Evaluation of Levels of Minerals and Trace Elements of Cocoa (*Theobroma cacao*) in côte d’ivoire

**Abstract**

Levels of minerals and trace elements of cocoa (*Theobroma cacao*) in Côte d’Ivoire were evaluated. The study focused on cocoa collected in six production areas selected according to major national production regions. The samples were collected in cloth bags cretonne for good aeration. This study allowed the determination of levels of minerals and trace elements by atomic absorption spectrometry (AAS). The results obtained showed that Iron (Fe) was represented in large quantities (9.71 mg / 100 g of cocoa). Copper (Cu) and Zinc (Zn) were represented in small quantities 3, 12 and 4.42 mg / 100 g of cocoa respectively. Regarding minerals, the results showed that Potassium (K) and Phosphorus (P) were represented in large quantities with respective maximum values of 637 and 623 mg/ 100 g of cocoa. Magnesium (Mg) was represented in small quantities with a maximum value of 304 mg/ 100 g of cocoa. The cocoa of Côte d’Ivoire contains minerals and trace elements which involve systems that allow the body to fight against the harmful effect of oxidative stress and cardiovascular diseases.

**Key words:** Cocoa (*Theobroma cacao*), minerals, trace elements, oxidative stress, cardiovascular diseases, Côte d’Ivoire.

**Introduction**

Cocoa is the fermented seed and dried fruit of the cacao tree (*Theobroma cacao*) (Antonio et al., 2011). The Forastero variety is the most cultivated in Côte d’Ivoire. This variety is considered the ancestor of all cocoa varieties. Its rugged design ensures very high yields; it represents about 80% of world culture (Mastroiacovo et al., 2014; Afoakwa et al., 2013). Côte d’Ivoire, the world’s largest cocoa producer provides about 40% of world cocoa. It is used as anti-stress in hepatic dysfunction, cardiac and respiratory. Côte d’Ivoire, an important economic and social sector is characterized by a population estimated at 800,000 cocoa producers (Marcy et al., 2012; Katz et al., 2011). The cocoa produced is in the form of powder, oil that contains medicinal and nutritional properties. It is used in dysfunctions of liver and heart (Soetan et al., 2010; Buijsse et al., 2006; Christelle., 2010). It contains many bioactive compounds with minerals and trace elements (Mastroiacovo et al., 2014).

Cocoa is a good provider of minerals. Minerals are components of all body tissues. They are found in large quantities in certain structures such as bones, teeth and nails (Meunier et al., 2003). The trace elements and minerals are extremely important for the proper functioning of the body (Soetan et al., 2010). Its low acidity makes the cocoa from Ivory Coast used a lot by chocolate manufacturers worldwide (Ramiro-Puig et al., 2009; Buijsse et al., 2006; Janszky et al., 2009).

The objective of this work was to evaluate levels of minerals and trace elements of cocoa in six areas where cocoa (*Theobroma cacao*) is produced in Côte d’Ivoire in order to have a competitive cocoa very good for the health of the consumer.
MATERIALS AND METHODS

Study samples

Cocoa beans (Theobroma cacao) was used. The sampling took place in the period of May and June matching the intermediate season. The samples were collected in cloth bags cretonne to promote good aeration.

Study areas

The study areas were production cities grouped into six areas namely; Area 1: South East; Area 2: South; Area 3: center; Area 4: West Central; Area 5: South West; Area 6: west.

Technical equipment

The samples were analyzed at the Company’s mineral analysis laboratory for the Mining Development of Côte d’Ivoire (SODEMI) in Abidjan. The study required a muffle furnace, an incubator, a dessicator, a precision balance and an atomic absorption spectrophotometer, concentrated nitric acid (HNO₃ 69%), demineralized water and standard solutions of different minerals (Magnesium, Potassium, Phosphorus) and trace elements (Iron, Copper, Zinc).

Mineralization

100 g of cocoa were taken in dry crucibles and heated to 105°C in an incubator for 08 h. The dry matter obtained was brought to 550°C in a muffle furnace for 08 h. The crucible containing the ashes was removed and placed in a desiccator to cool at room temperature.

Assay minerals

The assays were performed by atomic absorption spectrophotometry. 1 g of the ash was taken up with 2 ml of HNO₃ (69%). The mixture was transferred to plastic tubes of 50 ml and supplemented up to the gauge with demineralised water.

The solution obtained is homogenized. At the same time one blank for each mineral has been prepared, it consisted of demineralised water at 1%, nitric acid and the mineral from stallion to be assayed. A calibration curve resulting absorbance versus of the concentration was deduced for each sample the concentration of the element in percentage of dry matter.

Statistical analysis

The results are expressed as mean = SEM (Standard Error of Mean). We used the statistical programs: Stat View ® 4.01 (Mind Vision Logiciels, Concepts, Inc., Berkeley, CA, USA) and GraphPad Prism ® (version 4.00; GraphPad Software Inc., San Diego, CA, USA).

RESULTS

Trace elements

Iron content

Figure 1 gives iron content of cocoa produced in the six areas of our study. This level is very high in zones 1 and 4 with values of 9, 71 and 8, 33 mg / 100 g of cocoa. This value is low in zones 5 and 6 with the respective values of 2, 76 and 2, 53 mg / 100 g of cocoa.
Copper content

Copper content of cocoa in the six areas has a maximum value of 3,12 mg / 100 g of cocoa in Zone 1 and the lowest value was 2,08 mg / 100 g of cocoa in Zone 5 (Figure 2).

