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Determination of Some Essential Minerals in Honey Samples Collected from Chena District, Ethiopia

Dekamo Fiseha Lomiso[1] Engida Dessalegn (PhD)[2] Gezahegn Nigussie[3]
1.Southern Agricultural Research Institute, Bonga Agricultural Research Center, P.O.BOX: 101, Bonga, Ethiopia
2.Hawassa Teachers Education College, Hawassa, Ethiopia
3.Department of Food Science and Post-harvest Technology, Hawassa University, Ethiopia

Abstract
The objective of this study was to determine some essential minerals (Na, K, Ca and Mg) content of honey produced in Chena Woreda, Kaffa Zone, Ethiopia. For mineral analysis, nine (9) honey samples each of 0.5 to 1 kg were obtained from Chena district. Sodium, calcium, potassium and magnesium content of honey samples were determined by using atomic absorption spectrophotometer. There was significant variation ($p < 0.05$) observed between honey samples. The honey sample SC_1 had significantly ($p < 0.05$) highest calcium content (551.9 ± 21.9 mg/kg) and potassium (70.17 ± 1.24 mg/kg). The result also showed that sample SC_2 had significantly higher ($p < 0.05$) sodium (283.7 ± 18.7 mg/kg) and magnesium (47.7 ± 2.12 mg/kg) than other honey samples. Results obtained in this study, indicated that tested honey produced in Chena district are good for human consumption. More research should be conducted periodically on the elemental content of honey to indicate their origin and track the development of pollutants in particular areas.
Keywords: Essential elements; honey; potassium; calcium; magnesium; sodium
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1. Introduction

The demand for bio-products has been high in recent years. Bee honey, a bio-product consumed worldwide, is composed of sweet plant and bee secretions utilized and stored by honeybees in their hives as a source of energy. Honey has a content of 80 - 85 % carbohydrates (mainly glucose and fructose), 15-17 % water, 0.3 % proteins, 0.2 % ashes, and minor quantities of vitamins as well as other components in low levels of concentration (Buba *et al*., 2013; Cantarelli *et al.,* 2008). The composition of honey is influenced by some biotic and abiotic factors created around the bee colony, i.e., floral sources, climate conditions, soil, and beekeeper practices (White *et al.,* 1962). Honey contains different quantities of minerals ranging from 0.02 g/100 g to 1.03 g/100 g, with potassium being the most abundant element comprising approximately one-third of the total mineral content (White, 1975; De Ferrer *et al.,* 2004; Bogdanov *et al.,* 2007; Chakir *et al.,* 2011). Macro mineral elements, such as potassium, calcium, magnesium and sodium play a critical role in biological systems. These elements maintain normal physiological reactions, induce general metabolism, germination, circulatory systems and influence reproduction as catalysts of various biochemical reactions (Stanisˇkien *et al.,* 2006). Because of its chemical composition, honey has been found to significantly affect human nutrition, healing, and prevention of illness. Possible honey contaminants include pesticides and residues of antibiotics, minerals above permitted levels, and toxic heavy metals. Therefore, the production of honey free of harmful chemicals is necessary (McKee, 2003).

Honeybees are excellent monitors of contamination in their environment. They reflect the concentrations of pollutants over both time and large spatial areas (Sanford, 1994). Honey reflects the chemical constituents of the plants from which the bees collect their food, and the content of trace elements can indicate the botanical origin of particular honey (Celli and Maccagnani, 2003; Bogdanov, 2006). Dark honey was found to have higher contents of trace elements than light ones (Gonzalez-Miret *et al.,* 2005). Some of the elements might be contributed by environmental pollution resulted from human activities (Pohl, 2009).

Therefore, honey can be used as an effective bio-indicator for environmental pollution. The elemental profile of honey\ not only reflects the environmental condition, but also for honey quality assurance. To our knowledge, the scientific data on the mineral content of honey from Chena district is very limited. The present study was conducted to determine the concentrations of minerals of honey in Chena district to verify their quality and safety for human consumption.

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2. Materials and Methods

2.1 Study area

The study was conducted in Southern Nations, Nationalities and Peoples Regional State of Ethiopia, Kaffa zone, Chena district (Fig.1). The district was purposely chosen from out of 11 districts in the zone because of its high honey-producing potential (CDLFO, 2016/17). The total area of Chena district is estimated to be 901.92 km^2 that

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is endowed with natural tropical rain forests with suitable climates that favor high honeybee population density and forest beekeeping is widely practiced.

