
Crude fiber (%)	0.00±0.00[c]	3.40±0.03[b]	4.01±0.03[a]
Ash (%)	0.75±0.02[c]	0.97±0.03[b]	1.12±0.04[a]
pH	4.40 ± 0.11[b]	4.60 ± 0.11[a]	4.64 ± 0.11[a]
Energy value (Kcal/100 g)	77.98±0.16[a]	73.20±0.12[b]	72.69±0.07[b]

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

Table 4

Texture of the control and APP-supplemented yogurt samples

Component	*Type of Yogurt*		
	YC	**YAPP1**	**YAPP2**
Cohesiveness	0.36 ± 0.01^{b}	0.37 ± 0.01^{ab}	0.40 ± 0.01^{a}
Elasticity	5.20± 0.01^{a}	4.31± 0.01^{b}	2.98 ± 0.02^{c}
Firmness, N	5.45 ± 0.02^{c}	6.40 ± 0.02^{b}	7.10 ± 0.01^{a}
Gumminess,	2.00 ± 0.01^{b}	2.60 ± 0.01^{a}	2.64 ± 0.02^{a}
Chewiness, N	14.15± 0.03^{c}	16.11± 0.02^{b}	17.56± 0.03^{a}
Resilience	2.91± 0.01^{c}	3.54± 0.03^{b}	3.89± 0.02^{a}

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

Kennas A. *et al* (2020) documented the beneficial effects of including extra fruit by-products into yogurt polyphenols. They discovered a significant correlation between the levels of yogurt polyphenols and the quantities of added pomegranate peel. Chemical composition of supplemented yogurt. The results of physicochemical composition of yogurt supplemented with APP are summarized in *table 3*.

The addition of APP to yogurt resulted in a substantial enhancement of its chemical composition in comparison to the control. The addition of 1%, and 2%, of APP increased the dry matter, fat, total protein, ash content, and crude fiber of enriched yogurts compared with the control. These results may be due to apple pomace having a high amount of total solids, and proteins. The moisture and carbohydrate levels of all developed yogurts showed a considerable decrease compared to the control yogurt.

The pH of yogurt tends to rise, indicating a decrease in its acidity, which could be attributed to the dilution component. After introducing APP in ascending order, there was a considerable increase in the levels of total solids, as well as fat and ash. There were similar increases in total soluble solids levels when APP was added to the development of fiber-enriched yogurt, as reported in the study of Nagaoka S. (2019).

The textural characteristics of yogurt are essential in evaluating its quality, directly influencing the sensory perception and acceptability of the product by consumers. The evaluation of yogurt samples texture includes essential criteria such as hardness, cohesiveness, elasticity, gumminess chewiness and resilience, which are significantly influenced by the addition of apple powder. The results of these parameters are presented in *table 4*. The APP- supplemented yogurts exhibited lower elasticity, and higher firmness, cohesiveness, gumminess, chewiness, and resilience compared with the control sample.

Yogurt firmness, defined as the force required to cause a certain deformation, is a critical parameter in texture evaluation. Research have shown that yogurt firmness increases with increasing apple powder concentration (Wang X. *et al,* 2019). Thus, firmness was 5.45 N for YC, 6.40 N for yogurt with 1% apple powder (YAPP1) and 7.10 N for yogurt with 2% apple powder (YAPP2). This increase in firmness can be attributed to the interactions between the powder and the protein matrix, which modify the gel network formed during fermentation (Wang X. *et al,* 2019).

The energy required for food breakdown during mastication is referred to as chewiness. It was found to be 16.11± 0.02 N for YAPP1 and 17.56± 0.03 for YAPP2, indicating an increase. Yogurt cohesiveness, another crucial factor, indicates the internal strength of the product structure. The addition of apple powder caused a significant increase in cohesion compared to the control yogurt. Yogurt samples with the addition of 1% and 2% apple powder showed higher cohesion, due to the additional structure provided by the powder, suggesting that apple powder can strengthen the protein network and improve the textural stability of the yogurt.

Table 5

Color evaluation of the control and APP-supplemented yogurt samples

Parameters	*Type of Yogurt*		
	YC	**YAPP1**	**YAPP2**
L*	91.44±0.03^{a}	82.76±0.04^{b}	79.24±0.07^{c}
a*	-8.99±0.02^{a}	1.89±0.01^{b}	2.89±0.07^{c}
b*	11.16±0.01^{c}	16.57±0.02^{b}	19.33±0.10^{a}
Chroma	14.33±0.01^{c}	16.68±0.03^{b}	19.54±0.06^{a}
Hue angle	179.11±0.02^{a}	1.45±0.01^{b}	1.43±0.07^{b}
ΔE	92.53±0.01^{a}	84.41±0.02^{b}	81.58±0.10^{c}

The letters used for every sort of yogurt reflect a comparison based on color characteristics. The distinct characters in each row represent means that show significantly different results ($p < 0.05$).

The investigation of the texture showed that yogurts with APP had a thicker and creamier consistency. This can be ascribed to the high fiber content, which also had a favorable effect on the ability of the yogurt to retain water. Based on the texture analysis, the inclusion of RFP enhanced the textural characteristics of the yogurt in direct proportion to the concentration.

