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Chemical Profiling of Different Mango Peel Varieties

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Abstract: The present exploration was an attempt to investigate the therapeutic potential of mango peel extract. For the purpose, five different mango peels namely chaunsa, anwar ratol, langra, dusahri and desi were nutritionally characterized. The nutritional analysis indicated that mango peel is a good source of moisture, protein and minerals. The means elucidated highest moisture in the peel of desi mango 71.38±2.05 followed by anwar ratol, chaunsa, langra and dusahri as 71.01±3.91, 70.74±4.01, 69.86±5.20 and 68.33±4.14%, respectively. Moreover, protein contents were reported from 1.94±0.04 to 2.36±0.01 in respective varieties. Similarly, fat and fiber contents in respective varieties were 2.31±0.14 and 5.01±0.25, 2.26±0.10 and 5.47±0.31, 2.25±0.17 and 4.88±0.12, 2.18±0.18 and 4.69±0.17 and 2.11±0.12 and 4.53±0.18%. Likewise, the recorded NFE values for respective samples were 87.87±6.87, 87.60±3.41, 88.86±5.20, 89.09±3.85 and 89.58±2.89, respectively. In the present case, the highest K content was observed in chaunsa (18.78±1.26 mg/100g) followed by desi (18.76±0.96 mg/100g), anwar ratol (17.73±1.21 mg/100g), dusahri (17.16±1.02 mg/100g) and langra (16.21±1.12 mg/100g). Similarly, Mg and Ca were recorded as 56.11±4.21 and 87.46±6.32, 54.73±3.69 and 82.72±4.18, 52.54±1.16 and 79.81±3.85, 50.25±1.52 and 75.08±4.10 and 56.83±2.32 and 78.39±5.02 mg/100g in respective mango peels. Amongst tested mango peels, ethanolic extract of chaunsa exhibited the highest TPC (75.35±3.96 mg/100g GAE), DPPH (59.28±3.69%) and β-carotene (57.33±4.14%) activities however, FRAP value (7.88±0.19 mmol/100g) was maximum in the acetone extract of chaunsa peel. From the present investigation, it is concluded that mango peel powder potential is potential source of minerals and antioxidants.

Key words: Mango peel, minerals, polyphenol compounds, DPPH activity

INTRODUCTION

Global nutritional scenario has motivated the researchers for the development of novel dietary approaches to combat various physiological threats in the vulnerable segments. Nutritional diversity is the vital component of food system focusing on balanced nutrition for holistic outcomes. The fruits and vegetables based nutraceutical/functional foods have enormous potential to cope with the dietary needs of target population owing to their innate therapeutic nature against degenerative disorders. Accordingly, the food based bioactive ingredients are one of the key priorities of the consumers from various socioeconomic communities due to their positive impact on health and longevity (Roller *et al*., 2007; Jenkins *et al*., 2008).

On worldwide scale, fruits and vegetables processing industry are generating million tons of agro-industrial waste/byproducts per annum that not only creating a disposal problem but also aggravates the environmental pollution. Thus, their efficient, inexpensive and proper disposal is one of the fundamental prerequisites for friendly ecosystem. Industrial residues especially fruits/vegetables peels are concentrated source of phytonutrients that have acquired core attention of the processors for their extraction and maximum recovery (Pinelo *et al*., 2006; Ajila *et al*., 2007a).

Mango (*Mangifera indica*) is a popular fruit widely grown in tropical regions of the globe due to its sweet taste and high nutritive content (Kim *et al*., 2007; Palafox-Carlos *et al*., 2012). Currently, mango is considered as the 5th largest producing fruit throughout the world. The Pakistan contributes 7.6% share in the world market with production of 177 thousand tons (Akhtar *et al*., 2009). The mango mainly constitutes pulp 33-70% followed by kernel 7-24% and peel 15-20% of the total fruit weight. Considering nutritional value, mango peel contains moisture, protein, ash, fibre and carbohydrates as 68.50, 2.05, 2.62, 5.40 and 26.5%, respectively and 453.92 kJ/100g energy (Bede, 2010; Ajila *et al*., 2007a). Its peel is a promising source of phytonutrients such as polyphenols, carotenoids and vitamin E and C. Interestingly, higher polyphenol contents are present in mango peel than that of pulp (Ajila *et al*., 2007a). Similarly, some other fruits like apple and pear peels have higher antioxidant activity and mineral contents compared to the pulp extracts (Manzoor *et al*., 2012;

