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Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity

Suman Yadav, Rajinder K. Gupta

Abstract
Antioxidants and phytochemicals in foods or pharmaceutical supplements are bioactive compounds that have the ability to scavenge free radicals leading to oxidative stress and also to provide protection against several degenerative diseases. Apple is a temperate fruit widely consumed throughout the world for its health benefits. During juice processing, a large amount of apple pomace is generated which may result in serious environmental problems. On the contrary, apple pomace is known to be a good source of bioactive compounds like phytochemicals, antioxidants and dietary fibre. The aim of the present study, was to incorporate apple pomace powder into an extruded product (noodles) at three different levels (10, 15 & 20%) and to analyze its impact on the cooking properties and sensory characteristics of noodles. It was observed that the total dietary fibre and protein content of the noodles increased from 6.0 to 13.28% and 10.20 to 11.80%, respectively, as compared to the control noodles. The apple pomace enriched noodles exhibited improved antioxidant activity. The cooking loss of the noodles increased from 9.84 to 11.16%, and the swelling index increased from 1.85 to 2.31% upon incorporation of apple pomace powder. Incorporation of 10% apple pomace powder into wheat flour yielded high quality noodles. Thus, the results indicate that by incorporating apple pomace powder, it is possible to enhance the nutritional value of noodles without influencing its cooking, sensory and textural properties. Apple pomace can be used as a potential source for the development of functional foods. GC-MS analysis of apple pomace extract revealed the presence of 4H-Pyran-4-one, 2, 3-dihydro-3, 5-dihydroxy-6-methyl-, 2, 6, 10, 14, 18, 22 Tetracosahexaene, 2, 6, 10, 15, 19, 23-hexamethyl-,(all E)-, γ–Sitosterol**,** and 2-Furancarboxaldehyde, 5(hydroxymethyl), Vitamin E and fatty acids, all of which have significant therapeutic uses.

Keywords: Apple pomace, Noodles, Nutritional Value, Phytochemicals, Antioxidant Activity, GC-MS.

1. Introduction
Consumers all around the world, nowadays, are more at the risk of many diseases such as cardiovascular diseases and diabetes due to obesity, high cholesterol, high blood pressure and irregular blood sugar levels. These risk factors are because of the diet which is low in dietary fibre, phytochemicals and antioxidants. Functional foods provide health benefits and helps in the avoidance of diseases by incorporating nutraceutical ingredients. Foods that are excess in antioxidants and low in Glycemic Index (GI) can decrease the risk of increased postprandial oxidative stress, which is responsible for chronic diseases. The bioactive compounds that are responsible for providing health benefits in functional foods are phytochemicals, dietary fibre, and antioxidants.

Apple pomace is the main by-product of cider industry that is mainly composed of carbohydrates and high amount of dietary fibre, small amount of protein, fat and ash [1, 2]. It is an excellent source of phytochemicals such as phenolic acids and flavonoids, which make it a rich source of antioxidants [3, 4, 5].

The phytochemicals which are present in apple pomace are very beneficial in combating many health problems like decrease in lipid oxidation and lower cholesterol, reducing chronic diseases such as heart disease, obesity and cancer which are widespread in the western world. Phenolic acid such as chlorogenic acid, which is present in apple, has a high alkyl peroxyl radical scavenging activity because of which apples are very active against cancer. Apple pomace is, therefore, becoming very popular and can be incorporated into food products to develop functional foods.

Cookies were prepared by incorporating apple pomace powder in dough at different concentration (10-50%). It has been found that 30% formulation was better in taste, texture and appearance [6]. Apple pomace was also used in bakery products by Wang and Thomas, 1989 [2]. They examined the drum-dried apple pomace as a source of dietary fibre in bakery