Color evaluation of the control and APP-supplemented yogurt samples. The study revealed significant variations in L*, a* and b* values, depending on the concentration of added apple powder (*table 5*).

The control sample, without the addition of apple powder, showed a lighter color, highlighted by a higher L* value compared to yogurts containing apple powder. This observation suggests that the addition of apple powder lowers the brightness, resulting in a darker color. This change is attributed to the presence of colored compounds in apple powder, which absorb light and reduce the L* value. The a* and b* values increased with the increase in the percentage of apple powder added to the yogurt. Increasing a* values indicate an intensification of red hues, while increasing b* values reflect an accentuation of yellow hues. These changes suggest that the apple powder adds greater color complexity to the yogurt, perceptibly influencing the visual appearance of the product. The highest b* value was obtained for the YAPP2 sample, indicating an intense yellow hue. According to the data presented in *table 5*, yogurts enriched with apple powder (YAPP1 and YAPP2) are characterized by an increased intensity of yellow color, directly proportional to the concentration of added apple powder. This observation is consistent with the presence of phenolic and carotenoid compounds in apple powder, which contribute to the intensification of yellow shades. The hue of yellow was the most descriptive in describing the color of the sample, according to Chroma, a measure of color intensity and saturation, which showed the same trend as the parameter b*. ΔE is the attribute of total color change and ranged from 81.58 to 92.53. The results of the CIELAB colorimetric analysis demonstrate that the addition of apple powder significantly influences the color parameters of the yogurt. The decrease in the L* value and the increase in the a* and b* values reflect a noticeable change in visual appearance, giving the supplemented yogurt a darker and more complex color. These color changes not only improve the visual appeal of the product, but can also be correlated with increased content of bioactive compounds, bringing additional benefits to the final product.

Using a 9-point hedonic scale, the produced yogurts were subjected to a sensory examination, assessing sensory qualities such as appearance, color, odor, flavor, consistency, taste, aftertaste, and overall acceptability. The average results of the sensory evaluation are shown in *table 6*. The results showed that yogurt with 1% and 2% (*w/w*) APP had good overall consumer acceptability for the majority of the attributes assessed.

Table 6

Sensory evaluation scores of control and APP-supplemented yogurts

Sensory attributes	***Type of Yogurt samples***		
	YC	**YAPP1**	**YAPP2**
Color	8.01±0.09[c]	8.21±0.21[b]	8.33±0.29[a]
External appearance	7.27±0.11[b]	8.07±0.13[a]	8.22±0.19[a]
Odor	7.20±0.08[b]	8.00±0.17[a]	8.20±0.21[a]
Flavor	7.32±0.10[c]	8.12±0.20[b]	8.30±0.31[a]
Consistency	8.00±0.22[c]	8.14±0.33[b]	8.28±0.41[a]
Taste	8.07±0.13[c]	8.20±0.22[b]	8.32±0.34[a]
Aftertaste	8.03±0.11[c]	8.11±0.17[b]	8.25±0.22[a]
Overall acceptability	8.11±0.08[c]	8.31±0.16[b]	8.42±0.19[a]

Means that do not share a letter in a row are significantly different at level ($p < 0.05$).

All tested products received positive evaluations from the panelists. Overall acceptability hedonic scores increased as APP concentration increased. The YAPP2 yogurt with 2% APP scored highest overall for acceptance attributes in terms of sensory evaluation. This implies that incorporating APP into yogurts can improve their sensory attributes.

Figure 1 **Yogurt samples with different percentages of APP: YC (control), 1% (YAPP1), and 2% (YAPP2)**

The sensory evaluation scores exhibited a significant ($p<0.05$) disparity between the supplemented and control yogurt following the addition of varied quantities of APP. The inclusion of APP up to 2% in yogurt resulted in a high like score of "8" for appearance, odor, flavor, consistency, taste, aftertaste, and overall acceptability, as evaluated by the panelists. This was in comparison to the control yogurts (*figure 1*). The YAPP2 yogurt, which contain 2% APP, received the highest ratings across all 8 characteristics.

CONCLUSIONS

The efficacy of apple pomace as a natural and attractive ingredient in yogurt manufacturing has been proven. Apple pomace not only provides food but also serves as a valuable source of natural flavors and coloration. The yogurt samples that were treated showed a greater quantity of total phenolic contents and antioxidant potential compared to the control yogurt. When apple powder is added to yogurt, it improves some nutritional properties compared to the control sample. It offers the dairy industry new prospects to satisfy the increasing consumers desire for nutritious meals by creating inventive, healthy, and attractive yogurt products.

According to the sensory evaluations, the APP-supplemented yogurts are likely to be acceptable for consumers because they have generally satisfactory characteristics. Hence, apple pomace, a fruit by-product, can be integrated as a natural ingredient and texturizer during yogurt fermentation. This approach enhances the health benefits of yogurt and also encourages sustainable practices by utilizing agricultural by-products. Future research should focus on optimizing the concentration of APP and exploring the long-term health consequences of regular use of yogurt enriched with APP.

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