EFFECT OF APPLE POMACE POWDER ADDITION ON MILLIT FLOUR BASED BISCUITS QUALITY

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Abstract

Apple pomace is the primary byproduct generated from the production of apple juice. This study investigates the effect of apple pomace powder (APP) on baking quality of millit flour based biscuits

After preparing the biscuits were packaged in polypropylene bags and stored at room temperature for 14 days. During storage colour, water activity, moisture content measurements, sensory evaluation, total polyphenol content and FRAP value (antioxidant capacity) determination, therefore texture profile analysis were performed.

By increasing the concentration of apple pomace, the hardness, adhesion, cohesion, polyphenol content and antioxidant capacity increased, while their brightness, moisture content, water activity and overall popularity decreased. Apple pomace flour addition also increased the sweet taste intensity of cookies suggesting that in bakery products APF evolve a flavor enhancer role.

Based on the sensory and compositional attributes, it was concluded that good quality cookies can be prepared through using 5% apple pomace powder with millet flour. APP proved to be a promising alternative to increase dietary fiber content of millet flour based biscuits.
Keywords: *apple pomace, millet flour, texture profile analysis*

1. INTRODUCTION

Apple pomace is a by-product of the apple cider processing industry and represents about 20–35% of the original fruits (Rabetafika et al., 2014). It can be used for value-added products, because it is rich in pectin, dietary fibre, macro and micro elements, antioxidants, such as polyphenol (Soler et al., 2009). Apple pomace has a lot of utilization possibility, such as ethanol production, direct burning, gasification, methane generation, food (pomace in jams and in sauces, confectionery products such as pomace powder for toffees, using pomace powder in bakery products (Masoodi and Chauhan,1998; Rupasinghe et al., 2008; Sivam et al., 2011; Sudha et al., 2007), pectin production, citric acid production, fibre extraction, and livestock feed (Shalini et al., 2010; Wang and Thomas, 2008). In fresh state apple pomace can spoils very fast, because of the large amounts of water. Because of this drying of the pomace is an important technical step.

Dried apple pomace powder (APP) can use in bakery products to enhance dietary fiber and bioactive compounds in the products (Jung et al., 2015). This study is aimed to investigate the effect of apple pomace powder on baking quality of millit flour based biscuits.

2. MATERIALS AND METHODS

2.1. Materials

Wet apple pomace which had not been treated by pectic enzymes was obtained from a Hungarian juice processor (Agrana Juice Ltd.). Drying was performed using the conventional oven (LP 232/1, Hungary), 200g of the pomace were spread in a drying tray with a depth of 0.5 cm, the drying temperature was 80°C and samples were dried in the dryer until reached 4 % moisture content. Dried samples were ground into flour using a “PRINCESS” multi chopper and grinder and after it were vacuum packaged.

Coconut oil, millet flour, agave syrup, brown rice flour, erythritol (E 968) and coconut flour were purchased at the local supermarket.

2.2. Methods

2.2.1. Preparation of bakery products

Cookies were prepared by following: the formula for control (AP0) as: coconut oil (23.82 g), millet flour (22.86 g), agave syrup (19.05 g), brown rice flour (17.14 g), erythritol (9.52 g) and coconut flour (7.62 g). After it 2.5 (AP2.5); 5 (AP5) and 10% (AP10) APP were added to the formula. The cookies were round in shape with diameter of 45 mm and thickness of 6-8 mm and baked in an electric oven at 180 °C for 9 min. Figure 1. represents the samples.

