Original Research Article

A Comparison of the Chemical Composition of Cooked Maize and Beans *left-over-water*: Potentials as Food drinks and Fertilizers

ABSTRACT

The paper highlighted the chemical characteristics of broth from cooked maize and compared them with that from cooked beans. Left-over-water from boiled maize were produced by cooking 2kg of a variety of *Zea mays L.* with 8kg of water. After this stage, samples of those solutions and samples of the water used for the cooking process were collected for laboratory analysis. The IonPac CS12A and IonPac AS12A analytical columns were respectively used for the separation of ammonium ($NH4^{+}$), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), and potassium (K^{+}) as far as cations were concerned, and chloride (Cl) and sulfate ($SO4^{2-}$) in the case of anions. The measurements of pH and electric conductivity of fluids were respectively done with a pH-meter on the one hand and a conductivimetre on the other hand. Solutions from cooked maize are rich in mineral salts, particularly major macro elements (N and K) and minor macro elements (Ca, S, Mg). Concerning the third major macro element, notably the phosphorous, it is present in low amounts. The advantage of this fluid consists in its low electric conductivity. This fluid has a pH of 6.15. It is made of about 92% of water. Left-over-water from cooked maize and from cooked beans have very close chemical characteristics. In fact, these two fluids are rich in nitrogen and potassium, and mainly made of water. But, in detail, some particularities are present. The end-of cooking solutions of maize have higher amounts of sodium and chlorides, this joined with a higher electric conductivity. Concerning solutions from cooked beans, they have higher amounts of the different macro elements, and a lower electric conductivity. The recycling of end-of cooking solutions of maize must gainfully become for the nutritionists a favorable target for the future, and this due to the numerous nutrients contained. According however to the results obtained in the case of the present studies, the left-over-water from cooked maize can be gainfully use as fertilizers. Using it as manure requires an earthing-up directly after its application in other to avoid the loss of sulfur and nitrogen through gas emanation. Consuming solutions form cooked maize as herbal tea could be an excellent way to recycle the nutrients that have diffused from the seeds during the cooking process.

Keywords: Used water; sanitation; recycling; fertilization; agriculture; nutrition.

1. INTRODUCTION

In Africa, Caribbean, and Pacific (ACP) countries, the demographic explosion [1], the reduction of tillable lands, and the reducing of the fallow periods [2] represent today the most perceptible phenomenon. This part of the world is peopled essentially by resource-poor farmers, with soils as their principal source of earnings [3]. Hence, to insure their survival, they cultivate even the most sloping plots [4]. Various and risky farming techniques are noticeable here [4], the aim being the desire of the daily satisfaction of their needs in food. In consequence, the yields decrease years after years [5, 3], attesting then the permanent depletion of soils fertility. If a minority among these peoples can easily acquire synthetic fertilizers to solve short term problem of soils fertility depletion [6, 7, 8], the majority can't. But, even in the first group of these populations, the solution for soil fertility is not completely acquired because of the remaining of queries. In fact, a fraction of them up to today lacks knowledge about the use of these chemicals, since they could be pollutants when poorly used [9]. Moreover, those chemicals are sometimes rare, and their solubility is not often guaranteed [10]. Concerning the second group of these peoples, represented by resource-poor farmers, possess synthetic fertilizers is simply a fairytale. Their survival then appears today with acuteness. That's why day after day, researchers investigate different sectors since the beginning of the twentieth century in order to provide fertilizers at low costs, easily used, efficient, and available for the poorest people worldwide. The tendencies of the results obtained today are encouraging. So, in some parts of the world, many were taught in how to use rocks [11, 12], plants such as Titonia diversifolia [13], and mixtures of organic fluids [14, 15] among all as fertilizers. These approaches already constitute exits for that problem despite their local character; in fact, geological and floral diversity all over the world generates variations in their application. In front of these signs of potential victories, scientists have not given up; in that way, [14] recently showed that the mixture of human urine and left-over-water from cooked beans can pertinently enhance the growth of plants. To confirm that fact, [16] successfully tested it as substrate for some heterotrophic organisms [17], notably molds. From this, rises the idea according to which all food undergoing boiling process can generate fluids rich in mineral salts. That is why it might be then interesting to investigate the different left-over-water from diverse boiled food. For that purpose, maize is chosen for the present studies. At the end, could be highlighted the chemical characteristics of the left-over-water from cooked maize on the one hand, and the comparison between that fluid and the one from the cooked beans on the other hand. Finally, it could be determined if those two fluids could be recycling for the same purposes.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Beans seeds

Most of the Africa inhabitants practice agriculture [18, 19, 20], with beans as one of the main crops [21]. That plant is appreciated all over Cameroon because of its dietetically potential [22, 23, 24]. In that way, 100 g of that food is made of 9.06 g of proteins, 27.91 g of carbohydrates, 0.49 g of fats, 5.3 g of fibers, 61.2 g of water, 0.257 mg of B1 vitamin (thiamine), 0.063 mg of B2 vitamin (riboflavin), 0.57 mg of B3 vitamin (niacin), 0.299 mg of B5 vitamin (pantothenic acid), 0.175 mg of B6 vitamin , 0.98 mg of E vitamin (tocopherole), 3.7 µg of K vitamin, 168 µg of total folate, 1337 mg of potassium, 225 mg of sulphur, 414 mg of phosphorus, 140 mg of magnesium, 113mg of calcium, 47 mg of chloride, 6.5 mg of iron, 2.5 mg of zinc, 2.3 mg of iron, 3.5 mg of sodium, 0.96 mg of zinc, 0.635 mg of cupper, 0.548 mg of manganese, 0.430 mg of boron, 0.271 mg of cupper, 0.183 mg of nickel, 0.02 mg of chrome, 0.095 mg of fluoride, 0.0052 mg of cobalt, 0.0018 mg of iodate, and 0.0014 mg of selenium among others [25,26,27,28]. The amount of the total nitrogen can be deducted from the rate of the proteins with the help of the Jones factor [29]; in fact, the amount of the proteins = total nitrogen*6.25 (with 6.25 as the Jones factor). For the present case, we have 1.4496 g of total nitrogen in bean seeds.

