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Physicochemical and nutritional composition of mango (*Mangifera indica* Linn.)

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Abstract
The availability of mango in India is abundant, leading to significant amount of seed waste generated during processing. This study focuses on utilizing mango seed kernels, particularly from the Safeda variety, which has larger fruits and higher seed percentages, for the development of value added products. Physical characteristics like length, width, weight, seed percentage and chemical characteristics such as moisture content, TSS, Protein content, carbohydrates of two varieties, Safeda and Royal special are compared. Kernels of Safeda are found to have higher nutrient content, making them suitable for fortifying food products like pasta.

Keywords: Mango, physical properties, chemical properties

Introduction
Mango (*Mangifera indica* Linn.) which belongs to Anacardiaceae family is one of the world's most popular tropical fruits. Mango is a most cultivated fruit that originated in India around 4,000 years ago (Fowomola *et al.*, 2010) [1]. They were first introduced to Asia, then to the rest of the world. Mangoes rely on people to carry them throughout the world because of their enormous central seed.

The Persians brought mangoes throughout Western part of Asia and planted seeds in East Africa in the 10th century. Later Portuguese explorers has introduced mangoes to Brazil in the 16th century, and from there they spread across the Americas. They were first cultivated in Barbados in 1742, and by the early nineteenth century, they were being cultivated in Mexico. The United States did not commercially cultivate mangoes until the eighteenth century. Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat, and Tamil Nadu are the main mango-producing states. Uttar Pradesh is the largest producer of mangoes, accounting for 23.47% of total production and producing the most fruit (APEDA, 2021) [2]. India is a significant exporter of fresh mangoes to the foreign nations. During the 2020-21 fiscal year, India exported 21,033.58 metric tonnes (MT) of fresh mangoes valued at Rs. 271.84 crores/$36.23 million. Major export destinations in 2020-21 include the UAE, the UK, Oman, Qatar, and Kuwait (APEDA, 2021) [2].

Mango is composed of carbohydrates, minerals, fiber and vitamins which are highly essential for human health. It is rich in vitamins A and C, minerals like potassium, magnesium and calcium and antioxidants as well, which can help us to stay healthy. On other hand vitamin K, aids in blood clotting and helps to avoid anemia. They are also high in vitamin C, which is necessary for the formation of blood vessels and good collagen, as well as for healing. It contains fiber and protein content in noticeable levels. The proximate composition of mango was reported to have moisture content as 5.90 percent, crude protein content as 5.20 percent carbohydrates as 76.14 percent, fat as 9.84 percent, crude fibre of 0.49 percent and ash as 2.43 percent (Joyce *et al.*, 2014) [3]. Mango is also beneficial for the heart and circulation of blood. It is rich in magnesium and potassium, which are both associated with lower blood pressure and a regular heartbeat. In addition, it contains the chemical mangiferin, which may reduce heart inflammation (Abdalla *et al.*, 2007) [4]. The mango seed kernel is rich in starch, fiber, protein, and minerals and is potentially a good source of nutrients for human and animal feed. Although mango seed kernel contains low amount of protein but the quality of protein is good because it contains most of the essential amino acids with highest level of leucine, valine and lysine (Abdalla *et al.*, 2007) [4].

Materials and Methods

Mango that is fully ripened, matured and disease free of Safeda and Royal special varieties was bought from fruit market of Phagwara, Punjab. Semolina and packaging materials were procured from the agricultural laboratory store of the university. The fruits were washed and then peel, flesh and seeds were separated with the help of knife and the seeds are washed under tap water to remove the excess pulp over the seeds. The kernels were extracted from the seeds by using a knife for further utilization To achieve accurate and dependable findings, the physio-chemical properties were assessed using the Association of Official Analytical Chemists (AOAC 2000) [5] which are listed below.

Physical characteristics

The matured mango fruits were analyzed for different physical parameters like fruit weight, length, width, seed percentage and kernel percentage.

Fruit length and width (cm)

The length and diameter of ten mango fruits that are selected randomly, were measured by using digital vernier calipers and the average value was calculated and expressed in cm.

Fruit weight (g)

The weight of ten fruits were measured by placing the fruits on top of digital weighing machine and the average weight of the fresh fruits and seeds was calculated and expressed in grams.

