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Elemental Composition of Vegetable Salts from Ash of Four Common Plants Species from Chad

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Abstract: In Central Africa and particularly in Chad, salt prepared by burning parts of plants is consumed for therapeutic reasons. The aim of this study was the determination of elemental composition of these salts and the toxicity if any. Four salts were prepared from ash obtained by burning stems of maize (*Zea mays*), stems of sorghum (*Sorghum bicolor*), false trunks of pawpaw (*Carica papaya*) and whole parts of *Hygrophila auriculata*. The elemental analysis shows that all the four salts are potassium rich and sodium poor. Maize and sorghum salts present mainly potassium chloride (KCl) and potassium sulfate (K_2SO_4), whereas salts from pawpaw and *Hygrophila* are composed of three potassium forms: potassium chloride (KCl), potassium carbonate (K_2CO_3) and potassium sulfate (K_2SO_4). All the salts did not contain heavy metals. These salts can be used as dietetic salts and substitute of the industrial salt which contains mostly sodium chloride.

Key words: Ash salt, Chad, elemental composition, *Zea mays*, *Sorghum bicolor*, *Carica papaya*, *Hygrophila auriculata*, potassium, sodium

INTRODUCTION

Salt, chemically known as sodium chloride, sometimes called White Gold, is probably the oldest and the commonly used food additive. It improves the taste of foods and inhibits the growth of microorganisms. Salt mines have been exploited probably since Neolithic (Mollat, 1968; Lemonnier, 1984). Salt was used in China, Ethiopia and New Guinea for religious rites. In Europe Salt was so important that it was used for rates and taxes and to pay salaries (Godelier, 1969; Khodakov *et al*., 1989).

Today most people become accustomed to the taste of salt so that its consumption increased despite of numerous diseases it contribute to raise like hypertension, cardiovascular and kidney diseases. Bibliographic sources indicated that in France for example it caused 25,000 deaths per year by hypertension (Alderman *et al*., 1998). Because of the damage it does on the human health, many consumers and especially in Africa prefer vegetable salt from ash obtained by burning plants parts which is potassium rich.

In Africa, vegetable or ash salts were used formerly in economic activities before colonialism came. Porteres (1950, 1957) reported 158 different plants species used for the preparation of ash salts. With the colonization, the white salt appears. It is collected from salt mines or produced industrially and it is also cheaper. The former vegetable or ash salt have practically disappeared (Alexandre, 1989). It is still used in traditional magic or religious practices. In Central Africa, including Chad regions, vegetable salt is still traditionally produced and consumed either by alimentary habit or for therapeutic reasons. It is used as substitute of modern salt for atrophic gastritis, for icterus, to lower the blood pressure and as sedative against cough (Allaramadji, 2011). The traditional preparation of the vegetable salt is time consuming with low yielding quantity. Its chemical composition is also unknown. The salt production method proceeds largely by lixiviation but depends on the region. The plants used for preparation are mostly waste parts of cultivated plants like stems of maize, millet, sorghum and some widespread plants like *Hygrophila* species. Also false trunk of pawpaw or banana is used to produce vegetal salt (Allaramadji, 2011). The reports on chemical composition of vegetable salts are scarce. Zerries (1964) reported analyses of vegetable salts conducted by Martius in the Xingu river and by Sick in the British Guyana. Schmeda-Hirschmann (1994) analyzed four vegetable salts from the Papaguayan Chaco. Echeverri and Roman-Jitdutjaano (2011) have reported the chemical analyses of ash salts from 57 species used by the Witoto Indians of Amazon. Only little is known about ash salts from Africa. The aim of this study was to ameliorate the traditional method of salt preparation, to determine its

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chemical composition and its toxicity if any. Parts of four common plants were used to produce ash salts and their elemental composition was determined.

MATERIALS AND METHODS

Plant materials: In this study four plants were used to prepare salts: stems of maize (*Zea mays*), stems of sorghum (*Sorghum bicolor*), false trunks of papaya or pawpaw (*Carica papaya*) and whole parts of *Hygrophila auriculata,* a wildspread plant, traditionally used for ash salt production in the south of Chad. The three former samples were collected from December 2009 to January 2010 at the vicinity of Faculté des Sciences Exactes et Appliquées, University of N'Djaména. The last one was collected in October 2009 at Moundou (Southern Chad). All samples were collected and air dried at the laboratory temperature for two weeks and burned to obtain ashes.