About 85% of their product is directly eaten in some of the countries where it is produced. The remaining 15% is sold [30]. Particularly in Cameroon, large quantities are produced every year, and are mainly intended for export [31]. Bean seeds represent an important source of vegetal proteins, their flatulent effect is universally known and has, undoubtedly, been a source of discomfort throughout history [32]. Integument of bean seeds is permeable or semi permeable, allowing then diffusion phenomenon to occur through it [33].

2.1.1 Maize seeds

There are several varieties of corn. One can name the yellow, purple [34], white, blue, and red [35] varieties. The violet and blue color are due to the presence of anthocyanin pigments [36] while the carotenoid pigments give yellow and red maize their respective colors [37]. The differentiation of maize varieties also uses the shape, strength and composition of the kernels. Thus, there are "popcorn" varieties, others "soft" for human consumption fresh or canned, or even "horny" used in semolina [38]. According to consumers, the postharvest date and variety affects the taste and texture of boiled corn [39]. The color of the husks (leaves that wrap the cob) would be an indicator of the freshness and taste of the corn. Thus, the fresher the corn husks (bright green color), the more intense the sweetness of the corn, indicating that the corn is freshly harvested. In contrast, the less green color of corn husks indicates a less sweet taste and a long post-harvest period [39]. For 100g of corn, there is an average of 73.40g of water, 2.4g of fiber, 18.60g of carbohydrates, 1.7g of lipids, 3.41g of protein, 3mg of calcium, 0.05mg of copper, 0 , 45mg of iron, 0.001mg of iodine, 107.9mg of magnesium, 0.17mg of manganese, 299.6mg of phosphorus, 324.8mg of potassium, 59.2mg of sodium, 0.62mg of zinc, 0.066mg of provitamin A Beta carotene , 0.011mg of vitamin A, 0.09mg of vitamin B1, 0.06mg of vitamin B2, 1.68mg of vitamin B3, 0.79 mg of vitamin B5, 0.14mg of vitamin B6, 0.023mg of vitamin B9, 5 , 5mg of vitamin C, 0.09mg of vitamin E, 0.0004mg of vitamin K1, 0.01mg of flavonoids, 0.01mg of anthocyanins, 214.56mg of phenolic acids, 2.41mg of hydroxybenzoic acids, 212 , 15mg of hydroxycinnamic acids, 0.33mg of lignans [40].

2.1.3 Solutions from cooked beans

Solutions from cooked beans are heterogeneous mixtures, and particularly a proteic globular suspension, with considerable amounts of carbohydrates. It has a pH value of 6.4. At rest, that water divides itself into two superimposed domains: a flaky superficial domain and a liquid lower domain. The flaky domain is the organic part and the liquid domain is the water and the mineral salts provider. The density of the flaky domain is 0.964 and that of the liquid domain is 1.011. The average speed of the growth of *Aspergillus L.* at the surface of the solutions from cooked beans is 3,17 cm^2 /H; they cover in five days a surface of 379.74 cm^2 . These solutions are made of about 90% of water. Their electric conductivity is 0.668 mS/cm. Their pH is 6.31. The ionic composition of the solutions from cooked beans reveals the presence of: Ammonium (5.41g/l), Potassium (2.63 g/l), Phosphate (0.0333 g/l), Magnesium (0.538 g/l), Calcium (0.403g/l), Sulfate (0.29g/l), Sodium (0.07487g/l), Chlorides (0.029g/l) [41]. The physico-chemical characteristics of the flaky domain floating on the liquid domain make it an adequate area for the development of moulds (*Aspergillus L.*). Solutions from cooked beans contain all the nutrients required for an optimal fertilization of soils; this include water, organic matters and mineral salts among which nitrogen, potassium, phosphorus, sulfur and calcium can be named. It is then a complete liquid organic fertilizer. Those solutions position themselves also as a high grade activator for soils micro flora. It represents finally a way for a sustainable improvement of agriculture in developing countries and a way for a sustainable development of soils micro flora, required for achieve the food self-sufficiency [16].

In daily life, many pig farmers feed their animals with spent grain mixed with solutions from the end of cooking the beans; results are wonderful. Moreover, those solutions are used in the confection of some meals in Cameroon known as “pilé” in many tribes. This action is justified by the increasing of the nourishing potential of the food. In addition, when solutions from beans cooking are spread out, after ten of minutes, one can easily feel the emanation of a loud smell; that odor disappears within two or three day according to the quantity of solutions thrown [33].

2.1.2 Water used for cooking the maize seeds

The water for beans cooking has an electric conductivity of 0.029mS/cm and a pH of 5.1. This water is composed, in decreasing weight order, of 0.0154 g/l of sodium, 0.0095 g/l of potassium, 0.009 g/l of ammonium, 0.0045 g/l of calcium, and 0.0034 g/l of magnesium. Concerning anions, it has, in decreasing weight order, 0.0085 g/l of sulfate, 0.0016 g/l of chlorides, 0.00146 g/l of phosphate, and 0.0013 g/l of carbonate. Finally, the water used for the beans cooking process is chemically under the control of sodium as major cation and sulfate as major anion [41].

2.1.4 Area of the studies

The well for domestic use that provided the cooking water is located in the locality of Yaoundé, at mid-slope of an interfluves, at about 5.5m from latrines, and at open air. The climate of the locality is of Guinean equatorial type, with four different seasons [42]. The average annual rainfall in Yaoundé is 1,600 mm, for an average temperature of 23°C. [43]. The geological substratum is made of embrechites with quartz, garnet, biotite, feldspar, pyroxenes, plagioclase, and hornblende as main minerals. Soils are of lateritic type [44]. On the hydro geological point of view, the crystalline substratum of the Yaoundé region is essentially constituted by two superimposed aquifers: an upper aquifer (within alterites), located between 5 and 20 m depth, and a lower aquifer (in substratum discontinuities), located at depths greater than 20 m [45].

2.2 Methods

Field and laboratory studies help to reach the targets.

2.2.1 Field work

Field work made it possible to obtain the seeds (photograph 1) of maize necessary for the production of the studied solutions, to acquire the opinions of the populations on facts related to the daily management of maize, and finally to practice the tasting of the corn tea.

Photograph 1. « Maize seeds »

2.2.2 Laboratory tests

2.2.2.1 Manipulation of maize seeds samples and production of solutions from their end-of cooking process

In the laboratory, maize samples were sorted out in other to remove undesirable particles, and weighted. For the production of the samples of left-over-water from cooked maize, 2kg of seeds were quickly washed and cooked with 8kg of water without salt in other to avoid any out coming electrolytes. The resulting suspensions (so called left-over-water from cooked maize) were collected, cooled, and stored in the fridge for future lab tests.