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Leontowicz *et al*., 2003). The phytonutrients of mango byproduct are affected by several factors including climatic conditions, agronomic practices and varietal differences (Tavarini *et al*., 2007; Manzoor *et al*., 2012). Natural antioxidants are gaining popularity owing to their safe status and effectiveness in the physiological system. There is growing interest among the consumers against synthetic additives thereby diverting their trend towards natural counterparts (Siro *et al*., 2008; Sultan *et al*., 2009). These compounds act as free radical scavengers, metal chelators, free radical chain reaction and oxidative enzyme inhibitors and antioxidant enzyme cofactors (Karadag *et al*., 2009). During normal metabolic processes, free radicals are generated in the body that induce cellular damage in several ways. The most deleterious effect of free radicals i.e., singlet oxygen is the DNA damage (Van Langendonckt *et al*., 2002; Piconi *et al*., 2003). Besides, oxidized Low Density Lipoprotein (LDL) is one of the causative agents for the development of coronary diseases (Pardo-Andreu *et al*., 2006). The diverse phenolic compounds of plant origin exhibit differential antioxidative activity against reactive oxygen species by scavenging hydroxyl and peroxy radicals and singlet oxygen quenching thereby inhibit lipid peroxidation (Severi *et al*., 2009; Wang and Jiao, 2000; Singh *et al*., 2009).

MATERIALS AND METHODS

The present research project was carried out in the Functional and Nutraceutical Food Research Section, National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad. Different mango varieties i.e., Chaunsa, Anwar ratol, Langra, Dusehri and Desi were purchased from the local fruit market. The selected varieties were subjected to washing followed by peeling in the Canning Hall at NIFSAT. Afterwards, the separated peels of each variety were oven dried at 60°C for 1 h and ground to form respective powder.

Characterization of mango peel: Initially, the mango peel samples were examined for various quality traits including proximate and mineral analysis and polyphenols estimation.

Proximate analysis: The respective peel samples were evaluated for moisture, crude protein, crude fat, crude fiber, ash and Nitrogen Free Extract (NFE) and results are expressed on fresh weight basis.

Moisture content: The moisture content in the mango peel was determined by drying sample in an air forced draft oven (Model: DO-1-30/02, PCSIR, Pakistan) by keeping temperature at 105±5°C till constant weight according to the guidelines of AACC (2000).

Crude protein: The percentage of crude protein was estimated through Kjeltech Apparatus (Model: D-40599, Behr Labor Technik, Gmbh-Germany) by adopting the protocol of AACC (2000). Initially, sample was digested with conc. H_2SO_4 and digestion mixture for 6 h till light greenish color. Afterwards, 250 mL dilution of digested sample was made. The diluted sample was distilled by taking 10 mL of sample and 10 mL of 40% NaOH solution in the distillation assembly. The liberated ammonia was trapped in 2% boric acid solution. Lastly, distillate was titrated against 0.1 N H_2SO_4 till golden brown end point.

Crude fat: Crude fat contents in peel samples were estimated using hexane as solvent in Soxtec System (Model: H-2 1045 Extraction Unit, Hoganas, Sweden) as described in AACC (2000).

Crude fiber: The mango peel were subjected to crude fiber content determination by digesting the fat free samples in 1.25% H_2SO_4 followed by 1.25% NaOH using Labconco Fibertech (Labconco Corporation Kansas, USA) following the protocol of AACC (2000).

Total ash: Total ash was estimated by direct incineration of dried sample in a Muffle Furnace (MF-1/02, PCSIR, Pakistan) at 550°C after charring till grayish white residue by adopting the mentioned protocol of AACC (2000).