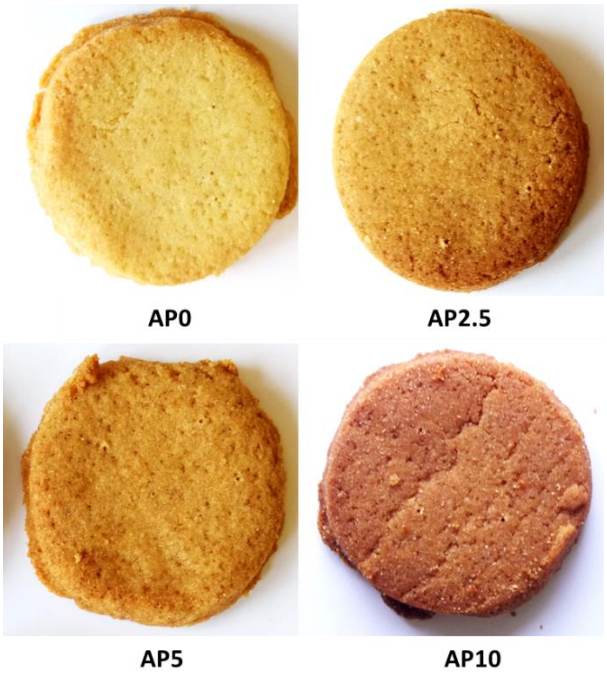


Figure 1. The different apple pomace content prepared biscuits

2.2.2. Determination of dry material content and water activity

Determination of dry material content of apple pomace and biscuits was performed by using a MAC-50 rapid moisture analyzer (Radwag Waagen GmbH, Hilden, Germany). To determine the water activity, Novasina, LabMaster-aw equipment was used.

2.2.3. Determination of baking loss values

After cooling to room temperature, biscuits were weighed and baking loss (Bl) was determined using this equation: $Bl = ((w_1-w_2)/w_1)\times100$, where w_1 is the weight of cookie prior to baking, w_2 is the weight of cookie after baking.

2.2.4. Colour measurements

Color of the surface of the baked biscuits was measured with 9 parallels (3 biscuits/3 places) using a Konica Minolta CR400 chromameter. Results were expressed as L*, a*, and b* values. L* is a measure of the brightness from black (0) to white (100), while a* describes the red green color (a*> 0 indicates redness, a* < 0 indicates greenness), and b* describes yellow-blue color (b*> 0 indicates yellowness, b* < 0 indicates blueness). To determine the total color difference between two samples using all the three coordinates, the following formula was used (CIE, 2004):

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

2.2.5. Texture analysis

Texture analysis of the biscuits was performed using a Brookfield LFRA Texture Analyzer (LFRA 4500 Texture Analyser; Brookfield, USA) with the probe-type TA43, metal needle. Three cookies were selected, and the measurement was performed on their center and two side points. The data were recorded, and the analysis of the texture profile was performed by using TexturePro Lite v1.1 Build 4 software. The test parameters were the follows: total cycles 2, test speed 2 mm/s, and target value 4 mm (distance reached by the test piece in the sample). Based on the texture profile load (g) in function of time (s), hardness (g) (maximum deformation force during the first mastication cycle), adhesion (gs) cohesiveness (dimensionless), springiness (mm), gumminess (g), and chewiness (gmm) were determined (Bourne 2002).

2.2.6. Sensory evaluation

Sensory evaluations were conducted at Hungarian University of Agriculture and Life Sciences, Sensory Evaluation Laboratory, using preference testing method. One special case of preference testing methods is the so-called Check-All-That-Apply (CATA) type tests. This is a widely used judging method, in which critics do not evaluate the intensity / popularity of a trait, but identify several traits or traits listed on the review sheet that are specific to that product (Meyners and Castura, 2014).

2.2.7. Determination of total polyphenol content

Total phenolics were determined using the Folin–Ciocalteu colorimetric method as described by Singleton and Rossi (1965). Briefly, 1250µL of Folin solution (1:10 v/v Folin; distilled water) was added in the test tube followed by addition of 150µL of methanol (4:1 v/v methanol; distilled water). Then, 200µL of the sample (biscuit extract) was added and the solution was allowed to stand for 1 minute, followed by the addition of 1000µL of sodium carbonate solution. The results were expressed in gallic acid equivalents (GAE, µg ml^{-1} pomace extract).

2.2.8. Determination of antioxidant capacity

Antioxidant capacity was determined using Ferric Reducing Ability of Plasma (FRAP) assay (Benzie and Strain, 1996). Producing FRAP reagent were used acetate buffer (pH 3.6), 2,4,6-tripyridyl-s-triazine (TPTZ) solution, and FeCl3 × 6 H2O solution. The reagent and samples (biscuit extracts) were added to each well and mixed thoroughly. The absorbance was taken at 593 nm after 5 min. Results were expressed in ascorbic acid equivalent (mg ascorbic acid mL^{-1} extract) using an ascorbic acid standard calibration curve.

2.2.9. Statistical analysis

In case of statistical analysis the mean values were compared by 2-way analysis of variance (ANOVA) when evaluating the sensory attributes of the products ($\alpha = 0.05$). Pair comparison was done by Tukey HSD post hoc test. The statistical analysis was carried out using SPSS ver.No.23.