2.2.2.2 Laboratory analysis

Physic-chemical analysis dealt with the identification of Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, PO_4^{3-}, SO_4^{2-}, $NH4^{+}$, Cl^{-}, and CO_3^{2-} since they are directly or indirectly present in maize seeds. Moreover, their choice is motivated by the fact that they can be organized as major macro elements (N, P, K), minor macro elements (S, Ca, Mg, Na), and oligo elements (Fe, Se, Mn, Zn, Cu) for plant nutrition [46]. The process started by the chemical characterization of the water used for the cooking process during which the quantities of the same ions were measured. The lab tests ended with the evaluation of the amount of water in the solutions from cooked maize.

The IonPac CS12A and IonPac AS12A analytical columns were respectively used for the separation of ammonium ($NH4^{+}$), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), and potassium (K^{+}) as far as cations were concerned, and chloride (Cl) and sulfate ($SO4^{2-}$) in the case of anions. The flow rate was set to 1.0 mL/min for both cations and anions optimization. The different cations were isocratically separated with a 20 mM Methanesulfonic acid solution within 15 minutes. Concerning the ions studied here, isocratic elution with 4mM and 20mM Sodium hydroxide solution were employed for their separation, respectively for chloride and sulfate, during 15 minutes. All eluents were degassed and pressurized under high purity nitrogen to prevent dissolution of carbon dioxide and subsequent production of carbonate.

Concerning bicarbonate ion ($HCO3^{2-}$), its amount was measured by using titrimetric method. The pH was determined with a pH-meter having a glass electrode. Electric conductivity for its own was measured using a conductivity meter fitted with a calibrated measuring cell; the results were expressed in mS/cm.

To determine the amount of water, heating was used. In fact, a given quantity of the solution was collected and weighted (M1). After the weighting, it was poured in a metallic container with known mass (M2). After the complete evaporation, the container and the residues were weighted (M3). The proportion of water was obtained through the following calculations: (M3-M2)*100/M1. The percentages of the macro elements were obtained as follow: %N= NH_4^+*100/(NH_4^+ + HPO_4^{2-} + K^+), %K= K^+*100/(NH_4^+ + HPO_4^{2-} + K^+), %P= HPO_4^{2-}*100/(NH_4^+ + HPO_4^{2-} + K^+), %Ca= Ca^{2+}*100/(Ca^{2+} + Mg^{2+} + SO_4^{2-}), %Mg= Mg^{2+}*100/(Ca^{2+} + Mg^{2+} + SO_4^{2-}), %S= SO_4^{2-}*100/(Ca^{2+} + Mg^{2+} + SO_4^{2-}).

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Water for maize cooking

The pH and the electric conductivity of the water used for the cooking process of maize are respectively 5.1 and 0.029mS/cm (Table 1).

This water is composed, in decreasing weight order, of 15.4 mg/l of sodium, 9.5 mg/l of potassium, 9 mg/l of ammonium, 4.5 mg/l of calcium, and 3.4 mg/l of magnesium. Concerning anions, it has, in decreasing weight order, 8.5 mg/l of sulfate, 1.6 mg/l of chlorides, 1.46 mg/l of phosphate, and 1.3 mg/l of carbonate. Finally, the water used for the beans cooking process is chemically under the control of sodium as major cations and sulfate as major anion (Table 1).

3.1.2 Left-over-water from cooked maize

While the corn is cooking, a pleasant aroma emerges from the pot. Also, the end of cooking liquid, drunk hot, is excellent. In this sense, of the 100 people selected at random to taste this solution whose identity was not revealed, 83 of them took it again, which corresponds to 83% of favorable cases. Interviews with many other people have revealed that they like to delight in the solution contained in the cob.
Solutions from cooked maize are made of about 92% of water. Its electric conductivity is 0.8158 mS/cm. Compared to the water used for the cooking process, a sensible increasing is noticed, about 0.7868mS/cm (Fig. 1 and Table 1).

Its pH is 6.15. Compared to the water used for the cooking process, a sensible increase of the present parameter is detected too, of about 1.05 (Fig. 2 and Table 1).

The ionic composition of the solutions from cooked beans reveals the presence of:

- **Ammonium (NH_4^+) :** Its amount is 4508.108 mg/l. Compared to the water used for the cooking process, a high increasing (4499.108 mg/l) of the amount of that ion is noticed (Fig. 3 and Table 1);

- **Potassium (K^+) :** Its concentration is 1163.35 mg/l. Compared to the water used for the cooking process, a high increasing (1153.85 mg/l) of the amount of this ion is detected (Fig. 3 and Table 1);

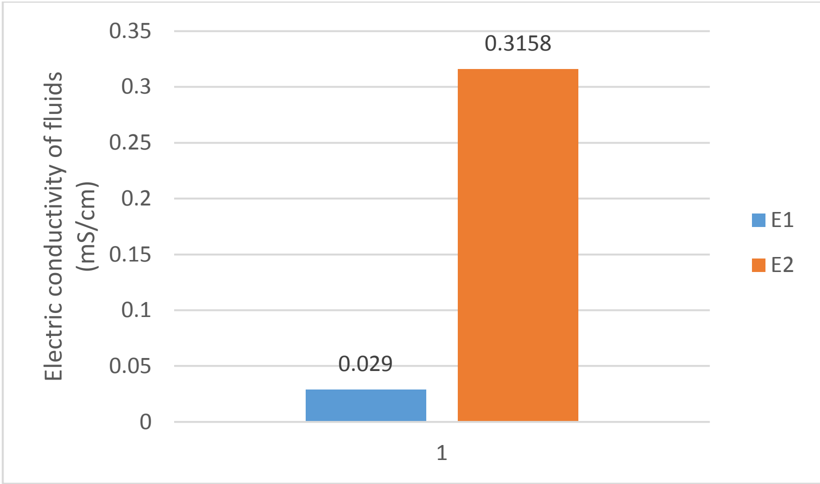

Fig. 1. Electric conductivity of the different fluids (water used for the maize cooking process (E1) and left-over-water from maize cooking (E2))

