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VALORIZATION OF APPLE POMACE POWDER IN DEVELOPMENT OF FUNCTIONAL COOKIES

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Abstract: **Apple pomace is a by-product of apple juice processing industry containing good nutritional value that provides health benefits. The chemical analysis revealed that apple pomace powder contains 3.57% protein, 20.1% crude fiber and 1.70% ash. It could be considered as a potential functional ingredient for food product development. The research study was conducted to incorporate apple pomace powder for nutritional upliftment of cookies. Fiber rich cookies were formulated by substituting refined wheat flour with apple pomace powder at 5%, 10%, 15% and evaluated for its physical, chemical and sensory characteristics. The sensory evaluation by semi-trained panels revealed that cookies incorporated with 10% apple pomace powder have shown maximum consumer acceptability in terms of all sensory attributes and recorded highest scores for colour (7.6), flavor (8.1), texture (8.4), taste (8.5) and overall acceptability (8.4). Thus, apple pomace powder can be successfully utilized in cookies resulting in enhanced nutritional & sensory characteristics.**

Keywords **- apple waste, pomace, valorization, cookies**

I. INTRODUCTION

Apple juice processing industries often produces a significant amount of by-product known as pomace which creates huge economic as well as environmental burden for the industry and society (Yadav *et al*., 2016). Apple pomace is a complex mixture consisting primarily skin as well as flesh (95%), including a small percentage of seeds (2–4%) and stems (1%). It is used as a functional component in food products owing to its excellent nutritional profile. Apple pomace are known to be a source of beneficial compounds including phytochemicals such as polyphenols and dietary fibers (Kohajdova *et al*., 2014). Apple fiber contains well balanced proportions of soluble and insoluble fiber and represents superior quality when compared to common cereals. Apple fiber is rich source of pectin, cellulose, hemicelluloses and lignin having hypocholestrolemic effect. (Negi and Vaidya, 2019). Apple pomace is a natural source of pectin substances (~8%), being an important raw material for pectin production throughout the world.

The ease of acquiring pomace and its low cost along with presence of many health promoting and bioactive substances makes it an attractive material for further processing. The pomace produced from the agri-food industry could be valorized due to the presence of bioactive molecules that could be extracted, purified and commercialized by food industries. The incorporation of apple pomace into bakery products is a judicious approach towards utilizing wastematerial from apple juice processing industry and represents good opportunity for food processors to provide healthy bakery products to consumers. Thus sincere efforts are taken to develop apple pomace enriched cookies and its quality evaluation with respect to physicochemical and sensorial characteristics.

II. MATERIALS AND METHODS

2.1 Raw Materials

The required raw materials like apple's, refined wheat flour, milk, milk powder, baking powder, sugar, margarine and salt were purchased from the local market in Loni Kalbhor, Pune

2.2 Preparation of apple pomace powder

The apples were cut into small pieces and grinded. The water in the ratio (2:1) was added to the pomace, immediate heating of the pulp was done to separate adhered pulp. The pomace pulp was separated by passing through stainless steel sieve. After juice extraction, to prevent browning reactions, the residual pomace was immersed in a solution of ascorbic acid (10g/lit) with sodium chloride (0.5g/lit) for 3-5 minutes. Further apple pomace was dried in oven at 60^0C for 10-12 hrs (Gupta, 2006). It was powdered after drying and stored in an airtight container in a cool dark place for further investigation.

2.3 Development of apple pomace powder incorporated cookies

The cookies were developed by substituting refined wheat flour with apple pomace powder at different proportions. The cookies formulated with 100 per cent refined wheat flour were treated as control sample whereas other proportionately replaced refined wheat flour with apple pomace powder were APC1 (95:5), APC2 (90:10), APC3 (85:15) respectively. Dry ingredients were weighed accurately and mixed into refined wheat flour. Margarine is creamed with sugar to form a uniform fluffy texture. The dry ingredients

were incorporated into the mixture of margarine and sugar to form a uniform smooth dough. The dough is rolled into sheet followed by cutting into desired size and shape of cookies. The cookies were baked at 160^0C for 10-15 in an electric oven (Suma & Nandini, 2015), cooled at ambient temperature and packed in low density polyethylene.

2.4 Physico-chemical & functional analysis of apple pomace powder and cookies

The proximate composition (crude fat, moisture, protein, crude fiber, ash) of raw material and cookies were analyzed as per standard procedures given by Ranganna (1986). The carbohydrate content was calculated by difference method. Functional properties of apple pomace powder were determined according to Grover *et.al.*, (2003).

