Selcuk J Agr Food Sci, 29(2):40-43

Selcuk Journal of Agriculture and Food Sciences

Effect of Concentration by Boiling at Atmospheric Pressure on Mineral Content of White and Red Grape Juices

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ARTICLE INFO

Article history:

Received 31 January 2015
Accepted 25 July 2015

Keywords:

Grape juices
Minerals
Pekmez
Concentration

ABSRACT

Pekmez (molasses), concentrated by boiling in open vessel at atmospheric pressure from sugar-rich fruit and vegetable juices, is a traditional product consumed widely in Turkey. In this works, heat treatment during the concentration by boiling in open vessel at atmospheric pressure was examined the effect on major and minor elements of grape juices. After the white and red grape juice were concentrated in open vessel at atmospheric pressure up to 50, 60 and 70 ^{o}Bx, minerals in samples were determined by ICP-AES. The content of Ca, B, Fe, K, Mn, and P increased in both grape juices concentrated up to 50 and 60 ^{o}Bx, and decreased in 70 ^{o}Bx. The highest decrease was occurred to be 96.83% in Pb of red grape juice during the concentration process. While, similar to the red grape juice, the most reduction was seen to be 79.23% in Pb of white grape juice concentrated up to 70 ^{o}Bx, decrease in the content of Ni, Zn, Fe, Cu and S was determined to be 74.37, 45.30, 34.88, 31.15 and 26.16%, respectively.

1. Introduction

Minerals are very important nutrients in terms of biochemistry and physiology of the human (Mayer, 1997). While there is more need in the human nutrition for some minerals, there is trace need for minerals such as Iron (Fe), Zinc (Zn), Cupper (Cu), and Selenium (Se) (White and Broadley, 2005). The most important sources of minerals in food chain constitute plant products. The most missing minerals in human diet are Fe and Zn, and deficiencies of both minerals are observed in the third of the world's population. The clinical symptoms of Fe deficiency in humans contain anemia, fatigue, dizziness, reduced intellectual progress and reduced work capacity. The clinical symptoms of Zn deficiency in humans include diarrhea, pneumonia in infants and growth retardation in children (Prasad, 2012). Magnesium, cupper and selenium deficiency can be observed in some societies. Calcium and magnesium is required for bone, teeth and muscle tissue. Potassium and sodium plays a role in the flow of the body fluids and in the transmission of impulses in nerve cells. These two minerals deficiency can lead to losses of muscle and bone tissue (Fox and Cameron, 1989). It is expressed that mineral deficiency are observed in the poor diet in terms of fruit, vegetable and see foods. An increase in the bone density are especially determined in the adults applied to a rich diet in terms of potassium, magnesium and fruit-vegetable (Tucker et al. 1999). Even though fruits and vegetables are rich resources in minerals, many process applied to them may lead to nutritionally significant losses or decreases in mineral bioavailability. Cooking, boiling, steaming and freezing processes may cause decreases in mineral bioavailability, but fermentation, baking and canning processes may lead to increases (Watzke, 1998).

Minerals are important not only in human nutrition, but also in food processing. Ascorbic acid is degraded in the presence of metal ions (Pinholt et al. 1966), and minerals such as Fe, Co, Mn and Cu lead to oxidation of oils, and, as the result of this, occurs the loss of flavor (Farhan et al. 1988). Metal ions can cause undesirable changes in the colors of foods. Metal ions interact with intermediate products in Maillard reaction in foods, and affect Maillard reaction products (Martins, 2003). Cupper catalyzes undesirable reactions during processing and storage of foods. Therefore, it is not desirable in foods too much (Belitz et al. 2009).

Pekmez is one of the popular and traditional food products, and it is consumed generally for breakfast in

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Turkey. Pekmez is commonly produced from sugar-rich fruits such as grape and mulberry by concentration of juices up to 70–80 soluble dry matter content. On the other hand, it is also produced from sugar-rich sugar-beet, sugarcane, sweet sorghum and carob. Pekmez can also be produced from sugar-rich fruits like apple, plum, watermelon, apricot and fig. Pekmez contains high amounts of sugar, mineral and organic acid; therefore, it is a very important food product in human nutrition (Akbulut and Ozcan, 2008). Pekmez (molasses) attract the attention of the human due to rich in minerals. They are also used in some foods, including cake, halva and biscuit, to nutritionally enrich (Celik and Bakırcı, 2003; Bilgicli and Akbulut 2009; Akbulut and Bilgicli, 2010).