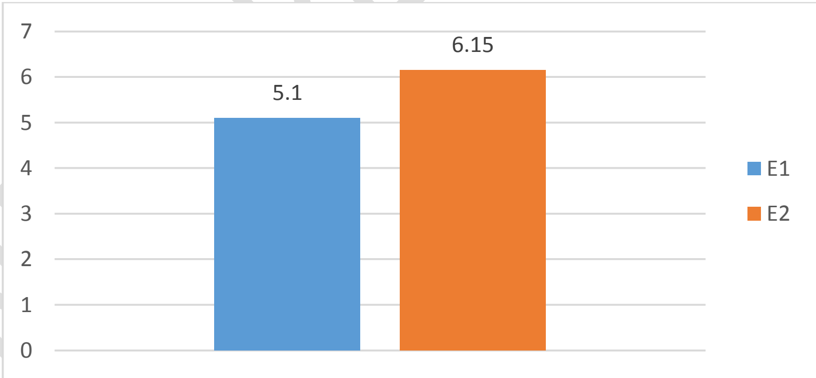

Fig. 2. **The changing in the pH values of the different fluids (water used for the maize cooking process (E1) and left-over-water from maize cooking (E2))**

Table 1. Chemical characteristics of solutions from cooked maize and the water used for the cooking process

	pH	**Ca^{2+} (mg/l)**	**Mg^{2+} (mg/l)**	**K^{+} (mg/l)**	**Na^{+} (mg/l)**	**CO_3^{2-} (mg/l)**	**$SO4^{2-}$ (mg/l)**	**HPO_4^{2-} (mg/l)**	**$NH4^{+}$ (mg/l)**	**E.C. (mS/cm)**
Water used for the cooking process (E1)	5.1	4.5	3.4	9.5	15.4	1.3	8.5	1.46	9	0.0290
Left-oevr-water from cooked maize (E2)	6.15	196.54	380.43	1163.35	205.3	152	264.23	57.96	4508.108	0.8158

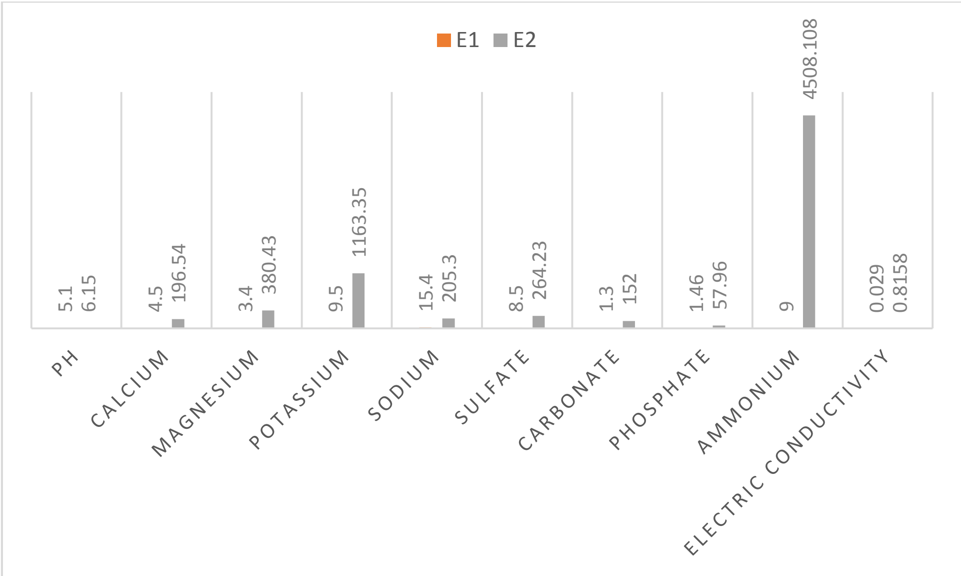

Fig. 3. Ionic composition of the water used for the maize cooking process (E1) and of the left-over-water from cooked maize (E2)

- **Phosphate (PO_4^{3-}).** Its concentration is about 57.96 mg/l. Compared to the water used for the cooking process, a high increasing (56.5 mg/l) of the amount of this ion is however detected (Fig. 3 and Table 1).;

- **Magnesium (Mg^{2+}) :** Its amount is 380.43 mg/l. Compared to the water used for the cooking process, a high increasing (377.03 mg/l) of the quantity of the present ions is detected (Fig. 3 and Table 1);

- **Calcium (Ca^{2+}) :** Its amount is 196.54 mg/l. Compared to the water used for the cooking process, a high increasing (192.04 mg/l) of the quantity of the present ions is highlighted (Fig. 3 and Table 1);

- **Sodium (Na^{+}) :** Its amount is 205.3 mg/l. Compared to the water used for the cooking process, a high increasing (189.9 mg/l) of the quantity of the present ions is highlighted (Fig. 3 and Table 1);

- **Chloride (Cl^{-}):** Its amount is 38.92 mg/l. Compared to the water used for the cooking process, a high increasing (37.32 mg/l) of the quantity of the present ions is highlighted (Fig. 3 and Table 1);

- **Sulphate (SO_4^{3-}):** Its amount is 264.23 mg/l. Compared to the water used for the cooking process, a high increasing (255.73 mg/l) of the quantity of the present ions is highlighted (Fig. 3 and Table 1);

- **Carbonates (HCO_3^{-}):** Its amount is 152 mg/l. Compared to the water used for the cooking process, a high increasing (150.7 mg/l) of the quantity of the present ions is highlighted (Fig. 3 and Table 1).

Chemically, all the parameters targeted in the context of this study increase when comparing the water used for cooking the maize and the end-of cooking solutions of maize (Figs. 1, 2,3 and Table 1). In detail, if the water used for the cooking process of maize is shyly under the control of sodium, solutions from cooked beans is largely dominated by ammonia, potassium, magnesium, sulphate, sodium, and calcium. Further on, then come respectively carbonate, phosphate, and below, chloride. On a completely different level, Fig. 4 reveals a positive correlation between the pH and the electrical conductivity of the solutions studied.