3. RESULTS AND DISCUSSION

In general geometry is an important parameter in baking quality of biscuits. Increased volume of baking products is associated with their improved quality (Hoseney and Rogers, 1994; Pareyt et al., 2011). Baking loss refers to the moisture loss during baking: The higher water binding capacity of dough is related to lower baking loss. The baking loss values of the biscuits are shown in Figure 2.

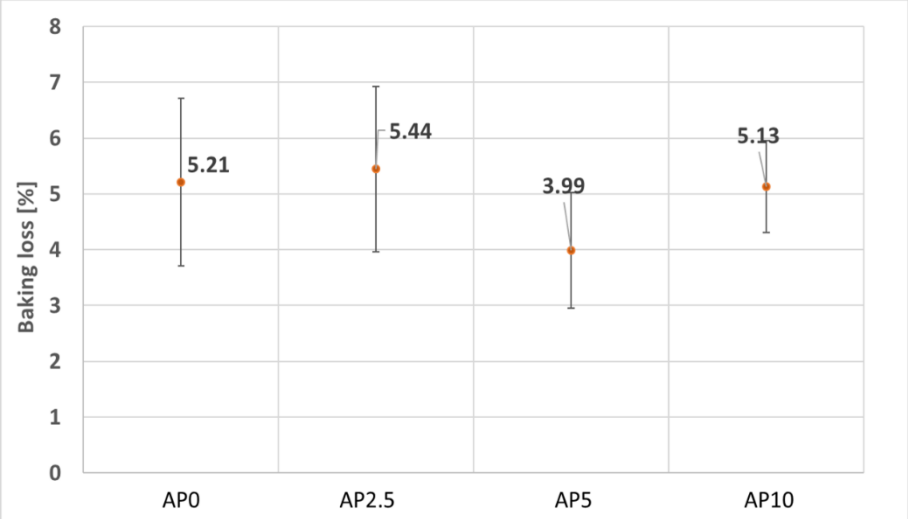


Figure 2. Baking loss of the biscuits

Color has primarily importance in acceptability of biscuits by costumers and an important parameter in determination of baking quality. During the color measurement, L* and ΔE* values were considered as these properties show the difference between the biscuits the most (Figure 3). In case of the biscuits, significant differences were observed during storage considering the L* values. Pairwise comparison shows that for all biscuits, the 14-days stored samples differed significantly from the samples measured on days 1, 5, and 10 (p=0.000). This shows that by day 14, the samples became darken.

Color difference (ΔE*) between control and APP added cookies was above 6.0 indicating huge difference. Critical values: ΔE* < 1.5: not perceptible; 1.5 < ΔE*<3.0: perceptible; 3.0 < ΔE* <6.0:well perceptible; 6.0 < ΔE*: huge (Juhász et al., 2020).

In addition, there were differences in the ΔE* values for apple pomace concentrations during storage. The AP2.5% biscuits showed no significant change, while the AP5% and AP10% biscuits showed a change over time. For AP5% biscuits, the 14-day samples differed from the other samples. Thus, there was no significant difference between the AP10% biscuits. Thus, a visible difference was seen only in the case of AP5% biscuits on day 14. ANOVA, examining the L* and ΔE* properties, showed a significant difference between the different apple pomace concentrations (p=0.000). When comparing the L * and ΔE * values in pairs there was no difference only between the AP2.5% and AP5% biscuits, so there was no visible difference between the two biscuits. In the case of AP biscuits, it can be said that with the increase of apple pomace, the brightness of the biscuits (except for the brightness between 2.5 and 5%) decreases.