Nitrogen Free Extract (NFE): The nitrogen free extract was calculated according to the expression given below:

NFE% = 100-(CP%+CF%+crude fiber%+ash%)
Where: CP = Crude protein, CF = Cruce fat

Mineral determination: The mango peel samples were subjected to mineral composition following the method of AOAC (2006). Minerals like calcium, magnesium, zinc, iron and phosphorous were estimated by Atomic Absorption Spectrophotometer (Varian AA240, Australia), while sodium and potassium were determined through Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge).

Preparation of antioxidant extracts: During the extraction of antioxidants from peel powder samples various solvents such as acetone, ethanol and water were used to assess their extraction efficiency (Table 1). Purposely, prepared samples were subjected to orbital shaker for 7 hr followed by centrifugation (15 min) at 7000 rpm. The resultant extracts were filtered using vacuum filtration assembly and solvents were recovered by Rotary Evaporator (EYELA, N-N series, Japan) at 40°C (Rusak *et al*., 2008). The extracts were evaluated

Table 1: Treatments used for estimation of extraction efficiency

Treatments	Mango peel varieties	Solvents
T_1	Chaunsa	Water
T_2	Dusehri	Water
T_3	Desi	Water
T_4	Langhra	Water
T_5	Anwar Ratool	Water
T_6	Chaunsa	Ethanol
T_7	Dusehri	Ethanol
T_8	Desi	Ethanol
T_9	Langhra	Ethanol
T_{10}	Anwar Ratool	Ethanol
T_{11}	Chaunsa	Acetone
T_{12}	Dusehri	Acetone
T_{13}	Desi	Acetone
T_{14}	Langhra	Acetone
T_{15}	Anwar Ratool	Acetone

for various antioxidant assays including Total Phenolic Contents (TPC), β-carotene antioxidant activity, free radical scavenging activity by DPPH (1, 1-diphenyl-2-picrylhydrazyl) and Ferric Reducing Antioxidant Power (FRAP) as discussed below.

Total Phenolic Content (TPC): Total phenolic contents in the resultant extracts were estimated by Folin-Ciocalteu method (Singleton *et al*., 1999). Accordingly, 125 µL sample was taken in a test tube followed by the addition of 500 µL distilled water and 125 µL of Folin-Ciocalteu reagent. Afterwards, 1.25 mL of 7% sodium carbonate was further added. Final volume upto 3 mL solution was made by adding distilled water and allowed to stand for 90 min. The absorbance of the antioxidant extracts was measured at 765 nm using UV-vis spectrophotometer (CECIL CE7200). Calibration/standard curve for gallic acid was drawn with concentrations of 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30 mg/mL:

$$C = c \times V/m$$

C = Total content of phenolic compounds in mg/g plant extract, in GAE
c = The concentration of gallic acid calculated from the calibration curve in mg/mL
V = The volume of extract in mL
m = The weight of plant methanolic extract in g

Antioxidant activity: Antioxidant activity of the resultant extracts were evaluated using assay based on coupled oxidation of β-carotene and linoleic acid following the protocol of Taga *et al*. (1984). For the purpose, β-carotene (2 mg) was dissolved in 20 mL of chloroform. Later, 3 mL aliquot of the solution was placed in 50 mL beaker and added 40 mg linoleic acid and 400 mg Tween 20. Afterwards, chloroform was removed by purging with nitrogen. Oxidation of β-carotene emulsion was monitored spectrophotometrically by measuring absorbance at 470 nm. The results was presented in percent inhibition using the following expression:

$$\ln (a/b) \times 1/t = \text{sample degradation rate}$$

ln = Natural log
a = Initial absorbance (470 nm) at time zero
b = Absorbance (470 nm) after 40 min
t = Time (min)

DPPH scavenging activity: The free radical scavenging activity of mango peel extracts was determined according to the method of Brand-williams *et al*. (1995). For experimental, fresh methanolic solution of DPPH (1, 1-diphenyl-2-picrylhdrazyl) was prepared before assay. Various concentrations of each sample (40, 80, 120, 160, 200 and 240 µg/mL) were added to 1 mL DPPH solution. The reaction mixtures were shaken gently and allowed to stand for 30 min at ambient temperature. The absorbance of the samples was measured at 520 nm by spectrophotometer.

