



Accumulation of mineral nutrients in fruit peel and pulp of loquat (*Eriobotrya japonica*) cultivars during fruit developmental stages

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Loquat (*Eriobotrya japonica*, Lindl) is a subtropical, evergreen pome fruit that belongs to the family Rosaceae and is popular in the international market. In addition to its fresh consumption, loquat fruit can be processed into number of products like jam, jelly etc. (Bons *et al.* 2016). In Punjab, it is highly preferred fruit for kitchen garden and recommended for cultivation in the sub-mountainous zone of Punjab (Bons and Pal 2022). Loquat fruits are considered to have higher medicinal value due to their anti-diabetic, anti-cancer and anti-aging properties (Li *et al.* 2016). Loquats are an excellent resource of minerals like potassium (266–1216 mg), phosphorus (20–126 mg), calcium (16–70 mg), magnesium (13 mg), sodium (1 mg), iron (0.28–1.40 mg) and manganese (0.14 mg/100 g) of fruit pulp that helps in regulating blood pressure (Shah *et al.* 2023). Approximately, 60–70% of fruit is pulp and 15–20% is seed portion (Bons 2023). Loquat peel is endowed with higher mineral nutrients as compared to pulp (Ali *et al.* 2021). Studies have demonstrated that minerals have important biochemical and nutritional functions (Pike and Brown 1984). They also contribute to food flavour and activate or inhibit enzyme activities and other reactions, affecting the texture of food (Zou *et al.* 2016). Up to date no systematic information is available regarding the dynamics of mineral nutrients at different stages of loquat fruit development. Therefore, a study was planned to assess the changes of mineral nutrients in peel and pulp of loquat cultivars at four developmental stages to explore its nutraceutical potential.

The experiment was conducted during the year 2023 at Punjab Agricultural University, Ludhiana (30° 89' N and 75° 80' E with an altitude of 190 m amsl), Punjab. Fruit samples (peel and pulp) of loquat cultivars, Golden Yellow, Saharanpur Special and Tanaka were collected from plants, planted at 6.5 m × 6.5 m spacing at Punjab Agricultural

University, Ludhiana, Punjab having sub-tropical climate. Uniform cultural practices were followed in all the plants as per the Package of Practices for Fruit Crops. Three plants per replication were selected and tagged for each cultivar. Healthy fruit samples were harvested at different fruit developmental stages i.e. 60 DAFS (days after fruit set) (green stage), 75 DAFS (colour break stage), 85 DAFS (yellow stage) and 92 DAFS (orange stage).

To determine macro and micronutrients, peel and pulp portions were separated with the help of knife from randomly selected uniform fruits. After that, it was dried at 65°C in a hot air oven until it reached constant weight. Macronutrients such as calcium, phosphorus, magnesium and potassium along with micronutrients i.e. iron, copper, manganese and zinc were determined by using method of an atomic absorption spectrophotometer (AAS) (Perkin Elmer A Analyst 200). To conduct the analysis, 0.5 g of powdered samples were placed into a porcelain crucible and subjected to heating in a muffle furnace at 550°C for duration of 6 h. Subsequently, the resulting ash was filtered after being diluted in 50 ml of 1% nitric acid. This filtered solution was utilized to assess the concentration of macronutrients and micronutrients from loquat peel and pulp. These mineral nutrients were expressed in mg/100 g of the sample. The data was analyzed using three replications and presented in terms of their mean values and standard error at 5% level of probability by one-way ANOVA using SPSS 24 for Windows® (SPSS Inc., Chicago, USA).

Macronutrients: A higher range of phosphorus content was found in peel (72–2354 mg/100 g) than pulp (43–1678 mg/100 g) during developmental stages (Fig. 1). Phosphorus content showed decreasing trend both in peel and pulp from 60–92 DAFS. Significant differences were observed in phosphorus content in both peel and pulp at different developmental stages. On the other hand, all the cultivars were at par with each other. Maximum phosphorus was observed at the final stage of maturity i.e. orange stage in Saharanpur Special. The results are in line with the findings of Ali *et al.* (2021a) in loquat fruits. Kaur *et al.* (2020) who