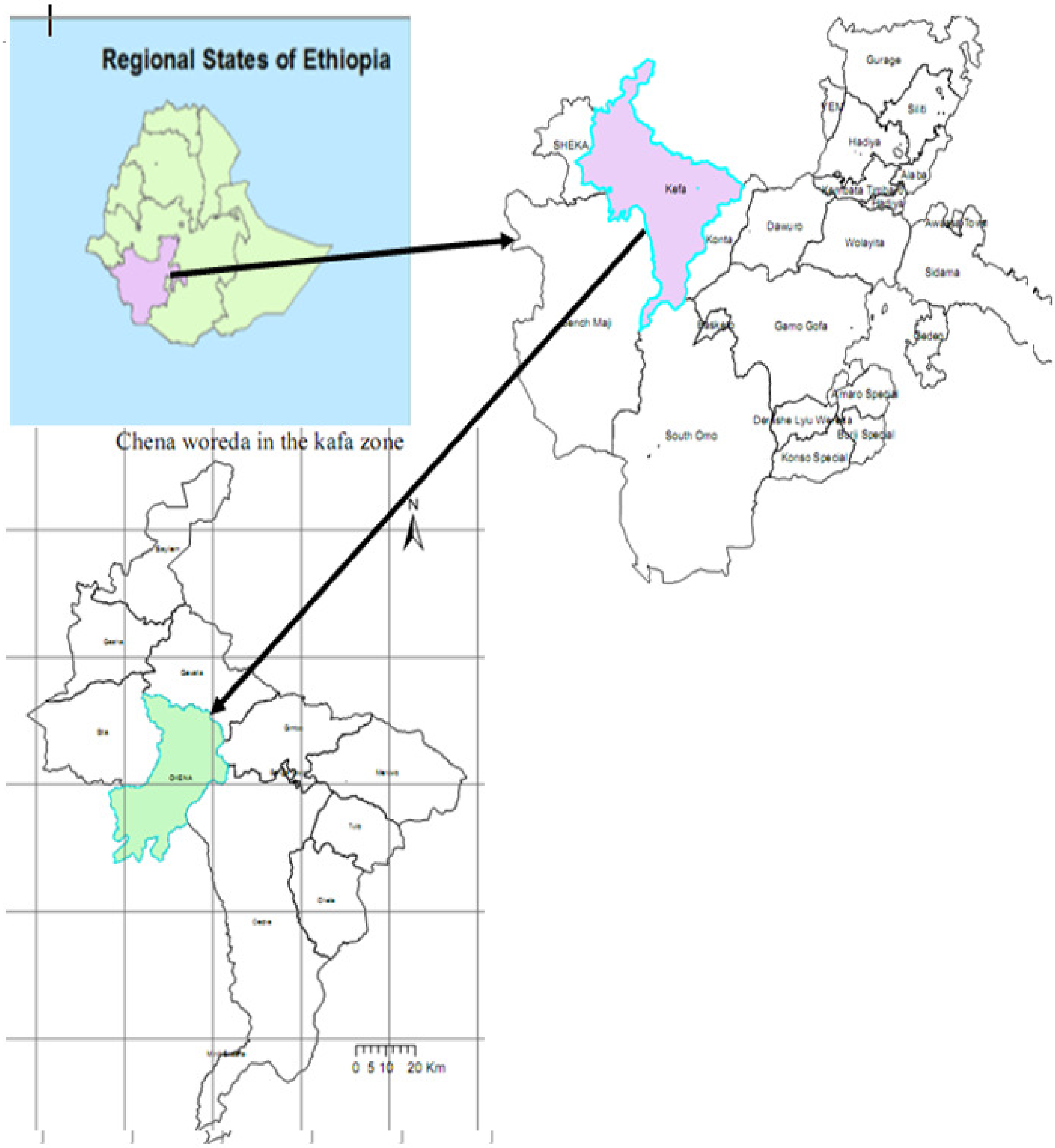

Figure 1**:** Map of the study area

2.2 Collection of Honey Samples

To determine the minerals in honey, 18 honey samples 0.5 – 1 kg each were randomly collected farm gates. The honey sample was homogenized by stirring thoroughly to prepare a representative sample and labeled. All the honey samples were stored at ambient temperature, in sample plastic-bottles with tight-fitting lids, during the period of analytical investigation. The laboratory analysis was done at Hawassa University Food Chemistry and Microbiology and Chemistry laboratory.