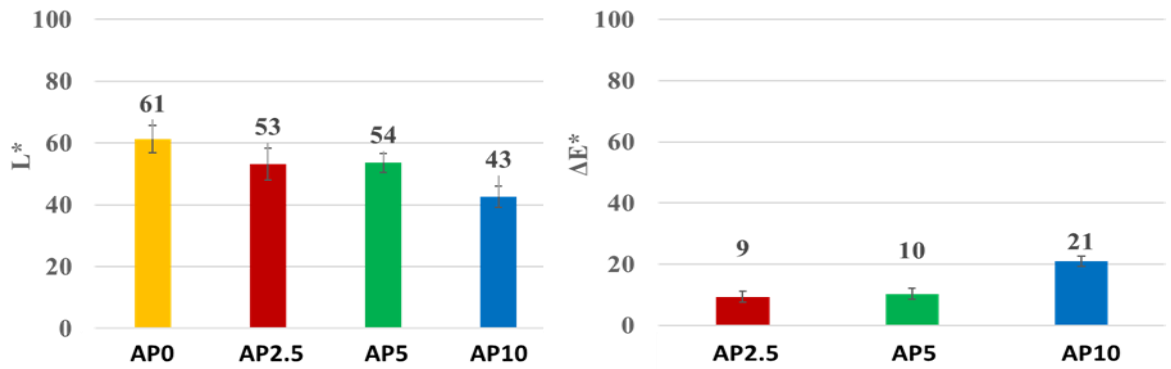


Figure 3. L* values and ΔE values

According to the literature the addition of apple pomace decreases the L* value of the samples and increases the color difference (Ajila et al., 2008; Sudha et al., 2007; Alongi et al., 2018). This decrease in L* and the color difference between the samples can be caused by the brown color of the pomace and the behavior of polyphenols as substrates, which can lead to enzymatic tanning (Sudha et al., 2007). In addition, glucose and fructose are present in the pomace, which are involved in the Maillard reaction. Melanoids and reaction products formed during the Maillard reaction cause browning in fried products (Martins et al., 2001; Belitz et al., 2009).

Moisture content and water activity did not change much during storage, so the differences between the biscuits weighed on the first day were examined. The water activity values of AP biscuits are below 0.6 (Figure 4.) which means a microbiological stability, but it can only be stated that these foods are stable with the knowledge of appropriate microbiological tests.

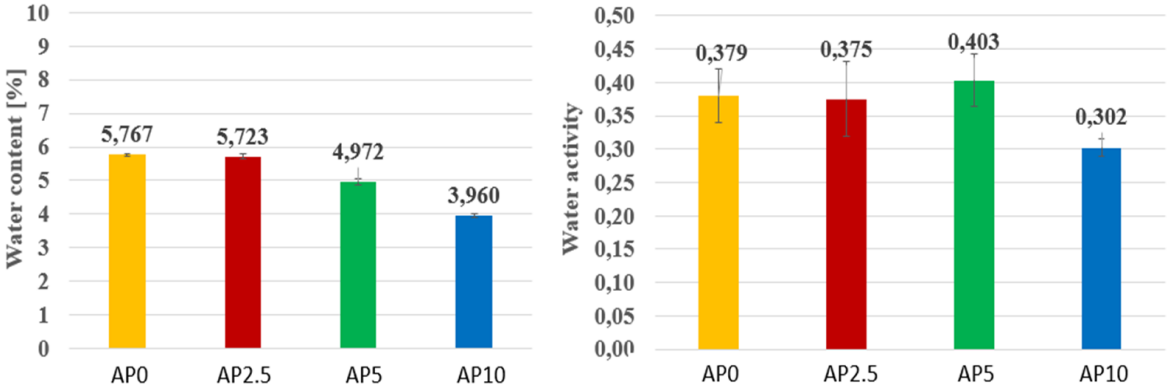


Figure 4. Water activity and water content of the biscuits

The moisture content of the biscuits ranged from 3.5 to 6.2. The AP biscuits show that the moisture content decreases with increasing pomace. The former may be due to the moisture remaining in the pomace, while the latter may be due to an increase in the dry matter content. AP control, AP2.5 and AP5 data show the same results as the moisture content measurement, where AP10 has a low moisture content. Control AP biscuits and AP5 biscuits showed higher a_w values, which may result from the water holding capacity of apple pomace (Chen et al., 1988a; Plazzotta et al., 2018).

During the texture measurements in the case of biscuits, the properties of hardness, adhesion and cohesion should be taken into account, as they best describe its texture.

The hardness of the biscuits did not show a significant difference during 14 days of storage ($p > 0.05$) Thus, during 14 days of storage, their hardness changed negligibly. Thus, the values the first measurement day of the biscuits were examined As the apple pomace content of the samples increased, their hardness also increased (Figure 5 and 6). This is contrary to several literature data. Apple pomace is famous for its good water holding capacity, thereby lending a softer stock to the foods in which it is used (Chen et al., 1988a; Chen et al., 1988b; Plazzotta et al., 2018). Although apple pomace was used as a flour substitute in these researches, the dry matter content of the biscuits remained the same, while in our case the biscuits were enriched with the pomace, thus also increasing the dry matter content. However, several studies report that the addition of fruit or pomace flour increases the hardness compared to the hardness of reference biscuits (Ajila et al., 2008; Norhidayah et al., 2014). By adding the pomace, oligofructose was added to the biscuits, which may have increased the hardness due to the crystallization of fructose (Pareyt et al., 2010).