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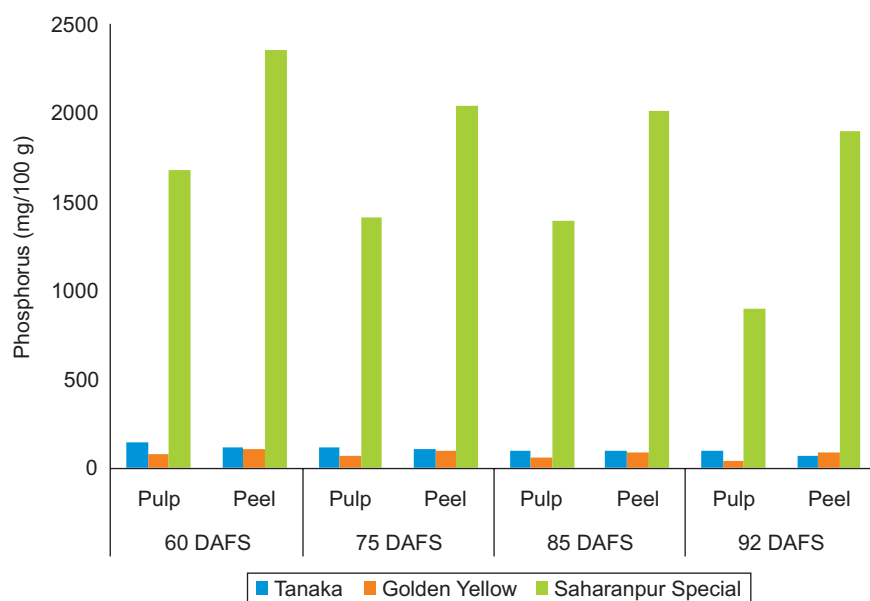


Fig. 1 Phosphorus content in peel and pulp of loquat cultivars at various stages of fruit development.

DAFS, Days after fruit set.

also observed decreasing trend in phosphorous content of mango peel. Further, Kaur (2018) also noticed similar trend of macro nutrients in sweet orange during developmental stages in both peel and pulp.

The highest fluctuation in the concentration of potassium was observed in the peel (Fig. 2) and it was maximum at the final stage (92 DAFS). Potassium in loquat peel and pulp varied from 124–1768 mg/100 g and 1218–1743 mg/100 g, respectively during all developmental stages. Overall higher potassium was observed in peel than pulp. At the orange stage in both peel and pulp cultivar Golden Yellow (1768 mg/100 mg in peel and 1743 mg/100 g in pulp) accumulated maximum potassium content followed by Saharanpur Special and Tanaka, respectively. The developing fruit acts as a strong sink for potassium (Menzel *et al.* 1992, Poovaradom *et al.* 2000). Overall decline in nutrient concentration during growth is due to less nutrient accumulation during growth of fruit (Kaur *et al.* 2020). The results are in agreement with the findings of Kaur *et al.* (2020) in mango fruits and Ali *et al.* (2021a) in loquat.

Calcium content was recorded more in fruit peel as compared to pulp. It varied from 554–1480 mg/100 g in peel. However, calcium content in loquat pulp displayed decreasing trend which ranged from 185–581 mg/100 g (Table 1). At full ripe orange stage, calcium accumulation was exhibited maximum in both peel and pulp of Tanaka followed by Golden Yellow

and Saharanpur Special. Similar outcomes were also reported by Ali *et al.* (2021a) and Ali *et al.* (2021b) in loquat cultivars. Similarly, decreasing trend was noticed in dates during fruit development from Kimri to Tamre stage. Higher calcium content analyzed in fruit peel than in pulp during fruit development may be attributed to the low mobility of Ca in phloem (Chitarra and Chitarra 2005).

Significant differences were observed in magnesium content in both peel as well as pulp at all developmental stages but non-significant differences were observed between different cultivars (Table 1). Magnesium content showed declining trend that ranged from 95–171 mg/100 g in peel and 168–386 mg/100 g in the pulp of different loquat cultivars. In contrast to K, P and Ca, Mg content

was recorded to be more in fruit pulp as compared to peel. At 92 DAFS, maximum magnesium was recorded in both peel and pulp of cultivar Saharanpur Special followed by Golden Yellow and Tanaka. Similar results were also recorded by Ali *et al.* (2021a) and (2021b) in loquat fruits.