In this research, changes in minerals during the concentration process of grape juice were investigated.

2. Material and Methods

2.1. Material

In this study, white and red grape fruit juices were used as the materials. Grape juices were produced in plant of TARGİD Agriculture and Food Products Industry and Trade Co. Ltd.

2.2. Concentration Process

Grape juices with 20% soluble solid (SS) were concentrated in atmospheric pressure (in open vessel). Brix were followed by refractometer, and then when they arrived 50, 60 and 70, the concentration process was ended.

2.3. Determination of Mineral Contents

For analyzing the minerals, about 0.5 g pekmez and 1.0 g grape juice samples were weighed, put into a burning cup, and then 10 ml 65% nitric acid (HNO_3) were added. The samples were incinerated in a MARS 5 Microwave Oven set to 1600 W at 200°C, and dissolved ash diluted to a certain volume with water. Concentrations were determined by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) (Varian Vista Model; Australia). The results were expressed to be mg per kg in dried weight (Akbulut and Ozcan, 2009).

2.4. Statistically Analysis

Data obtained from mineral analyses were analyzed for statistical significance by analyses of variance (Düzgüneş et al. 1987). Analysis of variance and least significant difference tests were conducted to identify differences among groups. (MSTATC, 1986). Data were reported as mean ± standard error.

3. Results and Discussions

Contents of macroelements of white and red grape juices and their pekmez are shown in Table 1, and amounts of micro elements are given in Table 2. It is observed that the values of macroelements ranged from 270.4 to 5007 mg/kg dry weight in white grape juice, and from 286.77 to 3006.6 mg/kg dry weight in red grape juice. The highest macroelement in the white and the red grape juices was potassium. The lowest macroelement was sulphur (270.4 mg/kg dry weight) in white grape juice and sodium (286.77 mg/kg dry weight) in red grape juice.

Potassium, magnesium, calcium, phosphor, sodium and sulphur in white grape juice were obtained to be 4622, 971.5, 679.5, 544.9, 486.4 and 240.5 mg/kg dry weight, respectively.

According to some researchers, the highest mineral in pekmez was potassium (Karakaya and Artık 1990; Yumlu 2006; Akbulut and Ozcan 2009). Karakaya and Artık (1990) determined that the highest mineral in Zile pekmez was potassium, and it ranged from 6216 to 7920 mg/kg. Similarly, Yumlu (2006) reported that the highest mineral in grape pekmez was potassium as 302.50 mg/100 g. Kayışoğlu and Demirci (2006) found that the amounts of sodium, calcium and potassium in grape pekmez ranged from 9341.3 to 11149.9 mg/kg, from 2946.3 to 1340.4 mg/kg and from 682.6 to 698.0 mg/kg, respectively. Üstün and Tosun (1997) determined that calcium, sodium, magnesium and phosphor contents were ranged from 50.86 to 206.13 mg/100 g, from 25.38 to 83.33 mg/100 g, mg/100 g, from 11.03 to 68.31 mg/100 g, from 0 to 95.06 mg/100 g, respectively. Yumlu (2006) exposed that calcium, sodium and magnesium contents were 153.49 mg/100g, 54.84 mg/100 g and 62.19 mg/100g, respectively.

Potassium is the highest mineral in the intracellular fluid inside the cell, and 98% of total body potassium is intracellular. It play a role to regulate the osmotic pressure within cell, is involved in cell membrane transport and also in the activation of a number of glycolytic and respiratory enzymes. Sodium in extracellular fluid regulates its osmotic pressure. It also activates some enzymes, such as amylase. Milk and milk products, followed at a considerable distance by fruit and vegetables, are the main source of calcium. 10-20% of minerals in human body are calcium. It is one of the most important minerals, and plays an important role in the skeleton and in some body tissues. There are very low trace elements in human body and foods, but they are components playing a significant role. The most of iron is present in hemoglobin and myoglobin. In addition, it is present in peroxidase, catalase and hydroxylase enzymes. Cupper is a component of oxidoreductase enzymes, and zinc is a component of a number of enzymes, such as alcohol dehydrogenase, lactate dehydrogenase (Belitz et al. 2009).