Salt preparation: One hundred grams of each ash from the four plants were dissolved in 500 mL of distilled water. The solution was mixed well and kept at room temperature for 45 min, mixed one more and kept for 30 min. The solution was passed through a sifter. It was than filtered and the filtrate placed in an oven at 100°C until it crystallized.

Chemical analyses: All salts were crystallized again before chemical analyses were conducted. Solutions of 0.5 g of salts in 500 mL of solvent were used in analysis. Sodium and potassium were determined by flame photometer 410 using butane at 2.1 kg cm^{-2} pressure with 0.4 L min^{-1} rate. Analyses were conducted at Laboratoire de Recherche sur les Substances Naturelles, Faculté des Sciences, University of N'Djaména. Magnesium and calcium were measured using atomic spectrometer absorption (Spectro Varian 20BQ). These analyses were conducted at the laboratory of Mines and Geology, Ministry of Mine and Geology, N'Djaména. Mercury was measured using atomic spectrometer (Spectre AA-400 plus SSA-01) coupled with MSH-10 Perkin Elmer using cathode lamp. Nitrogen was used as vector gas at 2.4 bars pressure. Cadmium, chrome, copper, iron, manganese, nickel, lead and zinc were determined using flame photometer atomic absorption Perkin Elmer with AAnalyst 300 software. Acetylene and air were used as combustible and combustive agent. All these analyses were conducted at the Laboratoire des Sciences Analytiques, UMR 518, Université Claude Bernard, Lyon I, France. All anions were determined at Laboratory of Natural Compounds Research, Faculty of Sciences, University of N'Djaména using photometer 700 of Polintest.

Statical analysis: All analyses were done in triplicate. Means were calculated and compared using t-test and the level of significant difference was determined at $p<0.05$.

RESULTS AND DISCUSSION

Salt content of ash and raw material: Table 1 shows the percent of the salt content of ash and raw material.

Table 1 shows that salt content of raw material do not exceed 10 and 35% in the ash obtained. The lowest salt in the raw material and in the ash is that of stems of sorghum bicolor followed by that of *Zea mays*. The greatest salt contents of the four materials are that of *Hygrophila auriculata* (34% for ash and 9.5% for raw material). *Carica papaya* contains, respectively 30.5% of salt in the ash obtained and 4.28% of the raw material. The lowest ratio of salt in cereals stems can be explained by the fact that they contain essentially carbohydrates like cellulose with burn in processing for ash production.

The high percentage of salt from *Hygrophila auriculata* explains why it's still the most traditionally used plant in the south of Chad to produce vegetable salt. Echeverri and Roman-Jitdutjaano (2011) have mentioned another species of the genius, *Hygrophila spinosa*, as one of the most plants used in Africa to produce ash salt. Bibliography reveals that salt contents of plant are generally low (http//www. alchimie–pratique.org/selplant.htlm). Most of the authors have found the ratio of 0.42% of raw fern, 0.55% of raw vine, 0.55% of raw willow and 0.15% of raw oak. All these data are lower than the results obtained in this study.

Cations composition: The cations contents of the four salts are presented in Table 2.

Table 1: Percent of salt obtained, calculated using ash and raw material

Vegetal	Ratio of salt to ash (%)	Ratio of Salt to raw material (%)
Zea mays	14.00	2.01
Sorghum bicolor	12.23	1.59
Carica papaya	30.50	4.28
Hygrophila auriculata	34.04	9.56

