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Determination of the physical characteristics of the left-over water from cooked maize and their comparison with those from cooked beans and human urine

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Abstract

The present paper aims to highlight the physical characteristics of the left over water from cooked maize and to compare them with those from fluids from cooked beans, human urine, and water used for the cooking process. This is motivated by the desire to verify if the set of information's collected during the studies made on fluids from cooked beans can be applied with all the foods undergoing a stage of boiling during their transformation at home. For that purpose, solutions from cooked maize were produced by cooking 2kg of sorted and quickly washed maize seed with 8kg of water with known physical characteristics. The cooking process was done just with water during 6 hours. The samples of solutions were collected, cooled, and store for the various tests. They include: color, mass, volumetric mass, density, settling, and infiltrometric tests. Apart from the infiltrometric tests which took place on the field, the different other measurements were made in the laboratory. The color of the water used for the cooking process is translucent. Concerning solutions from the cooking, those from cooked beans are brown while those from cooked maize are whitish to yellowish. Fluids from cooked beans contained greater quantities of flakes compared to those from cooked maize. From the water used for the cooking processes to the end of the different cooking fluids, the mass, the volumetric mass, and the density increase. The infiltration tests made show that the infiltration rate of the water from cooked beans is low compared to that of the water from cooked maize, and very low compared to that of human urine and water used for the cooking processes respectively. The total infiltration of solution of the end of cooking the bean and the maize reveals on the infiltration surface the presence of a film of a material bearing molds, generated by the progressive settling of this solution. Odor risen from fluids from cooked beans is stronger compared to that from fluids from cooked maize. The repulsive character of the odor from human urine is effective; however, the subjectivity of that character cannot really help to identify which among odor from liquid from cooked bean and human urine is more repulsive. At rest, one can find formed at the surface of the water from cooked maize the presence of a film. Settling occurs at rest within the fluids from cooked maize and cooked beans at rest. Flakes from cooked beans and cooked maize fluids both attract flies; but only those from cooked maize attract also mice. The correlations established between the different parameters followed up here are highly positive. But in detail, the influence of an under laid parameter, known here as temperature, has been identified as being the responsible of the questioned behavior of the parameters taken in peers in the case of correlation studies made.

Keywords: Recycling; Fertilization; Agriculture; Nutrition; Temperature

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1. Introduction

In Africa, Caribbean, and Pacific (ACP) countries, the demographic explosion (Isolina Boto) [1], the reduction of tillable lands, and the reducing of the fallow periods (FAO)[2] represent today the most perceptible phenomenon. This part of the world is peopled essentially by peasants, with soils as their principal source of earnings (Pradhan et *al*)[3]. Hence, to insure their survival, they cultivate even the most sloping plots [4]. Various and risky farming technics are noticeable here (Tematio and Olson)[4], the aim being the desire of the daily satisfaction of their needs in food. In consequence, the yields decrease years after years (Sanchez et *al;* Sanchez*)*[5; 6], attesting then the permanent depletion of soils fertility. If a minority among these peoples can easily acquire synthetic fertilizers to solve in short term this problem of soils fertility depletion (Zhou and Huang; Brady)[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 (Conway)[9]. Moreover, those chemicals are sometimes rare, and their solubility is not often guaranteed (Yusdar and Hanafi[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 days, 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 tendency of the results obtained today are encouraging. So, in some parts of the world, many were taught in how to use rocks (Prevosto and *al;* Kaho and *al)*[11; 12], plants such as *Titonia diversifolia* (Fopoussi Tuebue and *al)*[13], and mixtures of organic fluids (Fopoussi Tuebue and *al)*[14] 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, (Fopoussi Tuebue and *al)*[14] recently showed that the mixture of human urine and water from cooked beans can pertinently enhance the growth of plants. To confirm that fact, (Fopoussi Tuebue and *al)*[15] successfully tested it as substrate for some heterotrophic organisms (Djakou and Thanon)[16], notably molds. From this, rises the idea according to which all food undergoing boiling process can generate fluids rich in mineral salts. To have a deeper opinion about this fact, Fopoussi Tuebue[17] investigated left-over-water from cooked maize and reached to the same conclusion, this is to say the enrichment of the cooking water during the process. The author then concluded by proclaiming that left-over-water from cooked maize can be both used as food drink and fertilizer according to the target when recycling it. However, the studies of Fopoussi Tuebue and *al*[18] logically induced another interrogation about the left-over-water from cooked maize. This questioning deals with the physical characteristics of that fluid.

The present study aims then to bring those complementary information about the end of cooking fluid of maize. For that purpose, it will be in detail a question of shedding light on the physical aspects of the left-over-water from cooked maize. In that point of view, its color, its behavior at rest, its infiltration capacity, its ability to settling, its mass, its volumetric mass, and its density will be highlighted here. At the end, the physical characteristics determined for the present fluid will be compared to those from left-over-water from cooked beans, human urine, and water used for the cooking process.