Microelements analyzed in white grape juice were boron, iron, manganese, lead, zinc, copper, nickel and chromium, and they determined to be 25.18, 14.54, 12.38, 1.28, 1.09, 0.86, 0.80 and 0.33 mg/kg dry weight, respectively. Boron, iron, manganese contents are 22.54, 11.43, 10.55 mg/kg dry weight for white grape pekmez (70 ºBx), and 12.69, 17.87, 11.02 mg/kg dry weight for red grape pekmez (70 ºBx), respectively. Copper, nickel, lead and zinc contents of red grape juice were decreased by concentration process. Fennema (1985) have reported that losses of minerals from foods occur not so much through destruction by chemical reaction as through physical removal or combination in forms that are not biologically available. Cooking and blanching process can lead to considerable losses in foods due to contact with water. However, in some cases the mineral content may increase during processing (Pennington and Calloway, 1973). Akbulut and Ozcan (2009) determined that minerals in mulberry juice were decreased by concentration process in atmospheric pressure. These losses for Ca, Mg and Na were 84.79, 72.12 and 79.72%, respectively.

Table 1
Changes in the macro element contents (mg/kg dry weight) of grape juices and their pekmez

Samples	Concentrations (ºBx)	Ca	Na	P
White grape	20	795.01±3.29b	496.9±3.9bc	620.6±6.3b
	50	803.77±7.16b	546.3±2.8b	625.3±2.4b
	60	870.60±21.60a	637.1±10.7a	710.5±12.8a
	70	679.50±10.98c	486.4±20.6c	544.9±13.7c
Red grape	20	1214.2±18.7b	286.77±7.30c	771.3±6.9b
	50	1198.8±0.95b	338.8±14.2ab	777.4±4.9b
	60	1375.0±5.60a	380.23±5.56a	914.3±8.4a
	70	1139.5±17.1c	316.46±8.20bc	745.9±24.4b
Samples	Concentrations (ºBx)	S	K	Mg
White grape	20	270.4±1.4ab	5007±44.7b	1252.2±5.85a
	50	298.9±19.2a	5289±64.0b	1160.0±1.45b
	60	308.2±2.9a	5968±34.3a	1231.0±7.93a
	70	240.5±0.6b	4622±94.7c	971.5±23.8c
Red grape	20	1016±160a	3006.6±50.2b	1247.8±21.8b
	50	372.7±34.2b	3154.9±31.3b	1184.9±2.96c
	60	373.4±14.6b	3665.8±1.20a	1357.7±2.93a
	70	305.3±10.1b	3032.2±96.5b	1099.8±9.33d

Table 2
Changes in the micro element contents (mg/kg dry weight) of grape juices and their pekmez

Samples	Concentrations (ºBx)	B	Cr	Cu	Fe
White grape	20	25.18±0.62b	0.33±0.06	0.86±0.83	14.54±5.10
	50	23.61±0.62bc	0.51±0.11	1.36±1.17	14.23±2.19
	60	27.72±0.40a	0.50±0.01	1.14±0.24	16.09±1.32
	70	22.54±0.13c	0.36±0.00	0.76±0.33	11.43±0.23
Red grape	20	11.95±0.24b	0.35±0.09	3.29±1.37	18.69±2.93
	50	14.02±0.57ab	0.43±0.05	1.50±0.05	27.50±8.84
	60	16.21±1.48a	0.36±0.05	1.38±0.04	23.89±3.94
	70	12.69±0.29b	0.36±0.11	1.02±0.01	17.87±0.35
Samples	Concentrations (ºBx)	Mn	Ni	Pb	Zn
White grape	20	12.38±0.14b	0.80±0.09	1.28±0.71	1.09± 0.40c
	50	12.27±0.14c	0.43±0.54	1.31±0.14	3.69±0.04a
	60	13.72±0.20a	0.47±0.23	0.62±0.10	2.85± 1.08ab
	70	10.55±0.15d	0.33±0.16	0.26±0.04	1.86±0.08bc
Red grape	20	11.58±0.04b	1.21±1.66	3.10±3.08	5.21±0.19a
	50	11.61±0.04b	3.60±1.18	1.00±0.32	4.23±0.11ab
	60	13.53±0.01a	2.05±1.23	0.41±0.18	3.24±0.66b
	70	11.02±0.35b	0.74±0.06	0.10±0.14	2.59±0.35b

Similarly, Kayışoğlu and Demirci (2006) reported a change in minerals of grape pekmez produced in vessel under a vacuum and an atmospheric pressure according to the production methods. In addition, they observed that the minerals were decreased with both methods, but these decreases in minerals of pekmez produced by traditional method were higher than those in pekmez produced by vacuum.

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