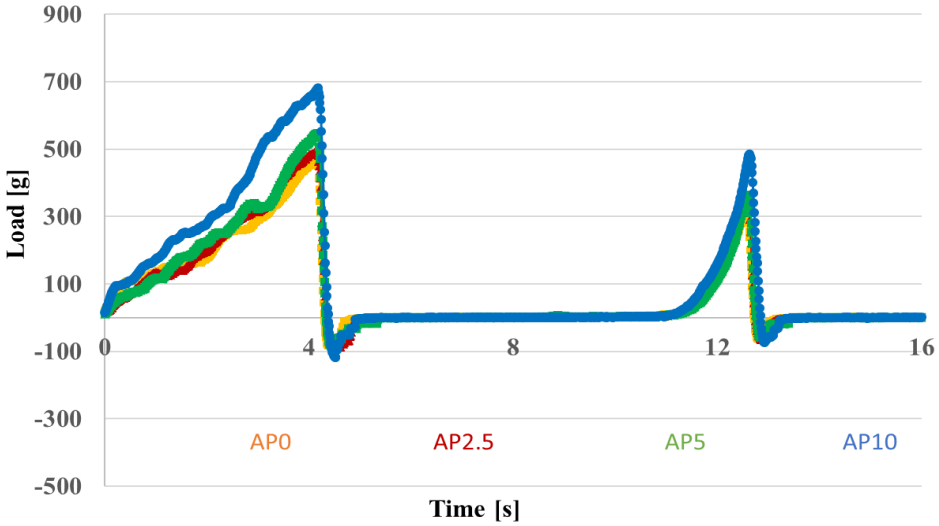


Figure 5. Texture profiles of the biscuits

The hardness of biscuits depends not only on the apple pomace, but also on the flours used in them (their grain size), the water, and the sweetener and fat, as well as the interactions between the ingredients. If the water content is low, the starch grains do not gelatinize, leaving some in the native state, leading to hardening of the biscuit (Kulp et al., 1991).

When comparing the biscuits in pairs the hardness of AP10% biscuits showed significantly different results from the other biscuits except AP5% (p=0.000). These biscuits do not differ significantly from either AP2.5% or AP10% biscuits, however, the similarity between AP2.5% and AP5% biscuits is greater than between AP10% and AP5% biscuits. The hardest stock was AP10% biscuits. Thus, we can state that in the case of ML biscuits we can add more apple pomace to the biscuits, since in these biscuits the pomace concentration has less influence on the hardness.

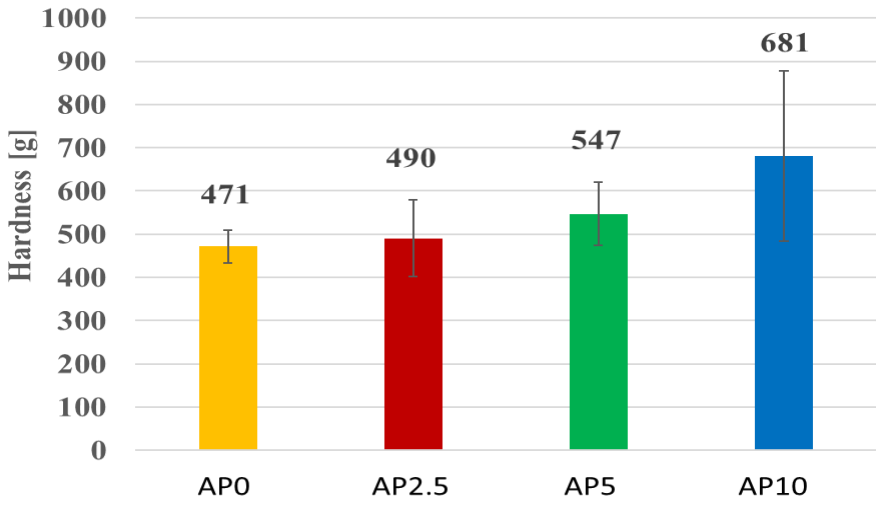


Figure 6. Hardness values of the samples

Table 1 contains the adhesion and cohesiveness values of the biscuits. With the increase of apple pomace, the properties of the texture showed a change, the hardness, adhesion and cohesion values of the biscuits also increased, so the biscuits became more and more resistant and harder to bite.

