

Research Article

Mineral profile of some selected citrus fruits collected from different localities of District Sargodha

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Citation

Ayesha Rasool, Mujahid Hussain, Iftikhar Ahmad, Abdul Ghani, Muhammad Nadeem, Muhammad Ikram and Muhammad Imran. Mineral profile of some selected citrus fruits collected from different localities of District Sargodha. Pure and Applied Biology. Vol. 9, Issue 4, pp2489-2496. <http://dx.doi.org/10.19045/bspab.2020.90265>

Received: 13/04/2020

Revised: 01/07/2020

Accepted: 06/07/2020

Online First: 06/08/2020

Abstract

The present study was conducted to determine the mineral profile of some selected Citrus fruits collected from different localities of district Sargodha i.e. Silanwali, Sargodha, Bhalwal. Plants include *Citrus reticulata* early mandarin (feutrell's early), *Citrus paradisi* (Grapefruit), *Citrus reticulata* mandarin (Kinnow), *Citrus jambhiri* (Khatti) and *Citrus sinensis* (Musambi). Results of the mineral analysis showed that the maximum concentration of Fe (6.52 ± 0.12 mg/100g), Mn (0.98 ± 0.08 mg/100g), Cr (0.46 ± 0.03 mg/100g) and Zn (1.88 ± 0.10 mg/100g) were analyzed in *Citrus sinensis* collected from Sargodha and Bhalwal respectively while the highest concentration of PO₄ (8.10 ± 0.09 mg/100g), Cu (33.59 ± 0.05 mg/100g) and Ca (50.71 ± 0.07 mg/100g) were noted in *Citrus jambhiri* and *Citrus reticulata* early mandarin collected from Bhalwal and Silanwali respectively. A highly significant variation in the mineral profile of all selected plants were observed which may be attributed to different environmental factors i.e. soil composition, water, temperature or may be linked to spatial variations.

Keywords: Citrus fruits; District Sargodha; Mineral profile; Pakistan

Introduction

Citrus is well known as the world's important fruit crop that is produced in a lot of parts of the world with different environmental conditions. Pakistan is one of the major citrus producer countries in the world. Citrus production is assessed to be 105 MMT per annum [1]. Pakistan establishes about 30% of the area under all citrus orchards represented by 11 genera and 27 species [2]. Pakistan is the twelfth citrus-producing country both in an area under cultivation (199.9 thousand hectares) and fruit production (2.35 MMT)

growing at an average annual rate of 3.93% [3, 4].

Citrus is grown in all four provinces of Pakistan but Punjab produces over 98% with an area of 183.21 thousand hectares under cultivation and 2.31 MMT in fruit production because of its greater population and favorable growing conditions [4]. Major varieties of citrus produced by Punjab includes Mandarins (Kinnow and Feutrell's early), Sweet Oranges (Musambi, Succri, Jaffa, Red Blood, Ruby Red), Lemon (Rough Lemon, Lisbon Lemon, Eureka), Lime

(Kaghzi lime, Sweet lime), Grapefruit (Mash seedless, Duncan, Foster, Shamber) [5]. A large part of citrus fruits consumed locally, however 10-12% of total production is exported to other countries of Asia and Europe. About 86% of citrus is covered by Kinnow followed by Musambi (10%), Feutrell's early (4%), Blood Red (1%) [4]. Different parts of citrus fruits possess various nutritive and therapeutic value. Citrus fruits and juice are excellent sources of health-promoting substances which are essential for many physiological functions of the body i.e. these are an important source of minerals that are vital to human health and survival. 5% of body mass is considered as minerals [6], as part of myoglobin, hemoglobin, maintain pH, acting as a catalyst in many biological reactions, important for proper food digestion, metabolism and Utilization of all the nutrients in food [3]. Minerals are also important to our mental health i.e. memory, learning. Helpful in curing headache,

weakness, stress, chronic fatigue, osteoporosis [7], arthritis, cancer, premenstrual disorders. These also take part in the formation of bones, teeth, enzymes, hormones, tissues [8], also used in fat and carbohydrate metabolism, ATP formation and cell proliferation [7]. This study is illustrating the mineral profile of some selected citrus fruits collected from different localities of district Sargodha.

Materials and methods

The study was conducted to analyze the mineral profile of some selected citrus fruits collected from different localities of district Sargodha (Fig. 1) i.e. Silanwali (S1), Sargodha (S2), Bhalwal (S3) while selected citrus fruits include *Citrus reticulata* early mandarin (feutrell's early) (P1), *Citrus paradisi* (Grapefruit) (P2), *Citrus reticulata* mandarin (Kinnow) (P3), *Citrus jambhiri* (Khatti) (P4), *Citrus sinensis* (Musambi) (P5).