products.
Black soybean flour was substituted with apple pomace to prepare biscuits to increase nutritional value [7]. Cakes were also prepared utilizing apple pomace as a source of dietary fibre [8]. Jams and sauces were also prepared by utilizing apple pomace [2, 6, 9]. Apple pomace (20%) was used to make extruded snacks and baked scones. By incorporating 20% of apple pomace, the phenolic content, dietary fibre content and antioxidant activity enhanced as compared to the products in which apple pomace was not used [10].
A study on noodles prepared from apple pomace (5%) and soy milk residue (10%) suggests that the noodles are a better source of dietary fibre compared to normal wheat noodles [11]. Another study indicates that addition of apple pomace to the ramen noodles retarded their acidification [12]. Both these studies favour the use of apple pomace for yielding healthier noodles. Noodles are widely consumed across the world and is the second highest in terms of consumption after bread. The market of instant noodles gaining popularity in the world. Usually, wheat flour is preferred to prepare instant noodles with low protein and dietary fibre content. Apple pomace, with numerous health benefits can thus be a better option instead of wheat flour to make healthy noodles. The world instant noodle market is projected to reach 158.7 billion packs by the year 2010 [13]. Instant noodles containing apple pomace and wheat flour leads to longer shelf life, lower cost and more nutritious product.

2. Materials and Methods

2.1. Raw Materials

Wheat flour, Common salt, Guar gum, Wheat gluten.

2.2. Apple pomace

Apples were purchased from a local market of New Delhi. They were first washed and then the juice was pressed from apples and pomace was obtained. It was then immediately dipped in a solution containing ascorbic acid (10g/lit) with sodium chloride (0.5g/lit) for 3-5 minutes to prevent browning reactions. It completely inhibits the browning of apple pomace. Apple pomace was then dried in an oven at 60°C for 24 hrs. After drying, it was coarsely ground and stored in airtight container and stored in a cool dark place until final analysis.

2.3. Chemicals

Acetic acid, aluminium chloride, ascorbic acid, catechin, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ferric chloride, folin Ciocalteu's phenol reagent, gallic acid, sodium acetate, sodium carbonate, sodium nitrite, 2,4,6-Tripyridyl-s-triazine (TPTZ), hydrochloric acid, liquor ammonia, n-butanol, sodium hydroxide, tannic acid, potassium ferrocyanide, methanol, ethanol, diethyl ether, petroleum ether, BHT.

2.4. Proximate analysis of apple pomace powder, apple pomace noodle

Apple Pomace Powder (APP) and its supplemented product (Noodle) were analyzed for their moisture, ash, total dietary fibre, protein, fat, carbohydrate, and energy value. Moisture and ash were determined according to AACC, 2000 [14] methods with slight change. Total dietary fibre & protein was determined by AOAC [15] method. Fat content was estimated by using Petroleum ether. Mineral content was also analyzed using ICP-OES. Total carbohydrates and energy content were calculated using formulae:

Total carbohydrates (% fresh weight) = 100 - moisture (%) - protein content (% fresh weight) - crude fat (% fresh weight) - ash (% fresh weight) and reported as total carbohydrates in % [16].

The calorific value in kilocalories (kcal) was calculated according to the system of Atwater, namely: kcal = (3.36 × % protein, fresh weight) + (3.60 × % total carbohydrate fresh weight) + (8.37 × % fat) [16].

2.5. Extraction of Apple Pomace

Fifty grams of apple pomace powder was taken in 100ml of methanol in a conical flask and plugged with cotton wool and then shaken at 60 °C overnight at 150 rpm and then the supernatant was filtered using what man filter paper. The residue was then mixed with another 100ml of methanol and filtration process was repeated. Both the supernatants were combined and then the solvent was evaporated at 60 °C and stored at 4 °C in airtight bottles.

2.6. Determination of phytochemicals of Apple Pomace

2.6.1. Total phenolic content (TPC)

Total phenolics were estimated using the Folin–Ciocalteu assay [17]. The reaction mixture was prepared by mixing 100 µL extract with 1.15 mL of distilled water and 250µL Folin-Ciocalteu phenol reagent and then the mixture was vortexed. After this 1.5 mL of 20% Na_2CO_3 was added. After 2 hours incubation at room temperature in the dark, 2 mL distilled water was added. The absorbance was measured at 765 nm and the results were expressed in terms of gallic acid equivalents.