At the time of fruit maturity (92 DAFS) the relative order of accumulation of macronutrients in peel was $P < K < Ca < Mg$ and in case of pulp it was $K < P < Ca < Mg$. The fluctuations in mineral contents might be attributed to the mobility of minerals within the phloem and their patterns of translocation. These translocation patterns are subject to

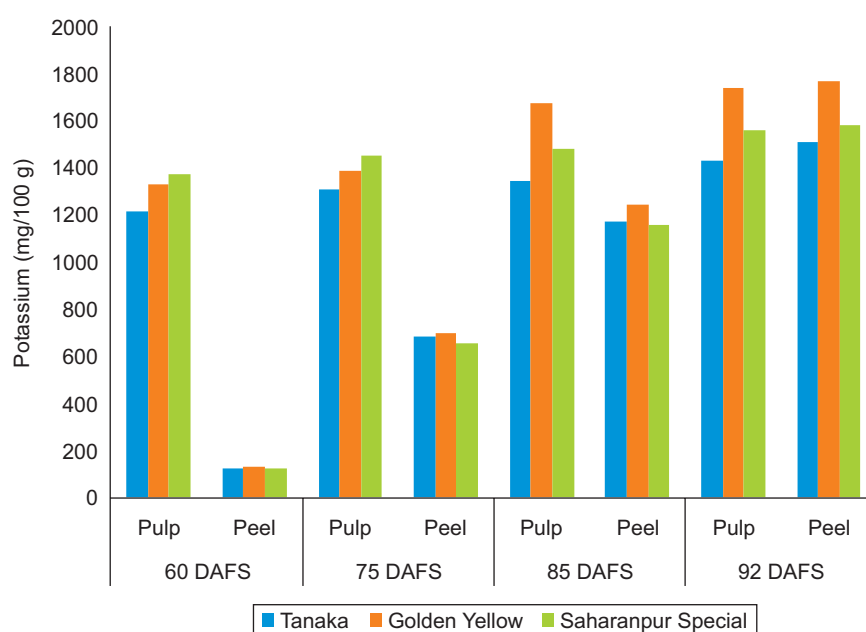


Fig. 2 Potassium content in peel and pulp of loquat cultivars at various stages of fruit development.

DAFS, Days after fruit set.

Table 1 Calcium and magnesium content in peel and pulp of loquat cultivars at various stages of fruit development

Developmental stages	Calcium (mg/100 g)						Magnesium (mg/100 g)					
	Cultivars						Cultivars					
	Peel			Pulp			Peel			Pulp		
	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special
Green 60 DAFS	652 ^d	650 ^d	554 ^d	455 ^a	581 ^a	543 ^a	160 ^a	162 ^a	171 ^a	235 ^a	345 ^a	386 ^a
Colour break 75 DAFS	1003 ^c	946 ^c	897 ^c	499 ^a	515 ^b	477 ^b	145 ^b	139 ^b	151 ^a	198 ^b	219 ^b	247 ^b
Yellow 85 DAFS	1136 ^b	1045 ^b	982 ^b	356 ^c	475 ^c	338 ^c	115 ^c	101 ^c	124 ^c	173 ^c	197 ^c	198 ^c
Orange 92 DAFS	1480 ^a	1356 ^a	1152 ^a	296 ^d	263 ^d	185 ^d	95 ^d	97 ^d	109 ^d	168 ^d	172 ^d	186 ^d
Mean	999.25	1067.75	896.25	458.5	381.5	385.75	129.25	124	138.75	193.5	230.5	254.25
CD ($P<0.05$)	23.49	21.01	23.09	12.76	9.54	8.45	5.65	7.65	5.32	3.99	3.85	4.02

DAFS. Days after fruit set.

change depending on factors such as the specific cultivars, environmental conditions and the growth stage of the fruits (Chitarra and Chitarra 2005).

Micronutrients: Iron content in loquat fruit peel exhibited a decreasing trend and pulp showed gradual increasing trend, with the progression of the fruit developmental stages but non-significant differences were recorded between different cultivars (Table 2). Iron content was recorded to be more in fruit pulp than peel. At the full ripe orange stage, the maximum iron content was recorded in the Golden Yellow cultivar. Peel iron content ranged from 22.51–32.64 mg/100 g at initial stage and 7.70–9.51 mg/100 g at the final stage. However, in case of pulp iron content varied from 3.92–7.62 mg/100 g at initial stage and 6.59–10.78 mg/100 g at final stage. Similar results regarding variation in the iron content of loquat peel and pulp during the developmental

stages were reported by Ali *et al.* (2021a) and Ali *et al.* (2021b) which aligns with the present results.

Significant differences were observed in manganese content with the progression of the fruit developmental stages in peel as well as pulp but non-significant differences were observed between different cultivars (Table 2). The manganese content in peel followed an increasing trend from 60–92 DAFS and ranged from 0.47–1.91 mg/100 g. In case of pulp, manganese content followed decreasing trend with advancement of fruit maturity and varied from 0.32–0.80 mg/100 g. The manganese content in loquat peel as well as pulp at orange stage was found maximum in cultivar Tanaka manganese content was recorded to be more in the peel as compared to pulp. These results are in line with the Ali *et al.* (2021a) and (2021b) in loquat fruits.