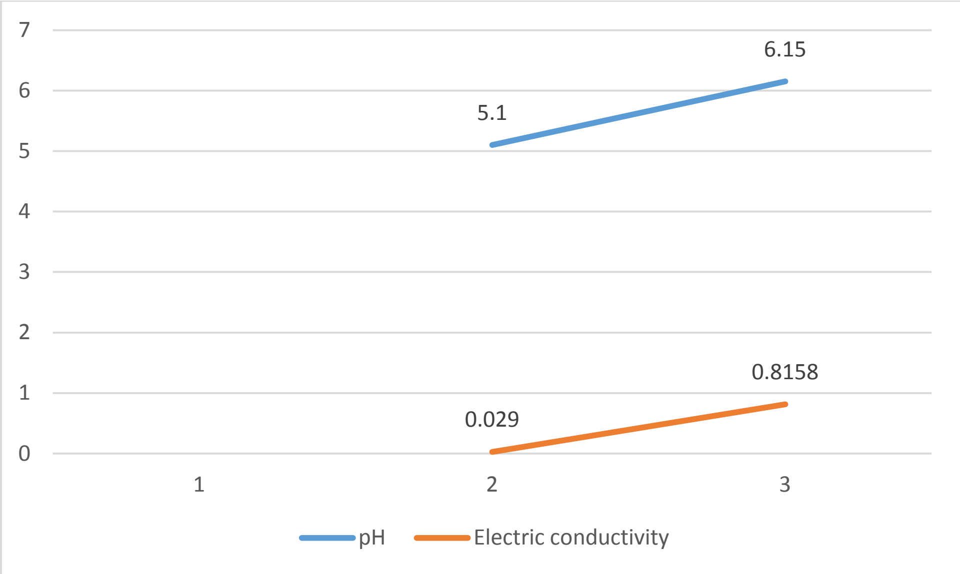

Fig. 4. Correlation between pH and electric conductivity (E.C.) of fluids

3.2 Discussion

3.2.1 Water used for maize cooking

The amount of sodium is greater in the water used for the cooking process of maize compared to the amount of potassium. This can be due to the greater stability of K-feldspar and K-micas in one hand, in other hand by the absorption of K in minerals newly formed during the process of alteration as showed by [47], and further on by the atomic mass of K, greater than that of Na, making then the motion of Na easier than that of K. Those two chemical elements are suspected to be from rocks alteration [48]. This is in accordance with the mineral composition (Feldspars, Plagioclases, Hornblende, and Ferromagnesian and the main minerals) of the geological substratum of Yaoundé. Calcium for its own could have been released after the weathering of Plagioclases, Garnet, and Hornblende contained in the substratum (Schist, Gneiss, and Granite) of Yaoundé. The presence of calcium can also be associated to the process of the impoverishment of soils as the consequence of lixiviation process according to [49]. Concerning magnesium ions, they are thought to be from the alteration of ferromagnesian minerals of the substratum. Nitrates are the major forms trough which nitrogen is present in water. That ion can be used as an indicator to testify the pollution of water according to [50]. But when oxygen lacks in an aquatic area, nitrogen manly appears as Ammonium. This corroborates the observations made by [51]. The presence of chlorides can be a direct consequence of the nature of some of the minerals from the Yaoundé

substratum. In fact, [52, 53] demonstrated that their presence is one of the prime characteristics of groundwater in basement region; it is then in accordance with the presence of Hornblende and Biotite, which are among the chloride bearers. Moreover, [54] demonstrated the possible substitution of Cl-OH type, responsible of the liberation of chloride in water. Further, the presence of chlorides in this water can be justified by atmospheric inputs following infiltration of rainwater [55], and by the alteration of silicate minerals [56]. Bicarbonates are present in the water used for the cooking process. This can be due to the dissolution of atmospheric and pedological carbon dioxide [57]. It can be also due to the anthropic factors as showed by [58, 59]; this is in accordance with the presence of latrines around the well from which the water used for the cooking process of the maize was collected. Regarding the presence of sulfates, it can be due to the alteration of sulfur bearing minerals from the substratum. This corroborates the presence of Pyrite in the gneissic rocks from the Yaoundé region as revealed by [54]. However, meteoric inputs [60] as same as anthropogenic pollution [81] could be considered as far as the presence of sulfates in the water used for the cooking process of maize is of concerned. The pH of the present water is 5.1; after [61], it is acid. The electric conductivity of the same water is 0.029mS/cm. Such a value certifies a low mineralization of the concerned water since it remains very low compared to the standard established by [62]. According to the abacus proposed by [61], the present water in nonconductive.
Finally, the results of analyzes of the water used for cooking the maize in the context of this study are consistent with the data obtained by [63, 64].

3.2.2 Left-over-water from cooked maize

Significant enrichment in the different chemical elements followed up in the present study is noticed in solutions from cooked maize. This can be explained by the leaching of those elements by maize seeds in contact with water during the cooking process. In fact, when the seeds come into contact with water during cooking, they absorb water and swell. Such phenomenon was previously described in the different stages of the germination of seeds by [65]. This observations corroborates the conclusions of [66] and [33], who consider biological membranes as permeable or semi-permeable, and then suggested to diffusion phenomenon, responsible here to the enrichment of the solutions from cooked maize in mineral salts and in protein derivatives as stated by [16]. This can then be used to explain the fact that in Cameroon, some pigs breeders often mix up the food of their animals with that fluids or simply give it to them as drink; on the field, the results of such practice are wonderful as highlight by [33]. In the same vein, according to [33, 67], and [65], this enrichment is facilitated by the temperature, materialized here by the boiling which leads to the cooked stage of the seeds. If such observations reminds the fertilizing characteristics of the solutions from cooked beans as showed by [33, 14], and [16], it also induces a real dietary concern with regard to the consumption of maize. In fact, solutions from cooked maize, considered as waste water in Cameroon by many populations, are most of the time threw away at the end of the cooking process. Much then remains to be done to reconcile these latter and this fluid which undoubtedly has an important nutritional value as shown by the sudden improvement in the contents of exchangeable basic cations, nitrogen, and phosphorus, among others. Many other facts contribute to certify the richness of the solutions from maize cooking. In fact, when those solutions are abandoned at open air, few hours after, they attract many drosophila. Such facts are often noticed when slice of fruits are exposed at open air. For

[68], those insects always followed matters rich in carbohydrates. Such facts are consistent with the observations made by [69].