2.6.2. Total flavonoid content (TFC)

Total flavonoids were analysed using Aluminium Chloride colorimetric method [18]. An aliquot of 250 µL extract was dissolved in a mixture of 4.5 mL of distilled water and 0.3 mL of 5% $NaNO_2$. After 5 min, 0.3 mL of 10% $AlCl_3$ was added. Finally, after an incubation of 6 minutes, 2 mL of 1M NaOH was added and the total volume was made up to 10 mL using distilled water and the mixture was then vortexed. Absorbance was measured at 510 nm. Results were expressed in terms of Catechin equivalents.

2.6.3. Estimation of Tannins

Tannins were analyzed according to the method described by Van-Buren and Robinson, 1981 [19] with some modification. Five grams of apple pomace powder was dissolved in 500mL distilled water in a conical flask and plugged with cotton wool and then shaken at 30 °C for one hour at 140 rpm and then 5ml filtrate was taken in a test tube. 1mL of 0.1M ferric chloride, 1mL of 0.1N HCL and 1mL of 0.008M potassium ferrocyanide was added to the test tube and then absorbance was measured at 605nm within 10 minutes and the result was expressed in Tannic Acid equivalents.

2.6.4. Estimation of Alkaloids

Crude alkaloid was estimated gravimetrically [20] with some modification. 2.5g of dry sample was taken in a conical flask.100mL of 10% acetic acid in ethanol was taken and mixed with dry sample and then incubation for 4 hours at room temperature. This sample was filtered and then concentrated to one fourth of the original volume using a water bath (50 °C). Then concentrated liquor ammonia was added drop wise until the precipitation was completed. Again the sample was filtered with filter paper and this filter paper was

pre-weight. This filter paper was dry and then weight was taken. The alkaloid content was calculated as a percentage.

$$\% \text{ of Alkaloid} = \frac{\text{Final Weight} - \text{Initial weight}}{\text{Sample Weight}} \times 100$$

2.6.5. Estimation of Saponins

The saponins content was determined according to the procedure described by Obadoni & Ochuko, 2001 [21]. In 50 ml of 20% ethanol, 5 g of sample powder was dissolved and then with continuous stirring, the sample was heated over a water bath for 4 hours at 55 °C. The mixture was filtered and then concentrated to 10 ml at 90 °C over a water bath. Diethyl ether was added to this concentrated solution into a separating funnel which was shaken vigorously. The aqueous layer was recovered, followed by the addition of n-butanol. The extracted solution was then washed with 10 ml of 5% aqueous sodium chloride. The resultant solution was heated over water bath. The sample was dried in the oven to a constant weight and the saponin content was calculated as a percentage.

$$\text{Saponin (\%)} = \frac{\text{Weight of saponin}}{\text{Weight of Sample}} \times 100$$

2.7. GC-MS Profiling

The Gas chromatography-Mass spectrometry (GC-MS) analysis was carried out for the methanolic extract of apple pomace powder. The carrier gas used was Helium. An Agilent 6890 GC with 5975B mass spectrometric detector (MSD) was used in the scan mode (m/z 35-1050) for the sample. Screening of volatiles and semi volatiles were performed using the automatic RTL screener software in combination with the Agilent NIST'05 library [16]. The temperature for the analysis was maintained at 300 °C, solvent delay was 3 min, ion source and quadruple temperature were 230 °C and 150 °C, respectively [22]. The detected compounds have been identified by the NIST'05 mass spectrum library. The identity of the secondary metabolites in the methanol extracts of apple pomace powder was carried out by Mass Spectroscopy based on the comparison of their retention time.

2.8. Antioxidant capacity evaluation

2.8.1. DPPH radical scavenging activity

DPPH radical scavenging activity was analyzed by the method of Blois [23] with slight modification**.** A 10 mg (1000PPM) of sample extract was dissolved in 10 mL methanol and then 1mL of sample was then taken from 10 mL and dissolved with 1mL of a 0.3 Mm methanol solution of DPPH (2,2-diphenyl-1 picrylhydrazyl), 1 mL methanol in a test tube. After this, test tube was incubated in dark for 10 minutes. Blank was prepared using 2ml methanol and 1ml DPPH. Methanol was used as a reference. Then absorbance was taken at 517nm.