$$\text{Reduction of absorbance (\%)} = [(AB-AA)/AB] \times 100$$

AB = Absorbance of blank sample (t = 0 min)
AA = Absorbance of tested extract solution (t = 15 min)

Ferric reducing antioxidant power: Ferric reducing antioxidant power of extracts was estimated by adapting the protocol of Sun *et al*. (2010). The peel extract (0.5 mL) was mixed with phosphate buffer (1.25 mL, 0.2 M, pH 6.6) and potassium ferricyanide (1.25 mL, 1%). After incubation, 10% TCA (1.25 mL) along with 0.1% ferric chloride were added in the mixture and then left at room temperature for 10 min. Sample absorbance was measured at 700 nm.

Statistical analysis: The collected data were subjected to statistical analysis using Completely Randomized Design (CRD) through statistical software Cohort version 6.1 (Co Stat, 2003). Furthermore, analysis of variance (ANOVA) technique was applied to determine the level of significance (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Dietary phytonutrients provide protection against various metabolic disparities and improve the overall health status. In this milieu, mango peel is a potential source of bioactive moieties that has ability to ameliorate various lifestyle related disorders. In current study, different mango peels were analyzed for compositional and nutritional assay, antioxidant and mangiferin isolation and quantification. During product development, three types of functional/nutraceutical drinks were prepared by supplementation of whole mango peel extract and mangiferin alongside control. Lastly, the prepared functional drinks were evaluated against hypercholesterolemia and diabetes through a model feeding trial. The results and discussion of examined parameters are elaborated herein:

Table 2: Means squares for proximate composition of different mango peels

SOV	df	Moisture	Protein	Fat	Fiber	Ash	NFE
Varieties	4	3.4841^{NS}	0.07977*	0.03024^{NS}	0.38481*	0.25745*	2.21124^{NS}
Error	10	3.46316	0.01373	0.01526	0.05116	0.06568	0.25634

NS = Non-significant, * = Significant

Table 3: Proximate composition of different mango peels

Parameters	Chaunsa	Anwar ratol	Langra	Dusahri	Desi
Moisture	70.74±4.01	71.01±3.91	69.86±5.20	68.33±4.14	71.38±2.05
Protein	2.25±0.05a	2.36±0.01a	2.20±0.04ab	2.06±0.05b	1.94±0.04c
Fat	2.31±0.14	2.26±0.10	2.25±0.17	2.18±0.18	2.11±0.12
Fiber	5.01±0.25a	5.47±0.31a	4.88±0.12ab	4.69±0.17b	4.53±0.18c
Ash	2.59±0.03a	2.31±0.02ab	2.21±0.19b	1.98±0.12c	1.84±0.02d
NFE	87.84±6.87	87.60±3.41	88.86±5.20	89.09±3.85	89.58±2.89

Table 4: Means squares for mineral contents of different mango peels

SOV	df	K	Mg	Ca	Na
Varieties	4	0.07977*	0.03024*	3.48413**	0.38481*
Error	10	0.01373	0.01526	3.46316	0.05116
SOV	df	Cr	Cu	Fe	Mn
Varieties	4	0.00749*	8.900*	8.87908**	2.233*
Error	10	0.00571	4.733	0.26019	4.867

*Significant, **Highly significant

Proximate composition: Proximate composition is important to estimate the quality of raw material. Mean squares in Table 2 showed that protein, fiber and ash contents varied significantly in different peel samples however, non-significant variations were noticed for moisture, fat and NFE.