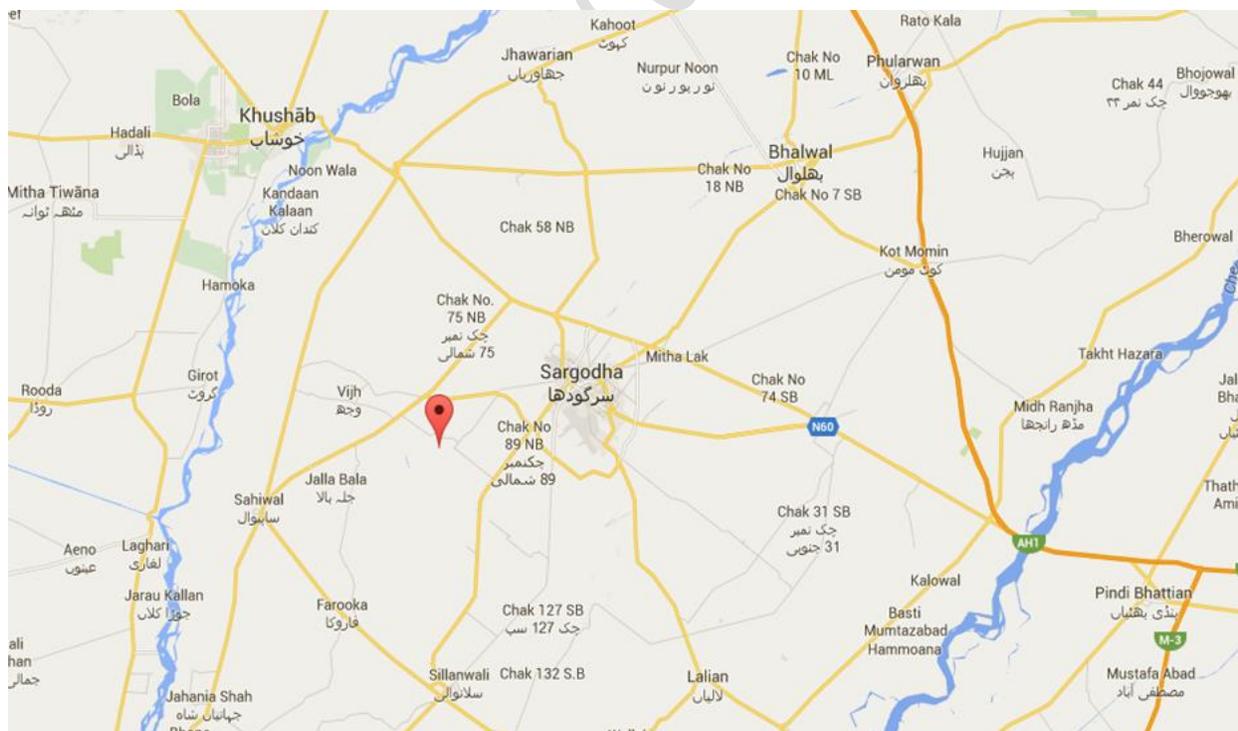


Figure 1. The map of district Sargodha (Google Map data)

Sample collection

Fruit samples of all selected plants were collected from all three sites for analysis. Each sample comprised of three replicates. Each sample was randomly handpicked, wrapped in a specific brown envelope, labeled and brought to the Department of Botany, University of Sargodha, Sargodha for further analysis.

Mineral analysis (mg/100g)

Elemental analysis was carried out according to the method AOAC [9]. Following Metals were studied using standard methods which include phosphate (PO₄), calcium (Ca), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn).

Digestion of fruit samples

The oven-dried fruit samples were grinded into a fine powder and then digested by a wet digestion method. 0.5 g of samples were taken into the digestion flask, 10 ml HNO₃

was added in each sample and kept it overnight. Then the process of digestion was carried out on a hot plate by adding 5ml Perchloric acid in the sample. The process was repeated until the sample solution becomes transparent. Then distilled water was added to make the solution up to 100 ml. Then standard solutions were also prepared for each element to be analyzed.

For elemental analysis, the filtered solution samples were loaded to the atomic absorption spectrophotometer (Model: Varian AA-240). The standard curve for each metal was prepared by running the standard solution. The mineral contents of the samples were estimated by standard curve prepared for each metal [9].