A radical scavenging activity was expressed by % of scavenging activity and was calculated by the following formula:

$$\text{Radical Scavenging Activity (\%)} = \frac{\text{OD Blank} - \text{OD Sample}}{\text{OD Blank}} \times 100$$

2.8.2. Ferric reducing antioxidant power (FRAP)

The FRAP assay was determined according to the procedure of Benzie and Strain, 1996 [24].The FRAP reagent was freshly prepared by mixing 2.5 mL of TPTZ (10 mM in 40 mM hydrochloric acid), 2.5 mL of ferric chloride (20 mM) and 25 mL of sodium acetate buffer (300 mM, pH 3.6). A 100 µl of extract was mixed with 900 µl of FRAP reagent. The mixture was allowed to stand for 4 minutes at 37 °C. The absorbance was taken at 593 nm and the result was expressed as BHT equivalents.

2.9. Noodles preparation

The wheat flour in the experimental formulation was replaced with 10, 15 and 20 % apple pomace powder. The flour was mixed with guar gum (0.25 g/100 g flour), wheat gluten (5 g/100 g flour) common salt (2 g/100 g flour) and tap water (33 mL/100 g of total weight). The dough was rounded, covered with muslin cloth, allowed to rest for 30 min, hand-kneaded for 1 min, and then sheeted using Noodle machine. Thereafter, the dough sheet was passed through a hand operated Noodle machine. The strands obtained were cut into 20 cm approximately and folded into the desired shape. 100% wheat flour was used to prepare the control sample. The strands were then steamed at 100 °C for 15 minutes followed by cooling to 25 °C and then dried in an oven at 60 °C [25]. Before packaging, the noodle strands were cooled to room temperature.

Control 10% Formulation

15% Formulation 20% Formulation

2.10. Noodles cooking qualities

2.10.1. Optimal cooking time

Cooking quality of a noodles were analysed according to the American Association of Cereal Chemists (AACC), (2000) [14] method. The time required for the noodle core to disappear, when pressed softly between two glass plates after cooking, is the optimum cooking time (OCT). The cooking period began as the noodles were put into boiling water. 300 mL tap water was taken in a beaker and then 25 grams of noodle was cooked to optimum time. After this, they were rinsed for 15 minutes in cold water before weighed. Percentage of increased weight was calculated as a cooking yield.

2.10.2. Cooking loss

Cooking loss was analysed according to the AACC 66-50 (2000) [26] procedure. In 300 mL of boiling water 25 grams of

noodle sample was cooked at an optimum cooking time (OCT). The cooking water was collected in a beaker and then solids material was determined in the cooking water by evaporating in a hot air oven at 105 °C overnight until a constant weight was reached. The cooking loss was expressed as a percentage, based on the weight difference between the final solid material and initial dry matter.

2.10.3. Swelling index and water absorption

The swelling index of cooked Noodles was estimated using the protocol stated by Cleary and Brennan (2006) [27]. The swelling index was expressed as (weight of cooked Noodles) - (weight of Noodles after drying) / (weight of Noodles after drying). The water absorption of the drained noodles was also determined as (weight of cooked Noodles) - (weight of raw Noodles) / (weight of raw Noodles).

2.11. Sensory evaluation of Noodles

The sensory evaluation was carried out to assess the overall acceptability of the apple pomace powder enriched noodles. The samples were cooked in boiling water for 8-10 minutes and quality attributes (colour, texture, taste, flavor) of prepared noodles were evaluated against the control sample. Optimally cooked noodles were then analyzed for overall liking of the samples by 10 members using a nine-point hedonic scale.

3. Results and Discussion

3.1. Chemical composition of Noodles, Apple pomace and Wheat flour

Supplementation of wheat flour with apple pomace powder in the formulation of instant noodles significantly improved its nutritional quality. Wheat flour was supplemented with 10%, 15% & 20% apple pomace powder to make noodle samples, but according to taste, texture & colour, 10% formulation was better. The chemical constituents of apple pomace powder dried noodles, the control dried noodles sample and wheat flour, apple pomace powder are presented in Table 1.