Seed percentage (%)

Seed percentage was calculated by dividing the weight of seed by the weight of whole fruit and the value was expressed in percentage. Which was recovered from the previous process.

$$\text{Seed percentage (\%)} = \frac{\text{Weight of seed}}{\text{Weight of whole fruit}} \text{ x } 100$$

Kernel percentage (%)

Kernel percentage was calculated by dividing the weight of kernel by the weight of whole fruit and the value was expressed in percentage.

$$\text{Kernel percentage (\%)} = \frac{\text{Weight of kernel}}{\text{Weight of whole fruit}} \text{ x } 100$$

Chemical characteristics

TSS, moisture, pH, reducing sugar, ascorbic acid concentration, non-reducing sugar, fat, total phenols, crude fibre, total sugar, total flavonoids, catotene, and antioxidants were assessed in ripened persimmon fruit for chemical characteristics.

Estimation of moisture content

2 g of pulp was weighed and dried for 4-5 hours in a 105 °C oven. After cooling, it was weighed periodically until a consistent weight was established. The moisture content was used for calculating weight loss. (AOAC, 2000) [5].

$$\text{Moisture content (\%)} = \frac{\text{Initial weight of sample} - \text{final weight of sample}}{\text{Initial weight of sample}} \text{ x } 100$$

Total soluble solids (º Brix)

At room temperature, the total soluble solids of fresh pulp were determined using a digital refractometer (MA871) with a range of 0 to 85 o Brix by putting a drop of pulp on the screen and taking readings. (Ranganna, 2014) [6]. The refractometer was calibrated with distilled water before every reading and the values were expressed in º Brix soluble solids.

Titratable acidity (%)

Titratable acidity was determined as per method suggested by Ranganna, (2014) [6]. Titration against 0.1 N NaOH solution was performed with 10 ml of sample and 2 - 3 drops of phenolphthalein solution as an indicator. The endpoint appeared as a light pink color. The acidity was calculated based on NaOH used and results were expressed in percentage.

$$\text{Titratable acidity (\% citric acid)} = \frac{\text{Titer value x Normality of alkali x Equivalent weight of acid x Volume made up}}{\text{Weight of sample x Volume of sample taken for estimation}} \text{ x } 100$$

pH

The pH of the fruit was determined by using a digital pH meter (CRISON Instrument). The pH meter was calibrated with standard buffers of pH 4, 7 and 9 before taking the readings of the sample (Ranganna, 2014) [6].

Crude Fibre

Moisture and fat-free samples of 3 to 5 grams were carefully measured and placed in a beaker. Next, 200 ml of boiling 0.25N (1.25 W/V) H2SO4 (sulfuric acid) was added to the beaker. The mixture was then boiled for a duration of 30 minutes, ensuring the volume remained constant by periodically adding water. After filtering the mixture through filter paper, the leftover residue was extensively rinsed with hot water to eliminate any traces of acid. After returning the material, 200 ml of boiling 0.313N NaOH (sodium hydroxide) solution was added in the same beaker. After another 30 minutes of boiling, the resulting substance was washed with hot water until it was completely alkali-free. The washing process was then repeated with alcohol. Finally, the mixture was put to a crucible and dried overnight at a temperature of 80-100 °C. After cooling, the crucible with its contents was weighed again. The weight difference between the original and final readings represented the amount of crude fibre, as determined by the AOAC, 2000 [5] method.

Ascorbic acid (mg/100 g)

The ascorbic acid content was estimated by the procedure given by Ranganna (2014) [6]. 100 ml solution was prepared by dissolving 100 mg of L - ascorbic acid in 3% metaphosphoric acid. The 10 mL was then diluted with 100 mL of 3% metaphosphoric acid (1 mL = 0.1 mg ascorbic acid). Five milliliters of standard ascorbic acid were used to standardize the dye, using pink as the end point. 10-20 mL of pulp and seed were treated in 100 mL of 3% metaphosphoric acid and filtered. In a conical flask, 10 mL of pulp and seed were titrated against 2, 6-dichloroindophenol dye. The arrival of pink hue was the tipping moment. The ascorbic acid

content was estimated using the formula below.

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titer x Dye factor x Volume made up x 100}}{\text{Aliquot of extract taken for estimation x Vol. of sample}}$$

$$\text{Dye factor} = \frac{0.5}{\text{Titer value of standard ascorbic acid}}$$

Total phenolic content (mg/ 100 g)

Total phenols were estimated as per the method given by (AOAC, 2012) [5]. Gallic acid standards of 0.2 mg, 0.4 mg, 0.6 mg, 0.8 mg, and 1mg concentration were produced. 0.1 g of material was collected, macerated with 5 ml of 80% ethanol, and centrifuged. The supernatant was held in a water bath until it boiled. 5 cc of distilled water was added to the residue after it had boiled. From this, 0.2 ml was transferred to another test tube and filled to a volume of 3 ml with distilled water. After 3 minutes, 0.5 ml of Follin Ciocalteu reagent was added. The absorbance at 750 nm was measured after 20 ml of sodium carbonate was added and heated for 1 minute. The total phenols present in the sample were calculated with the help of the standard curve prepared simultaneously by taking gallic acid as the standard phenol and results have been expressed as mg/100 g.