Statistical analysis

Results were statistically analyzed (Table 1) by analysis of variance and LSD using SPSS software [10].

Table 1 Analysis of variance of data regarding mineral profile in some selected citrus fruits collected from different localities of district Sargodha

ANOVA SOV	DF	Ca	Cr	Cu	Fe	Mn	PO ₄	Zn
Sites	2	2497.45**	0.10640**	958.815**	15.5546**	0.30880**	25.8776**	0.32074**
Plants	4	37.14**	0.00788**	7.420**	0.1564**	0.00435 ^{NS}	0.0691**	0.04310 ^{NS}
Sites * Plants	8	25.37**	0.01673**	3.706**	1.1354**	0.06693**	0.8642**	0.02207 ^{NS}
Error	30	0.19	0.00104	0.027	0.0252	0.00968	0.0074	0.01948
Total	44							

Results and discussion

Phosphorous is an essential constituent of bones, DNA, RNA, ATP. It makes up 0.5 to 1.1% of the human body, involved in many functions i.e. filtering waste, repairing tissues and cells. However, too much accumulation of phosphorus in the body leads to several health hazards which includes kidney disorders, heart diseases, joint pain and fatigue [3]. Results of the study showed that the maximum concentration of PO₄ was observed in P4 collected from S3 while the minimum was observed in P5 collected from

S2 with the mean value of 5.88±1.58 mg/100g as shown in (Table 2). Results regarding PO₄ in different varieties of citrus fruits are in collaboration with the findings of [11]. They showed that level of phosphorous ranged from 1.1 to 18.6 mg/100g in different varieties of citrus while findings of [12] showed that orange (12 mg/100g) and grapefruit (8 mg/100g) are also a good source of PO₄. Normal intake of phosphorus for adults and children should not be exceeded from 580 mg/day and 460 to 1250 mg/day respectively as suggested by [13].

Table 2. Mean values of data regarding PO₄ in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	5.11±0.25g	7.94±0.03b	4.77±0.05h	7.79±0.08c	4.11±0.09ij	5.94±1.65A
S2	5.85±0.11f	7.39±0.06d	4.15±0.09i	8.07±0.04ab	3.97±0.10j	5.88±1.71A
S3	4.85±0.07h	6.78±0.11e	4.17± 0.09i	8.10±0.09a	5.14±0.13g	5.81±1.48B
Mean	5.27±0.45C	7.37±0.50B	4.36±0.31D	7.98±0.16A	4.40±0.56D	

Calcium is a mineral that makes up approximately 2 percent of the human body. It is vital for life as a major part of our bones, teeth, nerve cells and body tissues [14]. It enables our heart to beat, Nerves to conduct signals, muscles to contract and blood to clot. Also involves in the secretion of certain enzymes. Its absorption is better in young than an old person with vitamin D [15]. Daily intake of calcium reduces blood pressure and cholesterol level especially LDL in blood and incidence of colon cancer [16] while results showed that the highest concentration of Ca

was noted in P5 collected from S2 while the lowest was observed in P4 collected from S3 with the mean value of 28.66±15.27 mg/100g (Table 3). Results regarding Ca in different varieties of citrus fruits are in collaboration with the findings of [17]. They showed that level of Ca in selected fruits was ranged from 3.1±0.08 to 30.0±3.8 mg/100g while grapefruit, orange, pomelo contains 20.0±5.4, 25.5±1.9, 10.0±0.8 mg/100g respectively. RDA for calcium for an adult is 800mg/day, for teenagers 1200 to 1500mg/day [18].

Table 3. Mean values of data regarding Ca in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	45.99±0.62b	17.26±0.09i	27.76±0.05f	9.35±0.12l	50.71±0.07a	30.21±16.54A
S2	44.70±0.05c	13.36±0.04j	24.47±0.13g	10.50±0.16k	50.43±0.30a	28.69±16.77B
S3	38.97±0.86e	19.66±0.20h	25.00±1.10g	8.49±0.32m	43.23±0.30d	27.07±13.16C
Mean	43.22±3.28B	16.76±2.75D	25.74±1.62C	9.45±0.89E	48.12±3.60A	

Chromium (Trivalent) is an essential trace element. A very small amount of chromium is necessary for the maintenance of human health. It is important for fat and carbohydrate metabolism, reduce the risk of diabetes, polycystic ovary syndrome, Turner’s syndrome, dysthymia. Also lowering cholesterol level in blood [19] while results showed that the maximum concentration of Cr was noted in P5 collected from S2 and the minimum was observed in P4 collected from S1 with the mean value of

0.19±0.11 mg/100g (Table 4). Results regarding Cr in citrus showed similar findings with [3]. They showed that level of Cr in selected citrus fruit varied from 0.15 to 0.063 mg/Kg while findings of [20] showed that orange fruits contains 46.2 to 84.7 mg/Kg. A normal dose of chromium for women is suggested as 14-25 µg/day while for men, it is suggested as 14-35 µg/day. Children with age between 1-13 years also require chromium ranged between 0.2 to 25 µg/day [21].