The means elucidated highest moisture in the peel of desi mango 71.38±2.05 followed by anwar ratol, chaunsa, langra and dusahri as 71.01±3.91, 70.74±4.01, 69.86±5.20 and 68.33±4.14%, respectively. Moreover, protein contents were recorded as 2.36±0.01, 2.25±0.05, 2.20±0.04, 2.06±0.05 and 1.94±0.04% in anwar ratol, chaunsa, langra, dusahri and desi, correspondingly. Similarly, fat and fiber contents in respective varieties were 2.31±0.14, 5.01±0.25, 2.26±0.10, 5.47±0.31, 2.25±0.17, 4.88±0.12, 2.18±0.18, 4.69±0.17, 2.11±0.12 and 4.53±0.18%. Besides, the ash contents ranged from 2.59±0.03 (chaunsa) to 1.84±0.02% (desi), respectively. Likewise, the recorded NFE values for respective samples were 87.87±6.87, 87.60±3.41, 88.86±5.20, 89.09±3.85 and 89.58±2.89, respectively (Table 3).

The results of present investigation are in accordance with the previous findings of Ajila *et al.* (2007b). They carried out proximate profiling of different mango peels and observed moisture, protein, fat, fiber and ash contents in the range of 66-75, 1.76-2.05, 2.16-2.66, 3.28-7.40 and 1.16-3.0%, respectively. Similarly, Ojokoh (2008) recorded the values for crude fat, crude protein and dietary fiber by 5.1, 6.16 and 11.2%, respectively.

The variations in the proximate composition of different peel samples are due to varietal differences, climatic conditions, topographic locations and agronomic practices (Granfeldt *et al*., 1992; Palafox-Carlos *et al*., 2012). Earlier, Zein *et al.* (2005) reported 77, 2, 6, 11 and 2% moisture, crude fiber, protein, fat and ash, respectively in mango peels. Likewise, Prasad *et al.* (2007) characterized mango peel and noticed protein 1.76%, fiber 7.4%, moisture 75.25%, fat 2.66% and ash 1.30%.

Previously, Ashoush *et al.* (2011) estimated the ash, fat, protein and crude fiber contents of mango peel powder by 3.88, 1.23, 3.6 and 9.33%, respectively. Likewise, Chau and Huang (2003) observed 2.24, 2.82, 10.35 and 4.23% fat, protein, fiber and ash respectively, in mango peel powder.

Mineral analysis: Mean squares explicated significant variations in the mineral contents of different mango peel samples (Table 4).

In the present case, the highest K content was observed in chaunsa (18.78±1.26 mg/100g) followed by desi (18.76±0.96 mg/100g), anwar ratol (17.73±1.21 mg/100g), dusahri (17.16±1.02 mg/100g) and langra (16.21±1.12 mg/100g). Similarly, Mg and Ca were recorded as 56.11±4.21 and 87.46±6.32, 54.73±3.69 and 82.72±4.18, 52.54±1.16 and 79.81±3.85, 50.25±1.52 and 75.08±4.10 and 56.83±2.32 and 78.39±5.02 mg/100g in chaunsa, anwar ratol, langra, dusahri and desi mango peels, respectively. Likewise, Na and Cr contents were 18.07±0.85 and 0.273±0.005, 17.77±1.41 and 0.263±0.006, 17.23±1.11 and 0.261±0.001, 16.50±1.01 and 0.256±0.003 and 17.02±0.96 and 0.258±0.004 mg/100g in respective peel samples, correspondingly. Moreover, maximum Cu content (0.076±0.002 mg/100g) was noticed in anwar ratol followed by desi (0.069±0.001 mg/100g), langra (0.066±0.006 mg/100g) and dusahri (0.063±0.002

mg/100g), whilst minimum (0.056±0.003 mg/100g) in chaunsa. Additionally, Fe and Mn contents were 8.826±0.25 and 0.043±0.005, 9.596±0.16 and 0.030±0.004, 7.896±0.21 and 0.026±0.006, 5.346±0.31 and 0.046±0.001 and 6.510±0.21 and 0.033±0.003 mg/100g in the respective peel samples (Table 5). The values regarding mineral composition in the instant research are in line with the earlier findings of Peter *et al*. (2007) and Gopalan *et al*. (1999), they explored the ripend mango for calcium, phosphorous and potassium contents and observed variations from 145-160, 26-35 and 180-211 mg/100 g, respectively.