It was observed that as the concentration of apple pomace powder was increased, the moisture content of dried noodles slightly reduced. According to Ovando-Martinez *et al*. (2009) [28], this reduction is due to the decrease in the protein content because of the decrease in the network produced by the gluten with the increase in the amount of apple pomace powder and the separation of water during drying is higher. Low-moisture content increases the shelf life of food products. By adding only 10% apple pomace powder, led to an increase in protein from 10.20 to 11.80 % and had slightly lower fat content as compared to control sample but the ash content increased. The ash content gives the approximate amount of minerals in the flour. Carbohydrates are one of the most abundant and widespread organic substances in nature. Carbohydrates are generally available as an immediate energy source. The carbohydrate content of 10 % formulation and control was found to be 67.20 % and 71.50 % respectively and thus with high energy value (291.61Kcal/100g and 303.39 Kcal/ 100g respectively).

The dietary fibre level varied in direct proportion with the amount of apple pomace powder. The control sample showed the low value of dietary fibre (6.0%) while the noodles containing 10% apple pomace powder possessed 13.28 % total dietary fibre. The protein, dietary fibre, moisture, fat, ash, carbohydrate and energy content of wheat flour used in this study were found to be, 13.70 %, 12.20 %, 11.86 %, 1.36 %, 0.59 %, 72.49 % and 318.37 kcal, respectively. Protein content of a flour is important because it influences the cooking quality of the product [29, 30]. The protein, dietary fibre, moisture, fat, ash, carbohydrate and energy content in apple pomace powder (APP) were found to be 4.63, 30.86, 6.6, 0.88, 11, 76.89 & 299.72 % respectively (Table 1).

Table 1:- Chemical compositions of noodles, apple pomace powder and wheat flour.

Sample	Moisture (%)	Ash (%)	Protein (%)	Dietary Fibre (%)	Fat (%)	Carbohydrate (%)	Energy value (kcal/ 100g)
Control	5.9	11	10.20	6.0	1.4	71.50	303.39
10% Formulation	5.8	14	11.80	13.28	1.2	67.20	291.61
Apple pomace powder	6.6	11	4.63	30.86	0.88	76.89	299.72
Wheat flour	11.86	0.59	13.70	12.20	1.36	72.49	318.37

Mineral content was determined by ICP-OES which shows the presence of essential minerals like phosphorus, calcium, magnesium, zinc, aluminium, iron, copper, manganese and many more. The important role of calcium is prevention and treatment of osteoporosis (together with vitamin D) [31], colorectal cancer [32], kidney stones [33, 34]. Magnesium is important for prevention or treatment of hypertension and heart diseases [35], diabetes [36], osteoporosis [37, 38], migraine headaches [39] and asthma [40]. Another important mineral was phosphorous which include many health benefits such as bone formation, proper digestion, regulated excretion, formation of protein, improved energy extraction, hormonal balance, cellular repair and also helps in constipation, diarrhoea, healthy bowel movements. Phosphorus also aids in the transmission of nerve impulses & helps in the treatment of cancer. Iron is a very important element for the formation of haemoglobin, brain function, body metabolism, anaemia, immunity, insomnia, muscle activity, restless leg syndrome, and the regulation of body temperature.

The amounts of minerals obtained in the sample are represented in Table 2.

Table 2:-Mineral content for apple pomace powder.

Minerals	Concentration(mg/100g)
P	48.4
Ca	53
Cu	0.22
Fe	2.4
Mg	37.6
Mn	0.61
Zn	0.22
Ni	ND*
Al	1.4
B	1.9
Cr	ND
Cd	ND
Ba	0.4
Sr	0.4
Pb	0.06
Mo	ND
Co	ND
Ti	0.1

* ND-Not Detected

3.2. Phytochemical Analysis

Phytochemicals such as phenolic acid, flavonoids are very useful for the prevention and treatment of many diseases such as cancer, high blood pressure and heart disease. Polyphenols of apple may also have valuable effects of Alzheimer's disease, diabetes and also reduce post-prandial blood glucose levels.

Phenolic compounds are antioxidants and secondary metabolites and they contribute to nutraceutical value. Flavonoids are very important and diverse group of phytochemicals and also act as antioxidants. Methanol extract of apple pomace was subjected to phytochemical analysis. Methanol extract of apple pomace showed phenolic compound, flavonoids, saponins, alkaloids and tannins (Table 3).