Table 4. Mean values of data regarding Cr in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	0.12±0.01fgh	0.12±0.04fgh	0.15±0.03ef	0.06±0.02i	0.36±0.04b	0.16±0.11B
S2	0.19±0.03cde	0.08±0.01ghi	0.22±0.03cd	0.07±0.04hi	0.46±0.03a	0.20±0.14A
S3	0.17±0.02def	0.13±0.02fg	0.34±0.02b	0.14±0.03ef	0.24±0.04c	0.20±0.08A
Mean	0.16±0.03C	0.11±0.03D	0.24±0.08B	0.09±0.04D	0.36±0.04A	

Copper is also an essential trace element that is required for the synthesis of hemoglobin. Important for respiration, oxidative defense system. Keeps bones, CNS, immune system healthy. Maintains body pigmentation, prevents anemia [3] while results showed that the maximum concentration of Cu was noted in P4 collected from S3 and the minimum was observed in P1 collected from S2 with the mean value of 17.43±9.39 mg/100g (Table 5). Results regarding Cu in citrus varied with the findings of Ghani *et al.* [3].

They showed that level of Cu in selected citrus fruit ranged from 0.15 to 0.063 mg/Kg while findings of [22] indicate that the concentration of copper is 5.90±0.075 mg/Kg in citrus fruit. Another has been noted in watermelon, orange and banana 1.22-2.13, 1.27- 2.13 and 2.51-0.95 mg/Kg respectively while adequate intake for copper is suggested as ranging from 200 to 220 µg/day. For adults it is suggested as 340 to 1,300 µg/day [23].

Table 5. Mean values of data regarding Cu in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	7.70±0.09k	24.14±0.07d	16.92±0.07f	32.30±0.10b	8.19±0.04k	17.85±9.77A
S2	6.59±0.29n	22.73±0.17e	14.51±0.15g	29.48±0.25c	9.79±0.16i	16.62±8.71B
S3	6.87±0.09m	23.88±0.10d	15.89±0.23g	33.59±0.05a	8.91±0.24j	17.83±10.23A
Mean	7.05±0.52E	23.58±0.65B	15.77±1.05C	31.79±1.82A	8.97±0.70D	

Iron is an essential mineral that performs many functions in the human body. It involved in the synthesis of hemoglobin, myoglobin, many enzymes and the generation of ATP. About 6 percent used in the formation of collagen and some neurotransmitters. It also plays a vital role in immune cells maturity and in the maintenance of normal cognitive functions i.e. alertness, intelligence, learning [24] while results showed that the highest concentration of Fe was noted in P5 collected from S2 and

the lowest was observed in P4 collected from S2 with the mean value of 3.34±1.28 mg/100g (Table 6). Results regarding Fe in different varieties of citrus fruits are in collaboration with the findings of [17]. They showed that level of Fe in selected fruits was ranged from 0.11±0.02 to 0.60±0.04 mg/100g while grapefruit, orange, pomeloe contains 0.50±0.02, 0.38±0.02, 0.4±0.03 mg/100g respectively. RDA for iron for an adult is 20 mg/day but for pregnant women, it needs 50 mg/day as reported by [24].

Table 6. Mean values of data regarding Fe in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	2.90±0.08fg	3.39±0.05e	2.88±0.10fgh	2.61±0.03hij	5.23±0.09b	3.40±0.98A
S2	2.59±0.22ij	3.72±0.18d	2.68±0.16ghi	1.54±0.38l	6.52±0.12a	3.41±1.77A
S3	2.18±0.07k	3.56±0.12de	2.40±0.16jk	3.09±0.09f	4.92±0.13c	3.23±1.28B
Mean	2.55±0.33CD	3.55±0.18B	2.65±0.24C	2.41±0.71D	5.56±0.74A	