2.5 Sensory Evaluation

The maximum consumer acceptability for developed cookies was assessed with sensory evaluation in accordance with colour and appearance, texture, taste, flavor, overall acceptability. The sensory evaluation was conducted with 9-point hedonic scale (1-extremely dislike to 9-extremely like) by ten semi trained panelists from MIT School of Technology (Suma 2015).

2.6 Statistical Analysis

The statistical analysis was conducted with Completely Randomized Design (CRD) to determine significance level by following the method of Panse and Sukhatme (1987). The level of significance was calculated at CD (critical difference at 5%).

III. RESULTS AND DISCUSSION

3.1 Proximate composition of apple pomace powder

The nutritional quality of final product is generally reflected by proximate composition of raw materials. The proximate composition of apple pomace powder was evaluated in terms of moisture, fat, protein, crude fiber, ash and carbohydrate. The obtained results are summarized in Table 1.

Table 1: Proximate composition of apple pomace powder

Parameters (%)	Results
Moisture	4.20
Fat	1.52
Protein	3.57
Crude fiber	20.1
Ash	1.70
Carbohydrates	68.91

* The value indicates an average of three readings

Moisture content has been established as an important shelf- life indicator of foods. The data presented in Table 1 shows that apple pomace powder was found to contain 4.20 per cent moisture. The fat and protein content of apple pomace powder was 1.52 and 3.57 percent respectively. Apple pomace, byproduct of apple juice industry also contains significant amounts of fiber. Apple pomace powder was reported to contain 20.1 per cent of crude fiber. Ash content refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter. Apple pomace powder was found to have less ash content i.e. 1.70 per cent which corresponds to the total mineral content. Apple pomace was found to be promising source of carbohydrate with 68.91 per cent. These findings are similar in accordance with results revealed by Wang *et al.*, (2019). The obtained results revealed that apple pomace powder has the potentialto be used as vital source of nutritive components.

3.2 Mineral content of apple pomace powder

The mineral content profile of apple pomace powder was examined in termsof Calcium, Potassium, Magnesium, Iron and the findings are tabulated in Table 2.

Table 2: Mineral content of apple pomace powder

Minerals	Results (mg/100g)
Calcium	48
Potassium	44.2
Magnesium	32.6
Iron	1.8

* The value indicates an average of three readings

The essential minerals like Calcium, Potassium, Magnesium and Iron were found in apple pomace powder. The Calcium has vital function in the prevention and treatment of osteoporosis. Potassium is an essential mineral that functions as an electrolyte and regulates fluid balance and blood pressure. Magnesium is vital component for prevention or treatment of hypertension, heart diseases and osteoporosis. Iron is key mineral for the synthesis of hemoglobin, body metabolism, immunity and regulation of body temperature (Yadav and Gupta, 2015).

The apple pomace powder was found to contain 48mg/100g of Calcium. 44.2mg/100g of Potassium, 32.6mg/100g of Magnesium and 1.8mg/100gm of Iron. The obtained results are in good agreement with Yadav and Gupta (2015) and O'Shea *et al.*, (2012).

3.3 Functional Properties of Apple pomace powder

The apple pomace powder was analyzed for its functional properties such as water holding capacity (WHC), oil holding capacity (OHC), foam capacity, solubility index, emulsion activity, emulsion stability and swelling powder. The obtained results are represented in Table 3.

Table 3: Functional properties of apple pomace powder

Functional Properties	Results
WHC (ml/g)	3.25
OHC (ml/g)	0.80
Foam Capacity (%)	2.00
Solubility Index (%)	3.00
Emulsion Activity (%)	45.87
Emulsion Stability (%)	33.25

* The value indicates an average of three readings

The functional properties of powders are linked to the interaction between water/oil and powder. They also are associated to the properties related with the protein structure, rheological characteristics, protein surface and the compatibility with other food components. WHC represents hydration properties of dietary fiber that refers to its ability to retain moisture withinits protein matrix (Moure *et al*., 2006). Apple pomace powder recorded WHC as 3.25 ml/g. Good hydration properties of pomace powders will allow its use as functional ingredient in food products as high WHC tend to exert their physiological effect by absorbing water in the gut and resulting in stool bulking (Sahni & Shere 2017). The OHC represents the retention of fat in the food. Apple pomace powder showed OHC of 0.80 ml/g. The foam capacity & solubility index in apple pomace powder was found to be 2.00 and 3.00 per cent respectively. The emulsion activity and emulsion stability of apple pomace was 45.87 and 33.25 per cent respectively. The ability of fibrous materials to absorb biliar acid in the small intestine is proof of their emulsion action, which helps to lower blood cholesterol levels (Younis and Ahmed 2015). It has been proved that apple pomace powder has wide range of functional properties and could be potentially utilized in the development of food products.