Table 2: Cations composition of the four salts

Cations (mg L^{-1})	*Zea mays*	*Sorghum bicolor*	*Carica papaya*	*Hygrophila auriculata*
Na^+	0.160	0.300	9.700	6.000
K^+	41.100	37.200	34.300	47.500
Mg^{++}	1.220	6.810	5.830	4.000
Ca^{++}	16.630	16.030	9.820	20.000
Cr^{++}	0.006	0.007	0.007	0.007
Mn^{++}(mg mL^{-1})	0.003	0.004	0.004	0.004
Fe^{++} (mg mL^{-1})	0.030	0.032	0.030	0.031
Ni^+	0.015	0.016	0.017	0.016
Cu^{++}	0.008	0.013	0.000	0.000
Zn^{++}	0.007	0.002	0.000	0.000
Cd^{++}	0.022	0.020	0.022	0.021
Pb^{++}	0.024	0.039	0.027	0.036
Hg^{++}	0.000	0.000	0.000	0.000

Table 3: Anions content of the four ash salts

Anions (mg L^{-1})	*Zea mays*	*Sorghum bicolor*	*Carica papaya*	*Hygrophila auriculata*
Cl^-	22.000	130.000	70.00	224.00
F^-	1.520	1 .070	1.08	0.76
CN^-	0.007	0.005	0.01	0.01
SO_4^{2-}	27.000	53.000	150.00	75.00
PO_4^{3-}	5.250	3.210	3.12	3.18
CO_3^{2-}	0.000	0.000	68.93	213.50

All the four salts are characterized by high concentration of potassium ranging from 34.3 mg L^{-1} for pawpaw to 47.5 mg L^{-1} for *Hygrophila auriculata* compared to sodium where the highest contents was in Pawpaw with less than 10 mg L^{-1}. These results explain why ash salts were recognized as preventing hypertension, cardiovascular and kidney diseases. Echeverri and Roman-Jitdutjaano (2011) reported that all the ash salts used by Witoto, Indians of the Amazon are potassium rich. Magnesium concentration ranges from 1.22 mg L^{-1} in the maize to 5.83 mg L^{-1} in pawpaw. These salts also contain calcium from less than 10-20 mg L^{-1}. Cadmium and lead contents are between 0.02-0.04 mg L^{-1} whereas other cations are only traces, while no mercury was found in these salts. All heavy metals concentrations are less than that defined by The European Guide and STAN 150/1985 Norma for alimentary salts (EP. 1995; CODEX STAN 150, 1985) making these salts suitable for human consumption.

These salts contain calcium, magnesium and phosphorous, three elements that human need much for a good metabolism.

Anions composition: Anions from the four salts are presented in Table 3.

All the four salts contain a great concentration of chloride and sulfate ions but their values varied greatly among the salts. *Hygrophila auriculata* presents the highest concentration of chloride (224 mg L^{-1}) and *Zea mays* the lowest (22 mg L^{-1}). Meanwhile, pawpaw shows the highest concentration of sulfate (150 mg L^{-1}) and maize the lowest (27 mg L^{-1}) while phosphate ion contents were less than 5 mg L^{-1}. Carbonate ions are totally absent in maize and sorghum salts but is in great concentration in pawpaw (68.93 mg L^{-1}) and *Hygrophila auriculata* (213.5 mg L^{-1}). The four salts exhibit only trace of cyanide. The highest concentrations of Chloride and carbonate ions in vegetable salts have been reported by some authors (Kuhnlein, 1980; Echeverri and Roman-Jitdutjaano, 2011). When considering together cations and anions contents of theses salts (Table 2 and 3), maize and sorghum are most composed of potassium chloride (KCl) and potassium sulfate (K_2SO_4). Pawpaw and *Hygrophila auriculata* contain three major salts compositions: potassium chloride (KCl), potassium carbonate (K_2CO_3) and potassium sulfate (K_2SO_4). Porteres (1950) reported about salts used in Central Africa that they didn't contain NaCl but they exhibit a high proportions of KCl and K_2SO_4.

CONCLUSION

The chemical analysis shows that all the four salts are potassium rich and sodium poor. Heavy metals are traces or in low concentration compared to European guide and STAN 150/1985 Norma for alimentary salts. They also contain minor elements which play important roles in the metabolism of human organism. These salts can be used as dietetic salts as substitute of the industrial salt which contains mostly sodium chloride especially for persons who have health problems like hypertension, cardiovascular and kidney diseases.

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