Likewise, Burns *et al*. (2003) also recorded calcium, phosphorous and potassium in mango peel that ranged from 153-167, 31-41 and 194-217 mg/100 g, respectively. In another study, Mahdavian and Somashekar (2008) reported Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn by 2.14, 85.71, 14.22, 189.31, 39.31, 14.06, 9.52 and 32.67 ug/g dry weight of mango, respectively. The results of present exploration concerning sodium, potassium and calcium are in harmony with the work of Akhtar *et al*. (2010), examined Na, K and Ca contents of dusahri mango peel and compiled the values as 6.33, 38.48 and 7.18 mg/100g, for respective minerals. The compositional variations among different peel samples regarding proximate and mineral assays are possibly due to varietal differences, soil type, environmental and climatic conditions and fruit maturity stage.

Antioxidant extracts: Mean squares elucidated that antioxidant indices of mango peel extracts significantly affected by treatments and solvents however, their interaction was non-momentous (Table 6).

The means for mango peel varieties (Table 7) showed that the highest TPC 75.35±3.96 mg/100g GAE was observed in chaunsa peel followed by 68.34±2.85 mg/100g GAE anwar ratol, 64.95±1.89 mg/100g GAE langra, 61.89±3.85 mg/100g GAE dusahri and the lowest output 58.85±2.45 mg/100 g GAE in desi mango peel. Means regarding solvents exposed the maximum TPC in ethanol 80.17±5.16 mg/100g GAE followed by acetone 62.28±3.12 mg/100g GAE and water extract 55.17±2.41 mg/100g GAE.

Likewise, chaunsa peel exhibited the highest DPPH activity 59.28±3.69% than that of anwar ratol 57.49±1.48%, langra 53.34±2.98%, dusahri 53.20±1.45% and desi 49.64±2.74%. The mean values for solvents showed maximum DPPH activity in ethanolic extract 60.42±2.41% followed by acetone 56.36±3.69% and water 46.98±2.78% (Table 8). The antioxidant activity β-carotene% and FRAP values for different mango peels i.e., chaunsa, anwar ratol, langra, dusahri and desi were 57.33±4.14% and 8.88±0.62 mmol/100g, 54.45±3.96% and 7.80±0.45 mmol/100g, 49.12±3.10% and 7.54±0.25 mmol/100g, 48.14±1.18% and 7.12±0.32 mmol/100g and 45.38±2.50% and 6.24±0.29 mmol/100g. Likewise, ethanolic extract had the maximum β-carotene value 58.59±3.69% followed by acetone 51.98±2.11% and water extract 42.08±1.85%. In contrary, highest FRAP activity was noticed in acetone 7.88±0.19 mmol/100g followed by ethanol 7.52±0.12 mmol/100g and water extract 7.13±0.21 mmol/100g (Table 9 and 10).

Table 5: Mineral profiling of different mango peels (mg/100g)

Minerals	Chaunsa	Anwar ratol	Langra	Dusahri	Desi
K	18.78±1.26a	17.73±1.21ab	16.21±1.12c	17.16±1.02b	18.76±0.96a
Mg	56.11±4.21a	54.73±3.69b	52.54±1.16bc	50.25±1.52c	56.83±2.32a
Ca	87.46±6.32a	82.72±4.18ab	79.81±3.85bc	75.08±4.10c	78.39±5.02b
Na	18.07±0.85a	17.77±1.41ab	17.23±1.11b	16.50±1.01d	17.02±0.96c
Cr	0.273±0.005a	0.263±0.006ab	0.261±0.001b	0.256±0.003c	0.258±0.004c
Cu	0.056±0.003d	0.076±0.002a	0.066±0.006ab	0.063±0.002b	0.069±0.001c
Fe	8.826±0.25ab	9.596±0.16a	7.896±0.21b	5.346±0.31d	6.510±0.21c
Mn	0.043±0.005a	0.030±0.004b	0.026±0.006c	0.046±0.001a	0.033±0.003b