Table 1. Adhesion and cohesiveness values of the biscuits

Sample	Adhesion [gs] ±SD	Cohesiveness ± SD [dimensionless]
AP0	-37.472±5.25[a]	0.241±0.05[a]
AP2.5	-38.713±7.15[a]	0.232±0.03[a]
AP5	-41.177±6.78[ab]	0.189±0.02[a]
AP10	-47.734±4.84[b]	0.258±0.06[b]

superscript letters (a,b,c) indicate the homogeneous and heterogeneous groups tested by Tukey HSD test at 95% confidence level

Examining the total phenolic content of the samples, there was a significant difference between each sample. The polyphenol content of the biscuits increased with increasing apple pomace (Figure 7). The samples showed a more than twofold increase in polyphenol content from control AP biscuits to AP 2.5%; AP 5%; and AP 10%. The polyphenol content of apple biscuits in the biscuits increased as the concentrations were 1.8 mg $100g^{-1}$ biscuits, 10 mg $100g^{-1}$ biscuits and 46 mg $100g^{-1}$ biscuits.

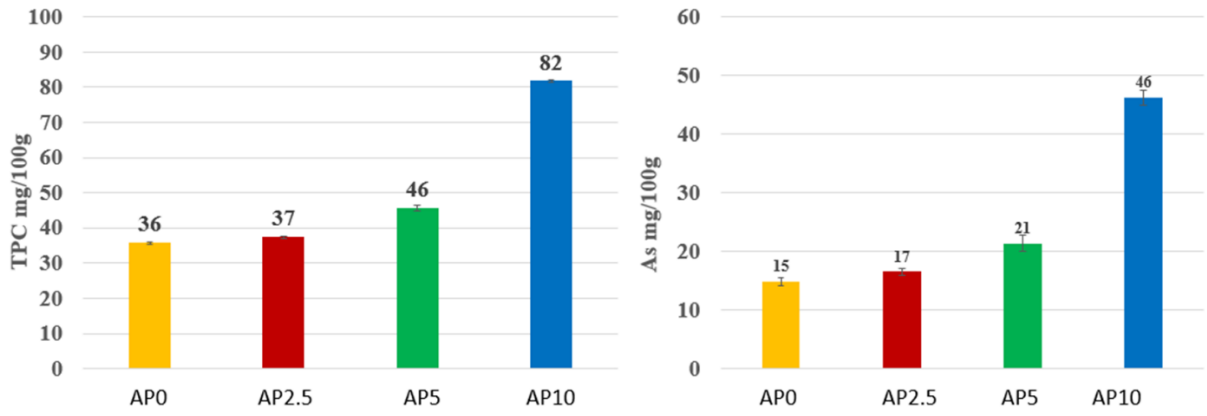


Figure 7. Total phenolic content and antioxidant capacity of the biscuits (mg $100g^{-1}$)

Investigation of the antioxidant capacity of the samples, there was no significant difference between the values of antioxidant capacity during storage ($p>0.005$). Therefore, the antioxidant capacity data of biscuits with different apple pomace concentrations measured on the first day were examined (Figure6). Tukey post-hoc test was also performed. These Statistical results showed, that there was no significant difference in antioxidant content between the control and AP2.5 samples, however, there was a significant difference between the samples in the other pairwise comparisons ($p=0.000$). Thus, detectable antioxidant growth can be achieved by enriching apple pomace flour to 5% or more. As the apple pomace concentration increased, the antioxidant capacity values of the biscuits also increased. From AP control biscuits, the antioxidant capacity increased by 23% in the AP5 sample, while a threefold increase was observed in the AP10 sample (Figure 7). The antioxidant capacity of the biscuits from apple pomace is in case of 5% and at 10% apple pomace concentrations 4.05 mg $100g^{-1}$ biscuits and 34.68 mg $100g^{-1}$ biscuits.

Effect of the added apple pomace powder on sensory attributes of biscuits was also investigated. There was also a significant difference between the values of total popularity between AP biscuits (Table 2), so a pairwise comparisons for these biscuits was performed Tukey and Games-Howell tests, respectively.