Methanol solvent was used to extract phenols & flavonoids in apple pomace. The phenolic concentration was examined using Folin- ciocalteau reagent, expressed in terms of gallic acid equivalents (Table 3). The flavonoid content was determined using Aluminium Chloride calorimetric method (Table 3). The concentration of Tannins in apple pomace was expressed in terms of Tannic acid equivalent table 3. The concentration of Alkaloids and saponins in apple pomace is given in table 3.

Table 3: Total phenol, total flavonoid, tannin, alkaloid and saponin content of apple pomace powder extract.

Analyte	Total Phenolic content (µg GAE/ mg sample)	Total Flavonoid content (µg CE/mg sample)	Tannin content (µg TAE/mg sample)	Alkaloid (%)	Saponin (%)
Sample	12.74	30.84	0.01175	4.38	28.40

3.3. Characterization of GC-MS analysis

The GC-MS analysis of methanolic extract of apple pomace powder resulted in identification of phytochemicals and common fatty acid. The results obtained indicated that the main compounds were 4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl-, 2,6,10,14,18,22 Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all E)-, hexadecanoic acid, octadecanoic acid, γ –Sitosterol**,** and 2-Furancarboxaldehyde, 5(hydroxymethyl)-. (Table 4).

4H-Pyran-4-one, 2, 3-dihydro-3, 5-dihydroxy-6-methyl (also called DDMP) exhibits anti-proliferative and pro-apoptotic effects which help in inhibition of colon cancer through inactivation of NF-kappaB [41]. DDMP was formed due to the Maillard reaction between carbonyl groups of reducing sugars and amino groups on proteins, amino acids, and peptides [42]. DDMP is a strong antioxidant. The other important compound was 2,6,10,14,18,22-tetracosahexaene, 2,6,10,15,19,23–hexamethyl- (common name- Squalene) which is an antibacterial, antioxidant, immunostimulant and also helps in the prevention & treatment of tumor and cancer [43]. Palmitic acid known as hexadecanoic acid and possesses anti-atherosclerotic and mild antioxidant properties [44]. The sample extract also contained (γ) sitosterol. γ sitosterol is a phytosterol which is present in many plants and possesses very strong anti-angiogenic, antifungal and antibacterial activity [45]. It is also used for the treatment of ulcers, bronchitis, diabetes, and heart diseases as phytomedicine [46]. γ sitosterol also found to lower the serum cholesterol. Another compound was 2-Furancarboxaldehyde, 5 (hydroxymethyl) - which helps in the treatment of sickle cell disease [47]. It also possesses an antimutagenic activity. Vitamin E possesses an antioxidant activity and prevent blood clot formation which is responsible for venous thromboembolism or heart attack [48].

Table 4:- Secondary metabolites in GC-MS analysis of apple pomace powder (Methanol extract).

Compound Name	CAS#	RT	% Area
4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6- methyl-	028564-83-2	9.895	5.29
Estragole	000140-67-0	10.702	6.17
2-Furancarboxaldehyde, 5(hydroxymethyl)-	000067-47-0	11.341	5.05
n-Hexadecanoic acid	000057-10-3	20.201	2.53
6-Octadecenoic acid, (Z)-	000593-39-5	21.895	4.37
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all E)-	000111-02-4	27.592	8.00
.gamma.-Sitosterol	000083-47-6	35.297	0.85
Vitamin E	000059-02-9	31.585	0.37
Hexadecanoic acid, 2-hydroxy-1 (hydroxymethyl)ethyl ester	023470-00-0	25.024	0.89

3.4. Determination of Antioxidant activity

Free radicals are harmful as they are responsible for oxidative stress. They react with cellular components such as DNA, proteins and may lead to cell damage [49]. Large amount of free radicals have been associated with some of the chronic diseases of liver, heart and cancers. Fruits are a good source of dietary fibre, phytochemicals and antioxidants. Antioxidant phytochemicals in fruits play an important role in preventing and treating many human diseases [50].