2.3 Mineral analysis (Na, K, Mg and Ca)

5 g of honey sample was weighed in the dry crucible; the crucible was placed in a muffle furnace at 550ºC for 2 hours. The contents were cooled and transferred to 250 mL beaker, and 10 mL of 5 N HCl was added. The beaker was placed in a sand bath to boil for 10 min, and then 50 mL of distilled water was added and the content

was filtered through whatman's ashless filter paper No. 41, and the volume was made to 100 mL with distilled water. The extract was stored in bottles for mineral analysis (AOAC, 2000).

Sodium, Magnesium, Calcium and Potassium were determined using flame atomic absorption photometer (Jenway, PFP7, U.K., Bibby Scientific Ltd, Staffordshire) based on the works of Aazza *et al.* (2013) with some modifications. Before sample analysis, the atomizer system was flushed thoroughly with distilled water and the instrument was calibrated to zero using distilled water. Distilled water was used between each analyte to make the instrument zero and avoid any source of contamination between samples. Propane gas was used as the burner fuel.

2.4 Statistical Analysis

Mineral contents were performed in triplicate and analyzed by SAS software 9.0 and expressed as mean standard deviation (±). The mean values of honey different samples were compared by using the least significant difference (LSD), whenever one way ANOVA showed statistically a significant difference ($p < 0.05$) among means.

3. Results and Discussion

3.1 Mineral Analysis (Na, K, Mg and Ca)

Table 1. Mineral compositions (Na, K, Mg and Ca) of honey samples

Sample	**Minerals (mg/Kg ± SD)**			
	Na	**K**	**Mg**	**Ca**
SC_1	274 ± 2.4^{b}	70.17 ± 1.24^{a}	46.3 ± 2.08^{a}	551.9 ± 21.9^{a}
SC_2	283.7 ± 1.87^{a}	66.84 ± 2.24^{b}	47.7 ± 2.12^{a}	535.5 ± 13.08^{ab}
SC_3	258.9 ± 2.33^{c}	62.2 ± 1.37^{c}	41.7 ± 10.4^{abc}	513.2 ± 4.93^{b}
SC_4	253.7 ± 6.32^{c}	62.1 ± 0.53^{c}	36.5 ± 0.91^{b}	$507.2 \pm 5.98b^{c}$
SC_5	209.8 ± 2.19^{f}	54.7 ± 1.3^{d}	31.2 ± 5.79^{bc}	433.7 ± 16.3^{d}
SC_6	205.2 ± 3.04^{f}	55.5 ± 1.09^{d}	29.6 ± 0.56^{c}	430.6 ± 1.49^{de}
SC_7	218.5 ± 1.48^{e}	65.4 ± 1.23^{b}	35.9 ± 13.5^{b}	487.07 ± 7.1^{c}
SC_8	209.3 ± 1.52^{f}	62.8 ± 1.06^{c}	44.2 ± 0.35^{ab}	420.4 ± 16.2^{e}
SC_9	248.2 ± 2.6^{d}	47.4 ± 1.5^{e}	42.5 ± 3.8^{abc}	491.3 ± 5.5^{c}

SD = standard deviation; mg = milligram; Kg = kilogram; SC = Sample from Chena; *Means within column followed by the same letter are not significantly different.*

Calcium

The mean value of calcium content of honey samples from Chena district SC_1, SC_2, SC_3, SC_4, SC_5, SC_6, SC_7, SC_8 and SC_9 were 551.9 ± 21.9 mg/kg, 535.5 ± 13.08 mg/kg, 513.2 ± 4.93 mg/kg, 507.2 ± 5.98 mg/kg, 433.7 ± 16.3 mg/kg, 430.6 ± 1.49 mg/kg, 487.07 ± 7.1 mg/kg, 420.4 ±16.2 mg/kg and 491.3 ± 5.5 mg/kg, respectively (Table 1). The highest calcium content (551.9± 21.9 mg/kg) was found in sample SC_1 and the lowest (420.4 ± 16.2 mg/kg) was found in honey sample SC_8. A Significant difference ($p < 0.05$) was observed between calcium content between honey samples from the area. According to Fernandez-Torres *et al.* (2005) and Silveira *et al.* (2009), calcium is the most dominant element among other elements. But, the present mean value of calcium (551.9 ± 21.9 mg/kg) is higher than the findings of Fernandez-Torres *et al.* (2005) who reported 341mg/kg of calcium content in honey samples from four different plant sources from different locations in Spain. The variability in calcium content might be due to botanical, environmental, and geographical factors.