Table 2 Iron and manganese content in peel and pulp of loquat cultivars at various stages of fruit development

Developmental stages	Iron (mg/100 g)						Manganese (mg/100 g)					
	Cultivars						Cultivars					
	Peel			Pulp			Peel			Pulp		
	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special
Green 60 DAFS	22.51 ^a	32.64 ^a	26.31 ^a	3.92 ^d	7.62 ^d	6.42 ^d	0.98 ^d	0.47 ^c	1.22 ^c	0.80 ^a	0.75 ^a	0.78 ^a
Colour break 75 DAFS	18.31 ^b	20.72 ^b	16.81 ^b	4.28 ^c	8.26 ^c	7.15 ^c	1.52 ^c	0.54 ^c	1.37 ^c	0.74 ^b	0.72 ^a	0.63 ^b
Yellow 85 DAFS	12.72 ^c	14.57 ^c	9.20 ^c	5.12 ^b	9.51 ^b	7.98 ^c	1.76 ^b	0.71 ^b	1.55 ^b	0.58 ^c	0.53 ^b	0.49 ^c
Orange 92 DAFS	8.35 ^d	9.51 ^d	7.70 ^d	6.59 ^a	10.78 ^a	6.53 ^a	1.91 ^a	0.82 ^a	1.61 ^a	0.43 ^d	0.32 ^c	0.38 ^d
Mean	15.46	19.32	15.01	4.92	9.01	7.47	1.54	0.63	1.42	0.63	0.59	0.55
CD ($P<0.05$)	4.70	5.44	4.45	5.47	3.99	4.51	0.286	0.273	0.335	0.275	0.283	0.184

DAFS, Days after fruit set.

Table 3 Zinc and copper content in peel and pulp of loquat cultivars at various stages of fruit development

Developmental stages	Zinc (mg/100 g)						Copper (mg/100 g)					
	Cultivars						Cultivars					
	Peel			Pulp			Peel			Pulp		
	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special	Tanaka	Golden Yellow	Saharanpur Special
Green 60 DAFS	1.81 ^d	2.07 ^d	2.33 ^d	2.54 ^c	3.06 ^d	2.81 ^c	2.20 ^a	2.63 ^a	2.42 ^a	2.89 ^a	2.67 ^a	3.10 ^a
Colour break 75 DAFS	2.02 ^c	2.35 ^b	2.52 ^c	2.62 ^b	3.13 ^c	2.89 ^c	2.10 ^a	2.50 ^b	2.37 ^a	2.42 ^b	2.40 ^b	2.68 ^b
Yellow 85 DAFS	2.44 ^b	2.23 ^c	2.87 ^b	3.06 ^a	3.22 ^b	3.32 ^b	1.90 ^c	2.47 ^c	2.29 ^b	2.21 ^c	2.32 ^c	2.10 ^c
Orange 92 DAFS	2.58 ^a	2.89 ^a	3.01 ^a	3.31 ^a	3.61 ^a	3.83 ^a	1.80 ^d	2.40 ^d	2.20 ^b	1.85 ^d	2.26 ^d	1.99 ^d
Mean	2.24	2.30	2.68	2.88	3.25	3.21	2	2.5	2.32	2.41	2.37	2.43
CD (P<0.05)	0.243	0.194	0.221	0.195	0.221	0.171	0.208	0.267	0.167	0.269	0.218	0.217

DAFS. Days after fruit set.

Significant difference was observed in zinc content at all developmental stages but non-significant differences were observed between different cultivars (Table 3). Zinc content exhibited an inclined trend during the fruit developmental stages both in peel and pulp and ranged from 1.81–3.01 mg/100 g in peel and 2.54–3.83 mg/100 g in pulp. Zinc content was recorded to be more in fruit pulp than peel. At the orange stage maximum zinc content was recorded in peel (3.01 mg/100 g) as well as pulp (3.83 mg/100 g) of cultivar Saharanpur Special. Our results are in line with Ali *et al.* (2021a) in loquat. Kaur (2018) reported that zinc content in peel ranged from 8.90–12.97 ppm and 3.56–6.84 ppm in pulp in sweet orange. Zinc showed fluctuation between the sampling dates, due to intermediate phloem mobility (Marschner 1995).