Table 6: Means squares for antioxidant indices of mango peel extracts

SOV	df	TPC	DPPH	β-carotene	FRAP
Treatments (A)	4	624.21**	337.971**	588.339**	18.2696*
Solvent (B)	2	2486.01**	743.764**	409.828**	0.7085**
A x B	8	13.15^{NS}	7.087^{NS}	8.956^{NS}	0.4888^{NS}
Error	30	1.00	1.452	0.0380	2.35

NS = Non-significant, **Highly significant

Table 7: Total phenolic contents (mg/100g GAE) of peel extracts

Parameters	Ethanol	Acetone	Water	Mean
Chaunsa	87.67±4.12	71.25±3.69	67.12±2.98	75.35±3.96a
Anwar ratol	81.09±4.85	64.29±3.01	59.63±3.41	68.34±2.85b
Langra	79.52±4.45	60.96±3.14	54.36±2.65	64.95±1.89c
Dusahri	77.28±4.10	58.86±3.29	49.52±2.91	61.89±3.85cd
Desi	75.28±4.29	56.03±3.21	45.25±2.25	58.85±2.45d
Mean	80.17±5.16a	62.28±3.12b	55.17±2.41c	

Table 8: Free radical scavenging (DPPH%) activity of peel extracts

Parameters	Ethanol	Acetone	Water	Mean
Chaunsa	65.23±4.11	60.25±4.23	52.36±2.12	59.28±3.69a
Anwar ratol	62.25±3.32	60.63±3.18	49.58±3.30	57.49±1.48ab
Langra	60.96±3.20	54.36±3.01	44.69±2.14	53.34±2.98b
Dusahri	58.32±2.45	54.69±2.15	46.58±2.89	53.20±1.45b
Desi	55.35±2.25	51.89±3.29	41.69±1.35	49.64±2.74c
Mean	60.42±2.41a	56.36±3.69b	46.98±2.78c	

Table 9: Antioxidant activity (β-carotene%) of peel extracts

Parameters	Ethanol	Acetone	Water	Mean
Chaunsa	63.59±5.01	59.68±4.23	48.71±2.12	57.33±4.14a
Anwar ratol	61.68±4.30	57.12±3.01	44.56±2.45	54.45±3.96b
Langra	57.25±2.25	49.16±3.01	40.96±2.24	49.12±3.10c
Dusahri	55.48±2.48	48.26±2.05	40.69±1.87	48.14±1.18c
Desi	54.96±1.78	45.68±1.15	35.51±0.96	45.38±2.50d
Mean	58.59±3.69a	51.98±2.11b	42.08±1.85c	

Table 10: Ferric Reducing Antioxidant Power (FRAP mmol/100g) of peel extracts

Parameters	Ethanol	Acetone	Water	Mean
Chaunsa	8.96±0.42	9.63±0.21	8.05±0.12	8.88±0.62a
Anwar ratol	7.89±0.52	8.25±0.14	7.25±0.19	7.80±0.45b
Langra	7.51±0.17	7.69±0.31	7.42±0.18	7.54±0.25c
Dusahri	7.02±0.21	7.39±0.05	6.96±0.21	7.12±0.32d
Desi	6.25±0.11	6.48±0.15	5.98±0.25	6.24±0.29e
Mean	7.52±0.12b	7.88±0.19a	7.13±0.21c	

The results regarding TPC contents in the current exploration are comparable with the findings of Kim *et al.* (2007). They examined the antioxidant capacity of ripend and unripend peels of different mango cultivars through total phenolics estimation. They observed higher TPC 90-110 mg/g GAE in ripend peels as compared to raw 55-85 mg/g GAE on dry basis. They further expressed that TPC contents were affected by maturity stage, cultivar type and agronomic practices. Likewise, Barreto *et al.* (2008) investigated the polyphenolic concentration in the peels of different mango cultivars including Embrapa-141-Roxa, Fafa, Van Dyke, Tommy Atkins, Amrapali and Kent and noticed 24.24, 52.28, 59.09, 25.13, 18.12 and 91.21 g/kg TPC values, respectively. One of the researchers groups, Nithitanakool *et al.* (2009) examined the antioxidant potential of mango peel and pomace. Purposely, they conducted polyphenolic estimation and detected higher value in peel 98.3 mg GAE/g as compared to pomace 68.8 mg GAE/g.