Table 2. The results of the variance analysis of the sensory evaluation of ML biscuits

Source	Degree of freedom	SUMSQ	Average SUMSQ	F-value	p-value
Model	3	72.146	24.049	8.849	< **0.0001**
Mistake	236	641.350	2.718		
Total	239	713.496			

According to the statistics there were differences between the control AP biscuits, and AP 2.5% and AP 5%, but showed a significant difference between the aforementioned three biscuits and AP10 biscuits.

Table 3. The relationship between AP biscuits (Tukey test)

Sample	SUMSQ	Homogen groups	
AP0	6.533	A	
AP2.5	6.050	A	
AP5	5.917	A	
AP10	5.017		B

Figure 8 shows the overall popularity of the biscuits in a bar graph. Critics preferred AP0 (control) biscuits the most, but there was no sensory difference in the popularity of AP2.5 and AP 5. These results suggest that biscuits can be fortified with up to 5% apple pomace, as there is no sensory difference from biscuit-free biscuits.

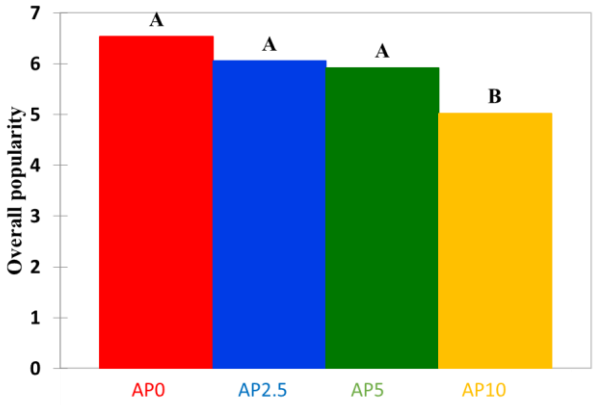


Figure 8. The overall popularity of AP biscuits

4. CONCLUSIONS

As the apple pomace concentration increased, the hardness, adhesion, cohesion, polyphenol content, and antioxidant capacity of the biscuits increased, while their lightness, moisture content, and overall popularity decreased. We can state that in the case of millet flour based biscuits, these products enriched with 5% apple pomace flour proved to be the most suitable by the reviewers. Thus, apple pomace is a great by-product for enriching biscuits, with which we can increase their content value. Further investigation needed to ascertain consumers' preference and regarding the changes occurred in presence of apple pomace powder.

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REFERENCES

1. Ajila, C.M., Leelavathi, K. & Rao, U.J.S.P. 2008, "Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder". *Journal of Cereal Science*, vol. 48, no. 2., pp.319–326.
2. Alongi, M., Melchior, S. & Anese, M. 2018, "Reducing the glycemic index of short dough biscuits by using apple pomace as a functional ingredient". *Food Science and Technology*, 100, pp. 300-305.
3. Belitz, H. D., Grosch, W. & Schieberle, P. 2009, "*Food Chemistry*". 4th revised and extended ed., pp. 270–285. Berlin, Germany: Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.
4. Benzie, I. F. F. & Strain, J. J. 1996, "The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay." *Analytical Biochemistry*, vol. 239, no. 1, pp. 70–76 doi:10.1006/ abio.1996.0292
5. Bourne, M. 2002, "*Food texture and viscosity: concept and measurement*". 2nd ed. Academic Press, San Diago California
6. Chen, H., Rubenthaler, G.L. & Schanu, E.G. 1988a, "Effect of apple fiber and cellulose on the physical properties of wheat flour". *Journal of Food Science*, 53, pp. 304-305.
7. Chen, H., Rubenthaler, G.L., Leung, H.K. & Barnowki, J.D. 1988b, "Chemical, physical and baking properties of apple fiber compared with wheat and oat bran". *Cereal Chemistry*, 65, pp. 244-247.
8. Commission Internationale de l'Éclairage (CIE) 2004, "*Colorimetry: technical report*". Central Bureau of the CIE, pp. 12–18
9. Hoseney, R. C. & Rogers, D. E. 1994, "Mechanism of sugar functionality in cookies". In H. Faridi (Ed.) *The science of cookie and cracker production*, pp. 203–225
10. Juhász, R., Penksza, P., & Sipos, L. 2020, Effect of xylo-oligosaccharides (XOS) addition on technological and sensory attributes of cookies. *Food Science and Nutrition.* 00, pp. 1–9. DOI: 10.1002/fsn3.1802
11. Jung, J.; Cavender, G. & Zhao, Y. 2015, "Impingement drying for preparing dried apple pomace flour and its fortification in bakery and meat products". *Journal of Food Science and Technology*, vol. 52, no. 9, pp. 5568–5578. DOI 10.1007/s13197-014-1680-4
12. Kulp, K., Olewnik, M. & Lorenz, K. 1991, "Starch functionality in cookie systems". *Starch*, 43, pp. 53-57.
13. Martins, S.I.F.S., Jongen, W.M.F. & Van Boekel, M.A.J.S. 2001, "A review of Maillard reaction in food and implications to kinetic modelling". *Trends in Food Science and Technology*, 11, pp. 364–373.
14. Masoodi, F.A. & Chauhan G.S. 1998, "Use of apple pomace as a source of dietary fiber in wheat bread." *Journal of Food Processing and Preservation*, 22, pp. 255–263.
15. Meyners, M. & Castura, J.C. 2014, "Check-All-That-Apply Questions." In: Varela, P., Ares, G, eds. *Novel Techniques in Sensory Characterization and Consumer Profiling*. 1st ed. Boca Raton. CRC Press. pp. 271-307.