In order of decreasing enrichment, we have nitrogen (4200 mg/l), potassium (1163.35 mg/l) and magnesium (380.43 mg/l). These are respectively two of the major macro elements, that is to say entering mainly in plant nutrition, and one of the minor macro elements [46]. According to the work of [40], potassium and phosphorus are among the most concentrated chemical elements in maize. Thus, these authors show that for 100 g of maize, we have 324.8 mg of potassium and 77mg (299.6mg) of phosphorus. By applying the Jones factor according to which proteins = 6.25 * total nitrogen [29], it comes that in 100g of beans, we have 1295mg (1.295g) of nitrogen, which is therefore the most concentrated chemical element in these seeds. The abundance of nitrogen and potassium in the maize end-cooking solutions is therefore consistent with their concentration in the seeds; their degree of abundance in the maize end-cooking solutions is in the same order as in the seeds; the third major macro element, however, is weakly expressed. This is in agreement with the observations of [33]. Beside the major macro elements, minor macro elements are also well expressed, In fact, calcium (196.54mg/l) and sulfate (264.23 mg/l) represent the most concentrated chemical elements after the previous in solutions from cooked maize.

The electrical conductivity remains below 1mS / cm. According to [61], the maize end cooking solution is a non-saline fluid. However, the electrical conductivity goes from 0.029 to 0.8158mS / cm from the water used for cooking the maize to solutions at the end of cooking. Even if this parameter is very low according to [61], it is however multiplied by approximately 28 (28.13) in solutions at the end of cooking of the maize. This therefore attests to a mineralization of the maize end-of-cooking solutions, which concretely results in a sudden increase in the contents of the various elements targeted in the context of the present study when switching from the water used for cooking the maize to the end-of-cooking solutions of this food. At the same time, there is a significant increase in the pH value, which goes from 5.1 in the water used for cooking the beans to 6.15 in the maize end solutions, an increase of 1.05 units. This is in agreement with the mineralization of the maize end cooking solutions, certified by the increase in the content of the different elements and the increase in electrical conductivity. Such an observation refers us to the remark made by [62] within the framework of their investigation on the mineralization of underground water in the locality of Yaoundé. The pH value (6.15) obtained in the case of the present study is closer to that previously obtained by [16] when studying solutions from cooked beans.

To help the characterization of drinkable water, [63] defined the following thresholds: less than 0.15 g / l for sodium, 0.25 g / l for sulfates, 0.25 g / l for calcium, 0.012 g / l for potassium, 0.05 g / l for magnesium, 0.05 g / l for nitrates, 0.25 g / l for chlorides, and 0.25 g / l for carbonates. Taken individually the chemical elements contained in the end of cooking solutions of the maize in relation to these standards, it returns that in the end of cooking solutions of the maize, the contents of the main major macro elements (nitrogen, potassium, calcium, magnesium) are well beyond the prefixed thresholds. Further on, the phosphate ion contents, according to the observations of [70], reached thresholds above which the phenomenon of eutrophication is noted in the environment. It is then a highly nutritious solution for plants. This is another argument that attests to the high chemical content of the maize end-of-cooking solutions. Such observations imposes the remark according to which during the process of the maize cooking, the leaching of mineral salts occurs from the seed towards the cooking solution. This is consistent with the observations made by [14, 15, 16, 33, 64] during their studies on solutions from cooked beans.

3.2.3 Comparison between left-over-water from cooked maize and that from cooked beans

As in bean, so proved by [41], nitrogen is predominantly expressed in the form of ammonium ion in the maize end-of-cooking water. One can explain such a fact by relying on the theory of loss of oxygen by water when its temperature increases as showed by [46].

In bean end-of cooking solutions, the ammonium content is 5410 mg / l according to [64]. In the maize end-of cooking fluid, it is 5200 mg / l (Table 2). Nitrogen represents 66.6% of all major macro elements [46] in beans end-of cooking solutions while it represents 67.37% of the same elements for the maize end-of cooking solutions. As shown in Fig. 5, nitrogen (ammonium) may be a little more concentrated in bean end-of cooking solutions than in the maize end-of cooking fluid. This is in accordance with the ratio between the ammonium content in the bean end-of cooking fluid and the content of the same element in the maize end-of cooking watery: 1.29 (Table 2).

Phosphate content is 33.3 mg/l in end-of cooking melted of beans. In the maize end-of-cooking solutions, it is 29.3 mg / l (Table 2). It represents 0.47% of all major macro elements [46] in the maize end-of cooking liquid and 0.4% in the end-of cooking solutions of beans. As showed in Fig. 5, phosphates are a little more concentrated in bean end-of cooking solutions than in the maize end-of cooking fluid as comforted by the ratio between the phosphate content in the bean-end-of-cooking solutions and the content of the same element in the maize end-cooking solutions: 1.14 (Table 2).

Potassium content is 2630 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 1163.35 mg / l (Table 2). It represents 16.66% of all major macro elements [46] in end-of-cooking solutions of maize and 33% of major macro elements in the end-of-cooking solutions of beans. As showed in Fig. 5, potassium is more concentrated in end-of cooking solutions of beans than in the maize end-of cooking solutions. To deepen this observation, one can refer to the ratio between the potassium content in the end-of cooking solutions of beans and the content of the same element in the maize end-of cooking solutions: 2.26 (Table 2). This parameter shows that the concentration of potassium in the end-of cooking solutions of beans is more than twice the concentration of the same element in fluids from the end of cooking the maize.

Table 2. Comparison between left-over-water from cooked maize and cooked beans

	Left-over-water from cooked beans	**Left-over-water from cooked maize**	**Percentage of macro elements**		**Left-over-water from cooked beans parameters/ Left-over-water from cooked maize parameters**
			Left-over-water from cooked maize	**Left-over-water from cooked beans**	
NH_4^+ (mg/l)	5410	4200	67.37	66.6	1.29
HPO_4^{2-} (mg/l)	33.3	29.3	0.47	0.4	1.14
K^+ (mg/l)	2630	1163.35	18.66	33	2.26
SO_4^{2-} (mg/l)	290	264,23	4.24	3.11	1.097
Ca2+ (mg/l)	403	196.54	3.15	32.73	2.05
Mg^{2+} (mg/l)	538	380.43	6.1	43.70	1.41
Na^+ (mg/l)	74.84	185,3			0.82
Cl^- (mg/l)	29	38.92			0.74
pH	6.31	6.15			1.02
E.C. (mS/cm)	0.668	0.8158			0.82
Water (%)	90	92			0.98