Zinc content

Zinc content of the six regions is shown in Figure 3. High values are found in zones 1 and 2 respectively of 4,42 and 4,15 mg / 100 g of cocoa. The weakest value is in zone 5, with a value of 3,09 mg / 100 g of cocoa.

Minerals

Potassium

Figure 4 gives Potassium content of cocoa produced in the
six areas of our study. This level is very high in zones 3 and 6 with values of 637 and 612 mg / 100 g of cocoa. This value is low in zones 4 and 1 with the respective values of 495 and 465 mg / 100 g of cocoa.

**Phosphorus**

Phosphorus content of cocoa in the six areas has a maximum value of 623 mg / 100 g of cocoa in Zone 5 and the lowest value was 366 mg / 100 g of cocoa in Zone 3 (Figure 5).

**Magnesium**

Magnesium content of the six regions is shown in Figure 6. High values are found in zones 3 and 6 of 304 and 298 mg / 100 g of cocoa respectively. The weakest value is in zone 4, with a value of 243 mg / 100 g of cocoa.
**DISCUSSION**

The study aimed to evaluate the levels of minerals (magnesium, phosphorus and potassium) and trace elements (iron, copper and zinc) of cocoa (*Theobroma cacao*) producing areas in Côte d’Ivoire. The results showed that the iron was strongly represented in the cocoa with a value of 9.71/100 g of cocoa (Figure 1). Trace elements such as copper and zinc are shown in small quantities with respective maximum values of 3.12 and 4.42 mg/100 g of cocoa (Figures 2 and 3). Regarding minerals, the results showed that potassium and phosphorus were represented in large quantities with respective maximum values of 637 and 623 mg/100 g of cocoa (Figures 4 and 5). Magnesium was represented in small quantities with a maximum value of 304 mg/100 g of cocoa (Figure 6). Our results are consistent with the results conducted by several research teams on proportions of trace elements such as iron, copper and zinc contained in cocoa. Proportions of trace elements ranged between 4 and 4.5% (Oliveira et al., 2013; Nuhu, 2014). Trace elements are not produced by the body, but in food (Ashu and Chandravanshi, 2011).

Cocoa is consumed much in our regions; it contains trace elements that are beneficial to our body (Mussatto et al., 2011; Nemlin et al., 2009). In our study, it was shown that iron had a high value in zone 1 with a value of 9.71/100 g of cocoa. Iron is essential for the production of hemoglobin of red blood cells and at proper functioning of muscles. Iron deficiency causes anemia, source of great tiredness (Mijanur et al., 2013). The low content of iron of 2.53 mg/100 g of cocoa in zone 6 is due to the variability of soil (Mussatto et al., 2011).

Copper is found in small quantities in the cocoa with a maximum value of 3.12 mg/100 g of cocoa. Cocoa is a provider of trace elements. Copper is essential for numerous reactions in the body, particularly in the digestion (Pohl et al., 2013). A deficiency of copper in the body causes a risk of cardiovascular disease (Esquivel et al., 2012). Our results showed that cocoa produced in the study areas gives a value of 4.42 mg/100 g of cocoa of Zinc. Zinc acts on the breath and is a vital element which acts as an antioxidant and prevents the harmful effects of free radicals (Abdel-Hamee et al., 2013).

Millions of people use chocolate every day; it is an energy source that contains important nutrients. Minerals Represent 5% of the cocoa mass, mainly in the form of magnesium, potassium and phosphorus (Özkutlu et al., 2011). However, the bioavailability of these minerals may consist of the presence chocolate in the certain fibers which may interfere with the gastrointestinal absorption of these minerals (Nathan, 2006). Cocoa minerals are endowed with a modulating effect of the immune system (Özkutlu et al., 2011). Tonus and relaxation of the blood vessels are also important in the development of heart disease and in the regulation of blood pressure. Cocoa minerals increase the relaxation of blood vessels *in vitro* (Palmer et al., 2012). The minerals contained in cocoa would influence cardiovascular function by allowing the body to produce peroxynitrite that the body uses as a defense against pathogenic microorganisms (Parker et al., 2012). To protect itself from this toxic effect of oxygen, the organism has developed defense systems that eliminate Free Radicals.

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**Figure 6.** Magnesium (Mg) content.
(FR). These systems consist of minerals, trace elements and proteins that prevent the iron to trigger production of free radicals (Jin et al., 2010; Feng-Lin et al., 2010). Minerals and trace elements are the only molecules that can trap and neutralize free radicals (Lohoues et al., 2014). Living organisms do not produce trace elements and minerals. They come from foods or beverages such as cocoa. These trace elements and minerals have systems that allow the body to fight against the harmful effects of oxidative stress and cardiovascular disease (Trébissou et al., 2014).

Conclusion

Our study aimed to determine minerals and trace elements contained in cocoa (Theobroma cacao) produced in six areas of Côte d’Ivoire. The results showed that our cocoa contains iron in large quantities. Copper and zinc are represented in small quantities. Regarding minerals, the results showed that potassium and phosphorus were represented in large quantities. Magnesium was represented in small quantities. The cocoa of Côte d’Ivoire contains trace elements and minerals that have systems allow the body to fight against the harmful effects of oxidative stress and cardiovascular disease.

REFERENCES


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