Antioxidant activity (%)

The antioxidant activity was estimated by using the procedure given by (AOAC, 2012) [5]. 1 ml of pulp and 1 gm of seed was macerated separately with 3 ml of 80% of methanol and filtered. 0.1 ml of filtrate and 3.9 ml of DPPH (2.3%) was added and incubated for 30 mins at dark and absorbance was recorded at 515 nm. The antioxidant activity was calculated by using the following formula and expressed percentage.

$$\text{Antioxidant activity (\%)} = \frac{(\text{Absorbance of control} - \text{Absorbance of sample})}{\text{Absorbance of control}} \text{ x } 100$$

Result and Discussion

Physical characteristics of fresh mango fruits and seeds

The physical properties of fresh mango, brought from the market are analysed for further study. After washing and separation, the mango seed kernels are measured for their physical analysis like length, width, weight, etc. Table 1 provides a comparison of the physical characteristics of fresh mango pulp and seeds for two varieties i.e., Safeda and Royal Special. The parameters measured include length, width, weight, and the percentage of seed and kernel in the fruit. For Safeda variety, the average length of the fruit was recorded as 12.26 cm, while the seed has an average length of 6.43 cm. On the other hand, the Royal special variety has a smaller fruit length of 6.46 cm and a seed length of 4.23 cm. This indicated Safeda variety could have larger seed size, due to longer length of the fruit. Safeda variety has a fruit width of 8.13 cm and a seed width of 3.60 cm, whereas the Royal special variety has a slightly smaller fruit width of 6.53 cm and a seed width of 3.12 cm. Similarly in case of weight, for Safeda variety, the fruit's average weight was recorded as 451.80 g, which was higher in size compared to most other varieties of mango, while the seed weight was recorded as 26.42 g. The average fruit weight of Royal special variety was recorded as 428 g and the seed weight as 19.39 g. These parameters represent the percentage of seed and kernel (edible part of the seed) in the fruit. For Safeda variety, the seed occupies about 19.33 percent of the fruit, and the kernel accounts for 14.25 percent. In contrast, the Royal special variety has a smaller seed percentage of 9.50 percent and a kernel percentage of 6.30 percent.

Table 1: Physical characteristics of fresh mango fruits and seeds

Variety / Parameter	Safeda variety		Royal special variety	
	Values (fruit)	Values (seed)	Values (fruit)	Values (seed)
Length (cm)	12.26±0.80^{a}	6.43±0.28^{c}	6.46±0.92^{a}	4.23±0.21^{c}
Width (cm)	8.13±0.35^{a}	3.60±0.18^{b}	6.53±0.05^{ab}	3.12±0.11^{bc}
Weight (gm)	451.80±15.2^{ab}	26.42±0.35^{ac}	428±2.50^{ab}	19.39±0.35^{a}
Seed (%)	19.33±0.66^{c}	-	9.50±1.21^{b}	-
Kernel (%)	-	14.25±0.21^{ca}	-	6.30±0.36^{ac}