Copper content was recorded to be more in fruit pulp as compared to peel. Significant differences were observed in both peel and pulp but non-significant differences were observed between different cultivars (Table 3). At orange stage, copper content was observed to be maximum in Golden Yellow both in peel and pulp. The general order for accumulation of micronutrients in both peel and pulp was Fe<Zn<Cu<Mn. These results are in accordance with Kaur (2018) in sweet orange and Ali *et al.* (2021a) in loquat fruits. Kaur (2018) also noticed that, copper content in sweet orange peel ranged from 8.90–12.97 ppm and 3.56–6.84 ppm in pulp. The fluctuations in mineral concentrations within fruits may be influenced by factors such as variation in cultivars, environmental conditions and the specific growth stage of fruits (Chitarra and Chitarra 2005).

SUMMARY

The experiment was conducted during 2023 at Punjab Agricultural University, Ludhiana, Punjab to assess the changes of mineral nutrients in peel and pulp of loquat cultivars at four developmental stages to explore its nutraceutical potential. During the development of loquat

fruits, K and Zn content both in peel and pulp showed increasing trend from 60–92 DAFS. Similarly, Ca content in loquat peel, Fe and Mn content in pulp also exhibited increasing trend. While P, Cu and Mg content showed a decreasing trend in both peel and pulp. Likewise, Ca content in loquat pulp, Fe and Mn content in peel decreased from 60–92 DAFS. This study provides an insight regarding the accumulation of mineral nutrients in fruit peel and pulp in loquat cultivars during four fruit developmental stages which could be helpful for exploring its nutraceutical potential.

REFERENCES

- Ali M M, Anwar R, Shafique M W, Yousef A F and Chen F. 2021a. Exogenous application of Mg, Zn and B influences phyto-nutritional composition of leaves and fruits of loquat (*Eriobotrya japonica* Lindl). *Agronomy* **11**: 220–24.
- Ali M M, Li B, Zhi C, Yousef A F and Chen F. 2021b. Foliar-supplied molybdenum improves phyto-nutritional composition of leaves and fruits of loquat (*Eriobotrya japonica* Lindl.). *Agronomy* **11**(5): 892.
- Bons H K, Gill K S and Sarabha J S. 2016. Evaluation and comparative performance of six loquat (*Eriobotrya japonica* Lindl) varieties under Punjab conditions. *Journal of Applied and Natural Science* **8**: 1831–34.
- Bons H K and Pal R K. 2022. Survival of loquat under the subtropical conditions of Punjab. *Journal of Agrometeorology* **24**(3): 321–24.
- Bons H K. 2023. Loquat, *Research Bulletin on Fruit Crops*, pp. 70–72. Department of Fruit Science, Punjab Agricultural University, Ludhiana, Punjab.
- Chitarra M I F and Chitarra A B. 2005. Postharvest of fruits and vegetables: Physiology and handling. Academic Press, Federal University of Lavras, Brazil.
- Kaur M. 2018. 'Phytochemical characterization of different sweet orange varieties during fruit development'. MSc Thesis, Punjab Agricultural University, Ludhiana, Punjab.
- Kaur R, Gill M S and Gill P P S. 2020. Seasonal accumulation of mineral nutrients in leaves, peel and stone of Dashehari mango. *Agricultural Research Journal* **57**(6): 887–91.

- Li X, Xu C and Chen K. 2016. Nutritional and composition of fruit cultivars: Loquat (*Eriobotrya japonica* Lindl.). *Nutritional Composition of Fruit Cultivars*, pp. 371–94. Academic Press.
- Marschner H. 1995. *Mineral Nutrition of Higher Plants*, 2nd edn, pp. 181. Academic Press, Institute of Plant Nutrition, University of Hohenheim, Stuttgart, Germany.
- Menzel C M, Haydon G F and Simpson D R. 1992. Mineral nutrient reserves in bearing litchi trees (*Litchi chinensis* Sonn.). *Journal of Horticultural Science* **67**: 149–60.
- Pike R L and Brown M L. 1984. *Nutrition: An Integrated Approach*. John Wiley and Sons, New York, USA.
- Poovarodom S N, Tawinteung N, Mairaing S, Prasittikhet J and Ketsayom P. 2000. Seasonal variations in nutrient concentrations of durian (*Durio zibethinus* Murr.) leaves. *Acta Horticulture* **564**: 235–42.
- Shah H M S, Khan A S, Singh Z and Ayyub S. 2023. Postharvest biology and technology of loquat (*Eriobotrya japonica*. Lindl). *Foods* **12**(6): 1329.
- Zou X, Xi W, Hu Y, Nie C and Zhou Z. 2016. Antioxidant activity of citrus fruits. *Food Chemistry* **196**: 885–96.