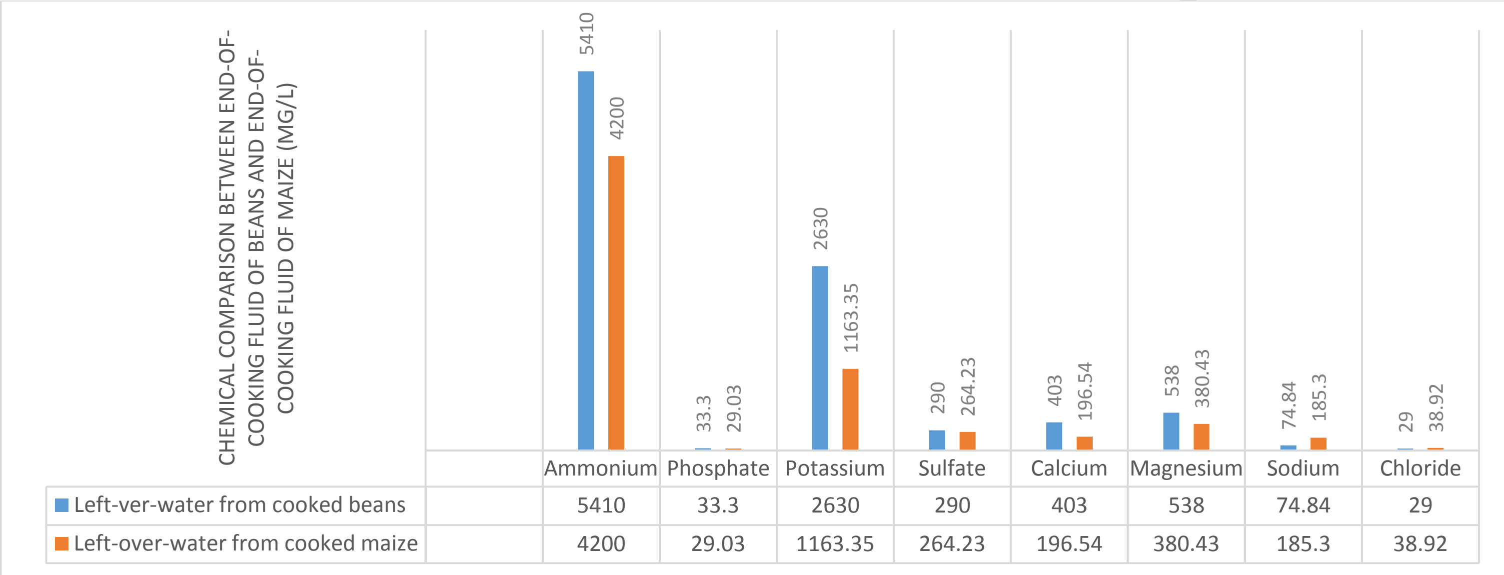

Fig. 5. Chemical composition of **left-over-water** from cooked maize and cooked beans

Sulfate content is 290 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 264.23 mg / l (Table 2). It represents 4.24% of all major macro elements [46] in the maize end-of-cooking solutions and 3.11% in the end-of cooking solutions of beans. As showed in Fig. 5, sulfates are a little more concentrated in bean end-of cooking solutions than in the maize end-of cooking solutions. This is in accordance with the ratio between the phosphate content in the bean-end-of cooking solutions and the content of the same element in the maize end-cooking solutions: 1.097 (Table 2).

Calcium content is 403 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 196.54 mg / l (Table 2). It represents 3.15% of all major macro elements [46] in the maize end-of-cooking solutions and 32.73% in the end-of cooking solutions of beans. As showed in Fig. 5, calcium is more concentrated in bean end-of cooking solutions than in the maize end-of cooking solutions as proved by the ratio between the calcium content in the bean end-of cooking solutions and the content of the same element in the maize end-of cooking solutions: 2.05 (Table 2).

Magnesium content is 538 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 380.43 mg / l (Table 2). It represents 6.1% of all major macro elements [46] in the maize end-of-cooking solutions and 43.70% in the end-of cooking solutions of beans. As showed in Fig. 5, calcium is more concentrated in bean-end-of cooking solutions than in the maize end-of cooking solutions. This is consistent with the ratio between the calcium content in the bean end-of cooking solutions and the content of the same element in the maize end-of cooking solutions: 1.41 (Table 2).

Sodium content is 74.84 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 205.3 mg / l (Table 2). As showed in Fig. 5, sodium is more concentrated in maize end-of cooking solutions than in the beans end-of cooking solutions as revealed by the ratio between the sodium content in the bean end-of cooking solutions and the content of the same element in the maize end-cooking solutions: 0.82 (Table 2).

Chlorides content is 29 mg/l in end-of cooking solutions of beans. In the maize end-of cooking solutions, it is 38.92 mg / l (Table 2). As showed in Fig. 5, Chlorides are more concentrated in maize end-of cooking solutions than in the beans end-of cooking solutions. The ratio between the sodium content in the bean end-of cooking solutions and the content of the same element in the maize end-of cooking solutions, of 0.74 (Table 2), is in agreement with that fact.

Electric conductivity of the end-of cooking solutions of beans is 0.668mS/cm. That of the maize end-of cooking solutions is 0.8158mS/cm (Table 2). As showed in Fig. 5, despite the low level in general, it is slightly higher in maize end-of cooking solutions than in the beans end-of cooking solutions. The ratio between its level in the bean end-of cooking solutions and in the maize end-cooking solutions, reaching 0.82 (Table 2), confirms it.

The pH of the end-of cooking solutions of beans is 6.31. That of the maize end-of cooking solutions is 6.15 (Table 2). As showed in Fig. 5, this parameter is comparable in the two solutions. The ratio between its level in the bean end-of cooking solutions and in the maize end-of cooking solutions, of about 1 (Table 2), is in accordance with that observation.

According to [64], water constitutes 90% of the beans end-of cooking solutions. Concerning the maize end-of cooking solutions, it represents 92%. Its quantities in both solutions are comparable (Table 2) as showed by the ration between its level in the bean end-of cooking solutions and in the maize end-of cooking solutions: 0.98.