16. Norhidayah, M., Noorlaila, A. & Nur Fatin Izzati, A, 2014, "Textural and sensorial properties of cookies prepared by partial substitution of wheat flour with unripe banana (*Musa x paradisiaca* var. Tanduk and *Musa acuminata* var. Emas) flour." *International Food Research Journal*, vol. 21, no.6, pp. 2133-2139.

17. Pareyt, B., Brijs, K. & Delcour, J.A. 2010, "Impact of fat on dough and cookie properties of sugar-snap cookies." *Cereal Chemistry*, 87, pp. 226-230.

18. Pareyt, B., Goovaerts, M., Broekaert, W.F., & Delcour, J.A. 2011, "Arabinoxylan oligosaccharides (AXOS) as a potential sucrose replacer in sugar-snap cookies." *LWT - Food Science and Technology*, 44, pp. 725-728. https://doi.org/10.1016/j.lwt.2010.11.008

19. Plazzotta, S., Calligaris, S. & Manzocco, L. 2018, "Application of different drying techniques to fresh-cut salad waste to obtain food ingredients rich in antioxidants and with high solvent loading capacity." *LWT - Food Science and Technology*, 89, pp. 276-283.

20. Rabetafika, H.N., Bchir, B., Blecker, C. & Richel, A. 2014, "Fractionation of apple by-products as source of new ingredients: Current situation and perspectives." *Trends in Food Science and Technology*, 40, pp. 99-114. doi: 10.1016/j.tifs.2014.08.004.

21. Rupasinghe, H.P.V., Wang, L., Huber, G.M. & Pitts, N.L. 2008, "Effect of baking on dietary fibre and phenolics of muffins incorporated with apple skin powder." *Food Chemistry*, 107, pp. 1217–1224

22. Shalini, R. & Gupta, D. K., 2010, "Utilization of pomace from apple processing industries: a review." *Journal of Food Science and Technology*, vol. 47, no. 4, pp. 365–371. http://dx.doi.org/10.1007/s13197-010-0061-x

23. Singleton, V.L. & Rossi, J.A. 1965, "Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents". *American Journal of Enology and Viticulture*, 16, pp.144–158.

24. Sivam, A.S., Sun-Waterhouse, D, Waterhouse, G.I.N, Quek, S. & Perera, C.O. 2011, "Physicochemical properties of bread dough and finished bread with added pectin fiber and phenolic antioxidants." *Journal of Food Science*, 76, pp. 97-107

25. Soler, C., Soriano, J. M., & Mañes, J. 2009, "Apple-products phytochemicals and processing: A review." *Natural Product Communications*, vol.4, no.5, pp. 659–670

26. Sudha, ML, Baskaran, V. & Leelavathi, K. 2007, "Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making." *Food Chemistry*, 104, pp. 686–692

27. Wang, H.J. & Thomas, R.I. 2008, "Direct Use of Apple Pomace in Bakery Products." *Journal of Food Science*, vol. 5, no. 3, pp. 618-620. DOI:10.1111/j.1365-2621.1989.tb04665.x