Chemical characteristics of fresh mango fruits and seeds

Table 2 provides the chemical characteristics of fresh mango fruits and seeds of two varieties Safeda and Royal Special. Safeda variety has a moisture content of 89.96 percent in fruit and 21.45 percent in the seed, while Royal special variety has 90.03 percent in fruit and 22.64 percent in the seed. The TSS content in Safeda variety was recorded as 7.6° Brix in the fruit, while in Royal special variety, it was recorded higher as 10.06° Brix. It measures the acidity or alkalinity of the fruit or seed. Safeda variety has a pH of 3.5 in the fruit and 3.2 in the seed. Royal special variety has a slightly lower pH of 3.1 in the fruit and 3.0 in the seed. The protein content in fruit of Safeda variety was recorded as 6.40% and 5.20% was recorded in the seed. Whereas in Royal special variety it was recorded 5.82% in the fruit and 4.16% in the seed. These results are similar to the research conducted by Nzikou *et al.*, (2010) [7] and Asma and Easa (2017) [8]. The fiber content in fruit of Safeda variety was recorded as 2.35% and 1.86% was recorded in the seed, Whereas in Royal Special variety it was recorded 1.75% in the fruit and 1.04% in the seed. These are in line with results of research conducted by Asma (2017) [8]. The titratable acidity in fruit of Safeda variety was recorded as 0.28% and 0.26% was recorded in the seed. While in Royal special variety it was recorded slightly lower as 0.25% in the fruit and 0.21% in the seed. The ascorbic acid content in fruit of Safeda variety has 23.1 mg/100 g and 20.8 mg/100 g was recorded in the seed which are similar to the findings of Gumte *et al.*, (2018) [9]. Whereas in Royal special variety it was slightly lower as 18.6 mg/100 g in the fruit and 16.9 mg/100 g in the seed. The carbohydrate content in the fruit of Safeda variety was recorded as 68.49% and 65.30% was recorded in the seed. Whereas Royal special variety recorded lower carbohydrate content as 58.12% in the fruit and 51.30% in the seed. These results are in consistent with the work done by Gumte *et al.*, (2018) [9] and Richa (2018) [10]. The total phenolic content in fruit of Safeda was recorded as 69.04

mg/100 g and 46.46 mg/100 g was recorded in the seed. Whereas in Royal special variety, it was recorded as 41.26 mg/100 g in the fruit and 32.28 mg/100 g in the seed. These are in line with the results of Richa (2018) [10]. The antioxidant activity in fruit of Safeda variety was recorded as 24.35 percent and 20.65 percent was recorded in the seed. These are similar to the results of Nzikou *et al.,* (2010) [7]. Whereas in Royal special variety it was recorded slightly lower as 21.62 percent in the fruit and 17.48 percent in the seed.

Table 2: Chemical characteristics of fresh mango fruits and seeds

Variety / Parameter	Safeda		Royal special	
	Fruit	**Seed**	**Fruit**	**Seed**
Moisture Content (%)	89.96±085^{a}	21.45±0.12^{b}	90.03±0.55^{de}	22.64±0.22^{a}
TSS (^{o}Brix)	7.60±0.08^{ab}	-	10.06±0.11^{c}	-
pH	3.5±0.02^{ab}	3.2±0.01^{bc}	3.1±0.01^{ac}	3.0±0.12^{ab}
Protein (%)	6.40±0.10^{a}	5.20±0.02^{ab}	5.82±0.06^{a}	4.16±0.17^{ab}
Fiber content (%)	2.35±0.18^{c}	1.86±0.11^{abc}	1.75±.012^{ac}	1.04±0.17^{ab}
Titratable acidity (%)	0.28±0.02^{ab}	0.26±0.05^{acd}	0.25±0.03^{cde}	0.21±0.02^{cd}
Ascorbic acid (mg/100 g)	23.10±0.21^{abcd}	20.80±0.12^{ef}	18.61±0.02^{bc}	16.90±0.26^{d}
Carbohydrates (%)	68.49±0.24^{abd}	65.3±0.55^{ad}	58.12±0.24^{ab}	51.3±0.4^{abcd}
Total Phenolic Content (mg GAE/100 g)	69.04±0.02^{bc}	46.46±0.05^{de}	41.26±0.06^{bce}	32.28±0.08^{ab}
Antioxidant activity (%)	24.35±0.35^{ac}	20.65±0.28^{abc}	21.62±0.19^{c}	17.48±0.12^{e}

Conclusion

The physical and chemical characteristics of fresh mango fruit and seed were analyzed. For the Safeda variety, the average fruit length was 12.26 cm and the average width was 8.13 cm. The average weight was 451.80 g, while the seed percentage was recorded 19.33 percent of the fruit and the kernel percentage was 14.25 percent. Whereas for the Royal special variety the average fruit length was 6.46 cm and the average width was 6.53 cm. The average fruit weight was recorded 428 g, while the seed percentage is approximately 9.50 percent of the fruit and the kernel percentage was recorded 6.30 percent of the seed. It had the highest protein content among all samples, with around 6.40% in the fruit and 6.20% in the seed. The fruit also exhibited a significant amount of fiber content (2.35%) compared to the seed (2.16%). Safeda mango fruit had a relatively low titratable acidity of 0.21%. The fruit was rich in ascorbic acid (Vitamin C) with a content of 23.10 mg/100 g. Carbohydrates made up the majority of the fruit's composition (68.49%). It also contained a substantial amount of total phenolic content (69.04 mg GAE/100 g), contributing to potential health benefits.

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