3.4 Sensory evaluation of apple pomace powder incorporated cookies

The developed apple pomace powder incorporated cookies were subjectedfor sensory evaluation to determine maximum consumer acceptability. The obtained sensory scores are compiled in Table 4.

Table 4: Sensory evaluation of apple pomace powder incorporated cookies

	Sensory Parameters				
Treatments	**Colour Appearance**	**Texture**	**Taste**	**Flavour**	**Overall Acceptability**
Control	8.0	8.1	7.8	7.8	7.9
APC_1	7.8	7.9	8.0	8.1	8.1
APC_2	7.6	7.8	8.3	8.5	8.4
APC_3	7.3	7.6	7.7	7.5	7.6
SE±	0.037	0.051	0.025	0.050	0.067
CD@ 5%	0.080	0.109	0.054	0.107	0.144

*The value indicates an average of three readings

Where, Control – 100 per cent refined wheat flour

APC_1- 95 per cent refined wheat flour + 5 per cent apple pomace powder

APC_2 -90 per cent refined wheat flour + 10 per cent apple pomace powder

APC_3-85 per cent refined wheat flour + 15 per cent apple pomace powder

The color and appearance are an important sensory parameter to determine overall consumer acceptability of products. The color and appearance scores for the cookies samples control, APC_1, APC_2 and APC_3 were 8.0, 7.8. 7.6 and 7.3 respectively. The values of each sample were not significantly different. However,marginal difference was recorded in APC_3 as compared to control sample and this could be due to increase in addition of APP (15%) compared to control sample which results in darkening of the cookies due to high amount of polyphenols in apple pomace powder that acts as substrate for enzymatic browning (Sudha *et.al.*, 2007).

The texture parameter for cookies was found to be maximum for control (8.1) which was statistically non-significant as compared with APC_3 (7.6). As substitution levels of APP increases, resulting increase in hardness and decrease incrispiness of the cookies. Increase in cookies hardness directly affected consumer acceptability. Similar trend for texture was reported by Mir *et al*. (2017) forcrackers by increasing apple pomace powder in formula.

The taste of cookies recorded non-significant difference among samples APC_1, APC_2 and APC_3 (8.0, 8.3 and 7.7) as compared to control sample (7.8). However, slight preference was given to sample APC_2 (8.3). It was further noticedthat sensory score for taste was increased up to 10 per cent addition of apple pomace powder due to peculiar fruity taste imparted to the cookies by apple pomace powder. The minimum score was obtained by APC_3 (7.6) and it was concluded that the addition of apple pomace powder above 10 per cent decreased the taste score for cookies attributed to slightly bitter taste due to high polyphenol content of apple pomace powder (Sahni and Shere, 2017). The similar trend of observations were recorded for flavour of cookies. The similar trend was reported by Suma and Nandini (2015) for non-significant differences in taste & flavour of cookies with apple pomace powder.

Sensory evaluation indicates that overall acceptability scores were non significantly different between control and apple pomace powder incorporated cookies. The marginal overall acceptability (8.4) was recorded by APC_2 (10% apple pomace powder + 90% refined wheat flour) followed by APC_1 (8.1),control sample (7.9) and the lowest score was obtained by APC_3 (7.6) cookies. Theseresults are good in fulfilling the argument of supplementing 10 per cent of apple pomace powder were found to be most acceptable owing to their fruity taste and flavor which increase its overall acceptability (Sahni & Shere, 2018). Hence, 10 per cent addition of apple pomace powder was found to be sensorially acceptable for enrichment of cookies.

3.5 Physical properties of apple pomace powder incorporated cookies

Physical properties of cookies incorporated with apple pomace powder were analyzed and obtained results are summarized in Table 5.

Table 5: Physical properties of apple pomace powder incorporated cookies

Treatments		Physical properties			
	Weight (g)	Diameter(mm)	Thickness(mm)	Volume(cm^3)	Spread ratio (%)
Control	16.21	56.10	11.2	11.22	5.01
APC 1	16.23	51.80	12.3	14.75	4.21
APC 2	16.28	49.12	12.7	13.15	3.85
APC 3	16.35	47.58	12.9	15.25	3.68
SE±	0.013	0.025	0.075	0.012	0.019
CD@ 5%	0.028	0.054	0.160	0.025	0.040

* The value indicates an average of three readings

The results showed non-significant increase in weight of cookies with increase in addition level of apple pomace powder. The weight of control sample, APC_1, APC_2, and APC_3, were 16.21g, 16.23g, 16.28g and 16.35g respectively. The increase in cookies weight could be because of more water holding capacity of apple pomace powder. This finding is in parallel accordance with Sharoba *et al.*, (2013) who investigated that increased in incorporation level of organic waste resulted in increase in weight of cake.