Generally speaking, bean and maize end-of cooking solutions are two fluids that are very similar in composition. Thus, as shown in Fig. 6 below, these are two fluids whose composition is largely dominated by nitrogen and potassium respectively. But, with regard to their respective origin, they will logically present particularities. Thus, bean end-of cooking solutions are richer in ammonium, potassium, calcium, magnesium, and phosphate, with lower electrical conductivity. The maize end-of cooking solutions for their own are richer in sodium and chloride. It comes that the end-of cooking solutions of beans are richer in the different macro elements than the end-of cooking solutions of maize do. According to [72] who recommends a dilution of human urine in the proportions 1: 4 (urine: water) before application in view of its too high concentration of sodium and chlorides, and, further, because of its high electrical conductivity, the same recommendation seems to be valid for the end-of cooking maize solutions. According to the observations of [14], the agri use of these two solutions requires hilling to prevent losses of nitrogen and sulfur, particularly in gaseous form. The strong parallelism that exists between their chemical compositions makes these two fluids excellent liquid organic fertilizers, with end-of cooking solutions of beans as the best among the two.

As it was done with the end-of cooking solutions of beans, it would be further important that the maize end-of-cooking solutions be reconsidered from a dietetic point of view with regard to its high nutritional potential. Indeed, in view of its chemical composition, this solution could be consumed as a soup in order to recycle the cohort of nutrients it contains.

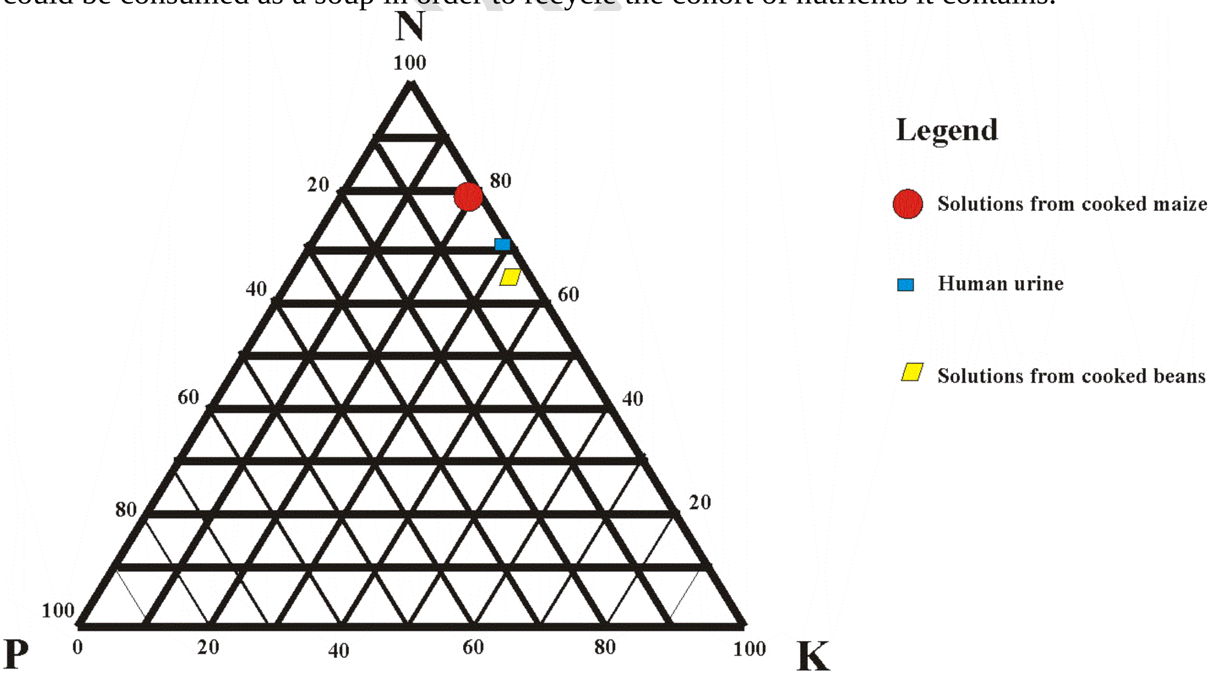

Fig. 6. Position of the end-of cooking fluids of beans and maize beside human urine in the N-P-K diagram of [73]

3.2.3. Phenomenon accompanying the cooking process of maize

While the corn is cooking, a pleasant aroma emerges from the pot. Also, the end of cooking liquid, drunk hot, is excellent. In this sense, from the 100 people selected at random to taste this solution whose identity was not revealed, 83 of them took it again, which corresponds to 83% of favorable cases. Interviews with many other people revealed that they like to delight in solutions contained in the cob; this fluid is nothing more than trapped corn end-cooking solution. Such a declaration gives meaning to the behavior of the 83 people who took up the herbal tea. It is common that smelling sauces are also palatable according to [74]. This is in accordance with the leaching of nutrients from maize seeds during cooking processes as previously demonstrated by [75]. According to the composition of the corn end-of-cooking solution, consuming it as a herbal tea could be an excellent way to recycle the nutrients that have diffused from the seeds during the cooking process; this mobility agrees with the observation made by [76] concerning the permeability and semi-permeability of biological membranes.

4. CONCLUSION

Fluids from cooked maize are rich in mineral salts, particularly major macro elements (N and K) and minor macro elements (Ca, S, Mg). Concerning the third major macro element, notably the phosphorous, it is present in low amounts. The advantage of this fluid consists in its low electric conductivity. This fluid has a pH of 6.15. It is made of about 92% of water. A deep parallelism can be drawn between the end-of cooking solutions of beans and solutions from cooked maize. In fact, these two fluids are rich in nitrogen and potassium, and mainly made of water. But, in the detail, some particularities are present. The end-of cooking solutions of maize have higher amounts of sodium and chlorides, this joined with a higher electric conductivity. Concerning solutions from cooked beans, they have higher amounts of the different macro elements, and a low electric conductivity. The recycling of end-of cooking solutions of maize must gainfully become for the nutritionists a favorable target for the future, and this due to the numerous nutrients contained. However, its agri use is directly topical according to the results obtained in the case of the present studies. To use it as manure requires an earthing-up directly after its application in other to avoid the loose of sulfur and nitrogen through gas emanation. Consuming solutions form cooked maize as herbal tea could be an excellent way to recycle the nutrients that have diffused from the seeds during the cooking process.

5. RECOMMANDATION

The use of solutions from cooked maize as fertilizers requires dilution; its farm application must be directly followed by earthing up in other to avoid the loose of nitrogen and sulfur through gas emanation. These solutions could be gainfully consumed as herbal tea.

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