3.4.1. DPPH radical scavenging activity

DPPH is broadly used to test the capability of compounds as free radical scavengers or hydrogen donors and to analyze antioxidant activity for liquids & food samples. DPPH is a stable free radical with violet colour. If free radicals have been scavenged, DPPH will change its colour from violet to pale yellow or colorless. This property allows visual monitoring at 517nm. Methanol solvent was used to examine antioxidant activity. Methanol extract of apple pomace showed better DPPH scavenging activity. A scavenging activity of methanol extract of apple pomace was 82.74 %.(Table 5).

3.4.2. Ferric reducing antioxidant power (FRAP)

This method is based on the principle of reduction of ferric tripyridyl-s-triazine complex to ferrous coloured form in the presence of antioxidants. The procedure was described by Benzie and Strain [24]. The antioxidants present in the samples reduce ferric tripyridyl-s-triazine complex to form a blue colored complex which results in an increase in the absorbance at 593 nm. The BHT equivalent to the respective sample is

mentioned below (Table 6). The result of the present study indicated that apples have good antioxidant activity with high levels of flavonoids and polyphenols.

Table 5: DPPH assay of apple pomace extract.

Sample	% Inhibition
Apple pomace extract	82.74

Table 6: BHT equivalents (µg BE/mg sample) for apple pomace Extract.

Sample	BE equivalents (µg BE/ mg sample)
Apple pomace extract	22.38

3.5. Cooking qualities

The evaluated cooking properties of the control and 10% formulation noodle sample are shown in Table 7. The level of cooking was estimated by the loss of the noodle core at the time of cooking. The perfect cooking time of a noodle trial sample varies from 5.0 to 8.5 min. The quantity of a dried material which was leached out in the cooking water of a cooked noodles, is its cooking loss. The cooking loss of apple pomace powder noodles increased due to weakening of the protein network, due to this, more solids were leached out [51].

The addition of apple pomace powder produced substantial differences in swelling index, water absorption and cooking loss of noodle sample (Table 7). The noodle sample that contained 10% apple pomace powder had significantly higher cooking loss values as compared to the control sample. The water absorption values and swelling index of the noodles that is supplemented with 10% apple pomace powder were significantly greater than the control noodle sample. (Table 7).

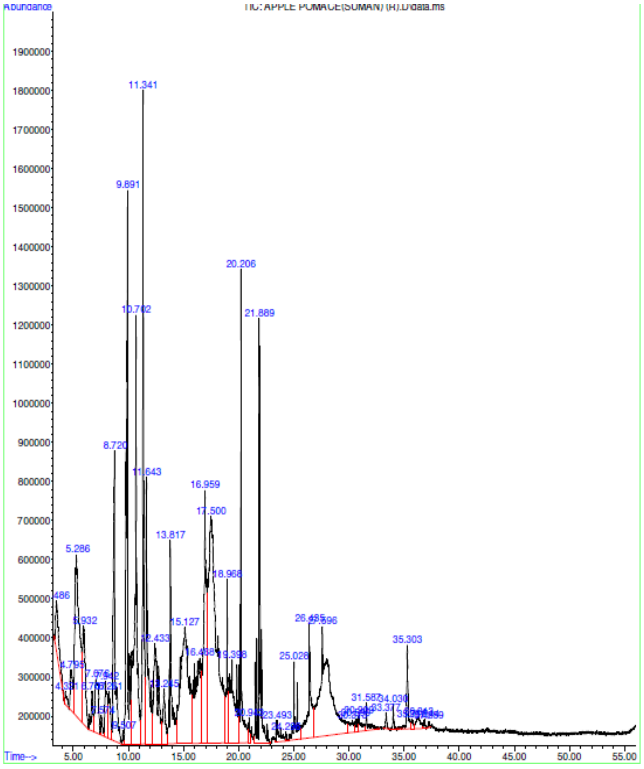

Fig 1: Chromatogram for GC-MS analysis of apple pomace methanol extract.