The diameter of cookies decreased from 56.10mm to 47.58mm with increase in apple pomace powder content from 0 to 15 per cent. Maximum diameter of cookies was observed in control sample (56.10mm). Further addition of apple pomace powder up to 15 per cent showed slight decrease in diameter (47.58) of APC_3. However, thickness of cookies was found to be marginally increased from control (11.2mm) to APC_3 (12.9mm) with increase in addition of apple pomace powder. The increased concentration of apple fibre causes a drop in cookie diameter and a rise in cookie thickness and similar trend was also observedby Chen *et al*. (1988).

Spread ratio is an important property in evaluation quality of cookies. The spread ratio ofcontrol cookie was higher than cookies containing 5, 10 and 15 per cent apple pomace powder. The reduction in spread ratio of cookies with increase in substitution level of apple pomace powder could be due to strong water bindingcharacteristics of apple pomace powder, which restrained the spread of dough. (Dhingra *et al.*, 2012)

3.6 Proximate composition of apple pomace powder incorporated cookies

The proximate composition of apple pomace powder incorporated cookies was analyzed which indicates effect of apple pomace powder incorporation on moisture, fat, protein, crude fiber, ash and carbohydrate content of cookies. The obtained results are depicted in Table 6.

Table 6: Proximate composition of apple pomace powder incorporated cookies

Treatments	Proximate composition (%)					
	Moisture	Fat	Protein	Crudefiber	Ash	Carbohydrate
Control	2.83	23.62	6.32	0.37	0.94	65.92
APC1	3.14	23.60	6.18	1.45	1.05	64.58
APC2	3.45	23.56	5.94	2.16	1.10	63.79
APC3	3.68	23.51	5.71	2.81	1.13	63.16
SE±	0.036	0.010	0.002	0.004	0.020	0.276
CD @ 5%	0.076	0.023	0.005	0.009	0.043	0.587

* The value indicates an average of three readings.

The control sample showed presence of 2.83 per cent moisture and that of cookies incorporated with apple pomace powder was observed to be marginally increased from 3.14 to 3.68 per cent. The increase in apple pomace powdersupplementation in the cookies showed increase in the moisture level. The fat content of cookies showed non-significant variation among control and APP incorporated samples. The fat content of control sample was 23.62 per cent whereas apple pomace powder incorporated cookies APC_1, APC_2 and APC_3 were found as 23.60, 23.56 and 23.51 per cent. The decrease in fat content of cookies with increase in addition of apple pomace powder could be due to low fat content of apple pomace powder. Apple pomace powder could be evaluated as fat replacer as per the finding of Sajad *et al.*, (2015) who observed that products formulated with apple pomace powder showed significant increase in moistureand ash contents but decrease in fat content.

Protein content of the cookies showed decreasing trend with addition of apple pomace powder. The maximum (6.32%) protein content was observed in control sample prepared with only refined wheat flour and minimum (5.71%) in sample containing 15 per cent apple pomace powder. As refined wheat flour contains more protein percentage than apple pomace powder, the increase insubstitution of refined wheat flour with apple pomace powder would be expected to lower the protein content in the cookies. (Sahni and Shere, 2017).

The crude fibre and ash content of cookies increased linearly with increasein apple pomace powder concentration in flour blend. Apple pomace powder incorporation showed marked increase in crude fibre content in the range of 1.45 to 2.81 per cent. This could be due to good fibre content of apple pomace powder. With increase in inclusion level of apple pomace powder, the ash content incookies was found to increase slightly. The maximum ash content (1.13) was found in the sample containing 15 per cent apple pomace powder and minimum (0.94) in control sample. However, no pronounced increase was observed as applepomace powder contains less ash content and further washing with warm water again reduces ash content (Larrauri *et al*., 2007). The cookies carbohydrate content was significantly decreased from 65.92 to 63.16 per cent with increase in addition of apple pomace powder. Similar decreasing trend in carbohydrate content in cookies was determined by Agrawal *et al.*, 2017.

IV. CONCLUSION

Apple pomace is an under-utilized industrial by-product that is rich source of dietary fiber and can be potentially utilized for manufacturing fiber rich cookies. Cookies with 10 per cent apple pomace powder were found to be most acceptable owing to their fruity tase and flavor which increased its overall acceptability. This apple pomace powder incorporated cookies marked increase in the fiber content and thus justifies its use for fiber enrichment in cookies. The present scenario of low fiber in diet is driving force for exploration of dietary fiber as novel ingredient in food product formulations. Apple pomace powder will aid in the valorization of food products owing to its low-cost source of nutritional fibre and can be used for designing new functional food. Thus opens the doorway of efficient waste management for apple juice manufacturing industries to earn profit.

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