Previously, Ajila *et al.* (2007b) compared different solvents like acetone, ethanol and water for total phenolic contents of mango peel. They were of the view that ethanol and acetone are more efficient than water due to their polarity differences. The recorded polyphenols in ethanol, acetone and water were 92.62, 90.02 and 55.05 mg GAE/g, respectively. Likewise in another experiment, Ajila *et al.* (2007b) explicated that acetone exhibits better affinity for mango polyphenol extraction than water and recorded 54.67, 90.18, 100.00 and 109.70 mg/g TPC for badami ripe, badami raw, raspuri ripe and raw, correspondingly.

Earlier, Larrauri *et al.* (1996) probed raw and ripend peels of hayden variety for their total phenolic contents. They used aqueous methanol for antioxidant extraction and then subjected to Folin-Ciocalteu assay. They observed higher TPC contents 70 mg GAE/g in ripend peel as compared to 55 mg GAE/g for raw peel. Likewise, Ueda *et al.* (2000) concluded that peel is a better source of antioxidant than pulp. Similarly, Jung *et al.* (2008) and Liu *et al.* (2008) reported a correlation between antioxidant activity and type of solvent for mango polyphenols extraction. The results concerning DPPH activity in instant study are in agreement with the outcomes of Ayala-Zavala *et al.* (2010). They evaluated the effect of different concentrations on DPPH activity of mango peel. They were of the view that polyphenol concentration has linear association with DPPH activity and observed 67.97% free radical inhibition at highest polyphenolic concentration (322 mg/mL). Previously, Ribeiro *et al.* (2008) observed that mango peel has higher free radical scavenging activity 53.3% than that of seed 24.2%.

Later, Kim *et al.* (2010) investigated the effect of polyphenolic concentration on free radical scavenging activity. They varied the concentration of mango peel extracts containing bioactive moieties from 12.5-50 ug/ml and observed a linear association between DPPH activity and polyphenolic concentration as 1.72-92.57 and 3.99-81.86% in unripend and ripend mango peel, respectively. Among the various mechanistic routes regarding antioxidant action of mango polyphenols, single electron transfer activity is promising due to its

ability to donate one electron thus reduces metals, carbonyls and free radicals moreover, hydrogen atom transfer also helps to quench free radicals through hydrogen donation (Wright *et al*., 2001).

The instant results regarding FRAP activity of mango peel are in accordance with the conclusions of Guo *et al*. (2003), evaluated ferric reducing antioxidant power of various mango byproducts i.e., peel and pulp. They observed higher FRAP value for peel 10.13 mmol/100g as compared to pulp 0.38 mmol/100g on wet weight basis. Different scientific groups like Scalzo *et al*. (2005) and Torunn *et al*. (2009) documented the higher FRAP activity of mango peel than papaya and lemon peels. The higher ferric reducing activity of mango polyphenols is due to their ability to chelate metal ions and free radicals. Likewise, Berardini *et al*. (2005a) evaluated the FRAP activity of mango peel water and ethanolic extracts. They noticed higher activity in ethanolic extract 436 µmolTrolox/100g in comparison to water 361 µmolTrolox/100g. In another study, Kawpoomhae *et al*. (2010) observed higher ferric reducing antioxidant power in ethanolic extract. Recently, Joona *et al*. (2013) noticed the FRAP activity in methanol extract of mango leaves as 0.85 ug/mL. Moreover, mango byproducts i.e., peel, seed, stem and bark possess high antioxidant activity in term of β-carotene that ranged from 42-71% (Scalzo *et al*., 2005).

From the above discussion, it is inferred that antioxidant indices of mango peel are influenced by the type of solvent and variety. Conclusively, all tested extracts exhibited good antioxidant ability however, ethanolic extract showed better performance as compared to acetone and water extracts. Amongst various mango peels, chaunsa showed better performance regarding polyphenol profile.

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