Table 7: Optimal cooking time, cooking yield, cooking loss, swelling index and water absorption of the dry cooked Noodle samples

Sample	Optimal cooking time(min)	Cooking yield (gm)	Cooking loss (%)	Swelling index (%)	Water absorption (%)
Control	5	35.75	9.84	1.85	1.43
10% formulation	8.5	42.34	11.16	2.31	1.69

3.6. Sensory properties of noodles

In the present study, the sensory judgement of cooked noodles supplemented with apple pomace powder was done to choose the most appropriate apple pomace powder that is 10, 15 and 20% for the formulation of the noodles. The results presented in figure 2 showed the sensorial attributes of noodles supplemented with apple pomace powder. Wheat flour was supplemented with 10%, 15% & 20% apple pomace powder in the formulation of instant noodle samples. The taste, texture and other sensory attributes of the samples (10%, 15% & 20%) with apple pomace powder were significantly reduced than the control sample except the sample that was supplemented with 10% apple pomace powder.

As the level of apple pomace powder increased, all the sensorial score slightly decreased. The sample that contained 10% apple pomace powder acquired highest sensory scores among all the noodle samples. The results of this research showed that the supplementation of apple pomace powder at different levels (10, 15, and 20%) into formulation had a significant outcome of the noodle quality. As the level of apple pomace powder increased ash, protein, dietary fibre also increased. Cooking loss of noodle increased by the supplementation of apple pomace powder and the colour of the product also adversely affected. Noodles supplemented with 10% and 15% apple pomace powder to be similarly satisfactory as the control noodles but 20% formulation was not accepted because of texture and taste. Finally, it can be concluded that the 10% formulation gave agreeable results in terms of acceptability.

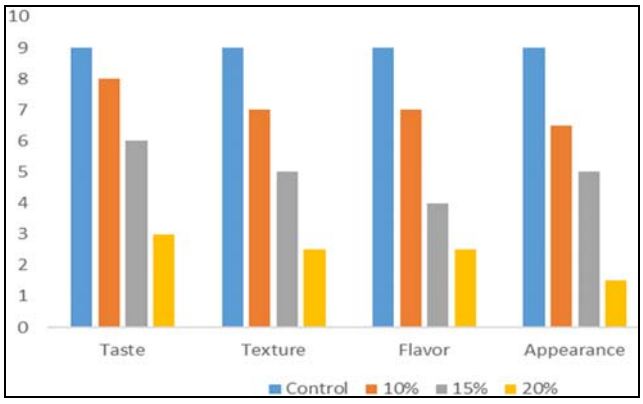

Fig 2: Sensory attributes of noodles supplemented with apple pomace powder.

Colour is the most important quality trait since it is the first thing that appeals to the customer's eye [52]. Normally, people favour shining or light colored yellow noodles that maintain a long lasting colour after preparation, whereas dark colored noodles are generally less attractive [53]. The present study

revealed that as the quantity of apple pomace powder is increased, the colour of both, the uncooked and the cooked noodles darkens gradually. Among all the formulations of Noodle samples supplemented with apple pomace powder i.e.10 %, 15%, & 20%, the 10% formulation was better in colour.

It has been found that the noodles supplemented with apple pomace powder had significantly lower lightness than the control sample. As the level of apple pomace powder increased in formulations (10%, 15% & 20%), the colour of the noodles became darker in comparison to the control, but 10% formulation was slightly less darker colour as compared to 15% & 20% formulations.

4. Conclusion

Apple pomace powder is observed to be an excellent source of dietary fibre, protein, phenolic acids and flavonoids which make it a valuable source of antioxidants. It can, therefore, be concluded that apple pomace can be used as a potential source of nutraceuticals. The present study unveils apple pomace as a promising material for the development of Noodles. Incorporation of apple pomace powder raised the dietary fibre and polyphenols' content in noodles and also showed enhanced antioxidant activity. The studies on the cooking traits such as texture, quality, colour and the most important sensory evaluation revealed that the noodle incorporated with 10% apple pomace powder was the most acceptable product both in terms of palatability and nutritional composition. Formulation of such type of functional foods can impart positive results against many diseases like cancer, cardiovascular diseases, obesity, heart problems etc. prevalent in the world. These noodles can be a good source of nutraceuticals containing functional food utilizing apple industry byproduct.

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