Manganese is also an important mineral in the human body which plays a vital role in the synthesis of blood clotting factors, sex hormones, enzymes, connective tissues [25]. It also involved in the regulation of blood sugar level, delays the process of aging, and reduces the risk of cancer and heart diseases [3]. Results showed that the level of Mn in selected citrus fruits ranged from 1.09 to 0.37 mg/100g while the highest concentration of Mn was noted in P5 collected from S2 and the

lowest was observed in P3 collected from S1 with the mean value of 0.70±0.21 mg/100g (Table 7). Results regarding Mn in different varieties of citrus fruits are in collaboration with the findings of [3]. They showed that level of Mn in selected citrus fruit was ranged from 0.153 to 0.226 mg/Kg. Adequate intake of manganese for infants ranged from 1.20 to 1.6 mg/day but for children age 9 to 14, it can be tolerated up to 2.20 mg/day [21].

Table 7. Mean values of data regarding Mn in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	0.74±0.06cd	0.62±0.06de	0.37±0.06f	0.78±0.08cd	0.96±0.06ab	0.69±0.20A
S2	0.67±0.03cde	0.52±0.05ef	0.40±0.04f	0.75±0.04cd	1.09±0.06a	0.68±0.24A
S3	0.67±0.08cde	0.62±0.15de	0.81±0.05bc	0.51±0.26ef	0.98±0.08a	0.72±0.20A
Mean	0.69±0.06B	0.59±0.10CD	0.53±0.21D	0.68±0.18BC	1.01±0.08A	

Zinc is also a very important metal that improves the body defense system. Plays a vital role in cell growth and division, carbohydrate metabolism, wound healing. It is good for the sexual system, memory and learning, zinc pills are helpful in the treatment of acne, osteoporosis, pneumonia, diarrhea, and the common cold. It delays the process of aging [19, 21] while results showed that maximum concentration of Zn was noted in P5 collected from S3 and the minimum was observed in P1 collected from S3 with the mean value of 1.67±0.22 mg/100g (Table 8). Results regarding Zn in

different varieties of citrus fruits are in collaboration with the findings of [17]. They showed that level of Zn in selected fruits was ranged from 0.12±0.03 to 0.48±0.08 mg/100g while grapefruit, orange, pomeloe contains 0.14±0.06, 0.48±0.08, 0.15±0.04 mg/100g respectively. RDA for zinc is 8 mg/day for women while during lactation and pregnancy, women may need extra and 11 mg/day for men while for children with age 6 months to 13 years is suggested as 2 to 8 mg/day while for above 13 years is suggested as to 13 mg/day [21].

Table 8. Mean values of data regarding Zn in some selected citrus fruits collected from different localities of district Sargodha

Sites	Plants					Mean
	P1	P2	P3	P4	P5	
S1	1.54±0.05cde	1.84±0.04ab	1.76±0.08abc	1.61±0.06bcde	1.86±0.07a	1.72±0.14A
S2	1.38±0.04ef	1.87±0.12a	1.80±0.05ab	1.55±0.28cde	1.69±0.13abcd	1.66±0.22AB
S3	1.23±0.11f	1.73±0.16abcd	1.72±0.17abcd	1.51±0.26de	1.88±0.10a	1.61±0.27B
Mean	1.38±0.14C	1.81±0.12A	1.78±0.10A	1.56±0.20B	1.81±0.12A	

Conclusion

All observed plants have a good source of minerals but there is fluctuation is present in all selected citrus fruits plants, even in the same plant fruits collected from the same as well as from different sites which may be attributed to different agro-climatic conditions or time of fruit harvest. However, the highest concentration of Fe, Mn, Cr and Zn were analyzed in *Citrus sinensis* (Musambi) collected from Sargodha and Bhalwal respectively while the maximum concentration of PO₄, Cu and Ca were noted in *Citrus jambhiri* (Khatti) and *Citrus reticulata* early mandarin (feutrell's early) collected from Bhalwal and Silanwali respectively. Studies also conclude that we have to focus on natural food supplements i.e. if a person is suffering from minerals deficiency than he/she would have to focus on taking more fruits in its diet instead of taking food supplements in the form of capsules, tablets, syrups. i.e. Fe deficiency can also be fulfilled by the intake of iron-rich fruits in its diet instead of taking iron supplements.

Authors' contributions

Conceived and designed the experiments: I Ahmad & A Ghani, Performed the experiments: A Rasool, Analysed the data: M Nadeem & M Hussain, Contributed materials/ analysis/ tools: M Ikram & M Imran, Wrote the paper: M Hussain.

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