Sodium

The second most prevalent mineral in the present honey samples was Na, with mean values of honey samples from Chena district SC_1, SC_2, SC_3, SC_4, SC_5, SC_6, SC_7, SC_8 and SC_9 were 274 ± 2.4 mg/kg, 283.7 ± 1.87 mg/kg, 258.9 ± 2.33 mg/kg, 253.7 ± 6.32 mg/kg, 209.8 ± 2.19 mg/kg, 205.2 ± 3.04 mg/kg, 218.5 ± 1.48 mg/kg, 209.3 ± 1.52 mg/kg and 248.2 ± 2.6 mg/kg, respectively (Table 1). The mean value of Na content of SC_2 was significantly higher ($p < 0.05$) than that of other honey samples. Moreover, there was a significant variation ($p > 0.05$) observed between the mean values of the sodium content of honey samples. Similar to our finding, Fernandez-Torres *et al.* (2005) reported that the sodium as the second most abundant mineral. He reported sodium content of 218.50 mg/kg for the honey samples from four different plant sources from different locations in Spain which are relatively within the range with the present study. Chua *et al.* (2012) also demonstrated that Na was the second most abundant minerals in Malaysian honey.

Potassium

The third prevalent mineral in the present study was potassium. The average value of honey samples SC_1, SC_2,

SC_3, SC_4, SC_5, SC_6, SC_7, SC_8 and SC_9 were 70.17 ± 1.24 mg/kg, 66.84 ± 2.24 mg/kg, 62.2 ± 1.37 mg/kg, 62.1 ± 0.53 mg/kg, 54.7 ± 1.3 mg/kg, 55.5 ± 1.09 mg/kg, 65.4 ± 1.23 mg/kg, 62.8 ± 1.06 mg/kg and 47.4 ± 1.5 mg/kg, respectively (Table 1). The mean value of the K content of honey sample SC_1 was significantly higher ($p < 0.05$) than that of other honey samples from Chena district. Contrary to this finding, Baroni *et al.* (2009) stated that the level of potassium in honey is low for different honey samples from the north/south provenance of Argentina. Moreover, the mean value of K in the current study is also different from the findings by Belay *et al.* (2017) who reported the high value of potassium in honey for monofloral honey in Ethiopia. The difference might be due to the level of minerals in honey varies according to the botanical origin and soil composition since the majority of minerals in honey originate from the soil.

Magnesium

The lowest mineral content identified during the present study was magnesium. The mean value of samples SC_1, SC_2, SC_3, SC_4, SC_5, SC_6, SC_7, SC_8 and SC_9 were 46.3 ± 2.08 mg/kg, 47.7 ± 2.12 mg/kg, 41.7 ± 10.4 mg/kg, 36.5 ± 0.91 mg/kg, 31.2 ± 5.79 mg/kg, 29.6 ± 0.56 mg/kg, 35.9 ± 13.5 mg/kg, 44.2 ± 0.35 mg/kg and 42.5 ± 3.8 mg/kg, respectively (Table 13). The magnesium content of honey samples SC_1 and SC_2 were significantly higher ($p < 0.05$) than that of the magnesium content of other honey samples. The present study result is within the range of the findings of Pohl (2009) who reported magnesium content ranging from 13.26 to 74.38 mg/kg in honey samples. According to Pohl (2009), the level of minerals in honey varies according to the botanical origin and soil composition since the majority of minerals in honey originate from the soil. Similarly, Bogdanov *et al.* (2009) stated that the variability in mineral content from different locations can be attributed to botanical, environmental, and geographical factors.

4. Conclusion

It was found that calcium and sodium are the most abundant minerals in honey samples from Chena district. The honey produced in the area examined was found to be safe for human consumption; their mineral contents were comparable to permitted levels. More research should be conducted periodically on the elemental content of honey to indicate their origin and track the development of pollutants in particular areas.

5. Conflict of interest

The authors would like to declare that this study was carried out, mainly for academic research purpose without any conflict of interest.

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