2. Material and methods

2.1. Materials

2.1.1. Beans seeds

Most of the African population is engaged in agriculture Isolina Boto[1], Tematio and Olson[4], and Aufrey[19]. Among the main cultivars, we have the bean CIAT[20]. This food is very popular throughout Cameroon because of its flavor and its dietary potential Skrypetz[21]. For 100 g of this food, there are organic compounds such as proteins (9.06 g), carbohydrates (27.91 g), lipids (0.49 g), fibers (5.3 g); water (61.2 g); varieties of vitamins including vitamins B1 or thiamine (0.257 mg), B2 or riboflavin (0.063 mg), B3 / PP or niacin (0.57 mg), B5 or pantothenic acid (0.299 mg), B6 (0.175 mg), E or tocopherol (0.98 mg), K (3.7 µg); total folate (168 µg); many mineral elements including potassium (508mg), sulfur (225 mg), phosphorus (165 mg), magnesium (65 mg), calcium (52 mg), iron (2.3 mg), sodium (2 mg), zinc (0.96 mg), manganese (0.548 mg), copper (0.271 mg), selenium (1.4 µg) (Press; Shackleton and *al;* Souci et *al;* Journal des femmes*;* AndriniainaHarivola)[22; 23; 24; 25; 26]. The total nitrogen content (1450 mg) was deduced from the protein content by applying the Jones factor (Jones)[27] according to which protein content = total nitrogen * 6.25.

About 85% of dry beans are consumed in some of the countries where they are grown up (Sánchez-Tapia et *al;* Khavari H, Shakarami)[28; 29]. The remaining 15% are marketed (Pasquet and Fotso; Boissard)[30; 31]. In the case of Cameroon, importation is almost absent. Large quantities are produced, but the bulk is for export (Fanantenana)[32].

The flatulent effect of beans is universally known and has, undoubtedly, been a source of discomfort throughout history (Azeufouet and *al*; Fenwick and *al)*[33; 34].

2.1.2. Water from cooked beans

The water from cooked beans is a heterogeneous mixture, and particularly a proteic globular suspension, with considerable amounts of carbohydrates within. 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 water from cooked beans is 3,17 cm^2 /H; they cover in five days a surface of 379.74 cm^2 .The physic-chemical characteristics of the flaky domain floating on the liquid domain make it an adequate area for the development of moulds (*Aspergillus L.*). The water from cooked beans seems then to contain all the nutrients required for an optimal development of moulds (*Aspergillus L.*), and in the same way 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. That water positions itself also as a high grade activator for soils micro flora (Fopoussi Tuebue and *al;* Winham and Hutchins; Fopoussi Tuebue; Fopoussi Tuebue and *al;* Fopoussi Tuebue and *al)*[15; 35; 36; 37; 38].

In everyday life, many pig farmers feed their animals with spent grain mixed with water from the end of cooking the beans; the results are extraordinary. Also, when making the culinary delicacy called "pilé≈pounded in Cameroon", many women, after boiling the beans, use the water from the boiling of the beans to cook what they will pound the beans with. They justify this act by the fact that cooked in this way, the food would be more nourishing for their family. Moreover, when the bean seeds have finished cooking and the solution resulted is poured around the house, shortly afterwards, we notice the emanation of a strong odor that cannot disappear before two or even three days depending on the amount of solution poured (Fopoussi Tuebue and Tchinda)[39].

2.1.3. Maize seeds

There are several varieties of corn. One can name the yellow, purple (Hongbete)[40], white, blue, and red (Lopez-Martinez)[41] varieties. The violet and blue color are due to the presence of anthocyanin pigments (Lao and *al)*[42] while the carotenoid pigments give yellow and red maize their respective colors (Muzhingi et *al)*[43]. 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 (Chégut et *al)*)[44]. According to consumers, the postharvest date and variety affects the taste and texture of boiled corn (Hongbete)[40]. 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 (Hongbete)[40]. For 100 g of corn, there is an average of 73.40 g of water, 2.4 g of fiber, 18.60 g of carbohydrates, 1.7 g of lipids, 3.41 g of protein, 3 mg of calcium, 0.05 mg of copper, 0 , 45 mg of iron, 0.001 mg of iodine, 107.9 mg of magnesium, 0.17 mg of manganese, 299.6 mg of phosphorus, 324.8 mg of potassium, 59.2 mg of sodium, 0.62 mg of zinc, 0.066 mg of provitamin A Beta carotene , 0.011 mg of vitamin A, 0.09 mg of vitamin B1, 0.06 mg of vitamin B2, 1.68 mg of vitamin B3, 0.79 mg of vitamin B5, 0.14 mg of vitamin B6, 0.023 mg of vitamin B9, 5.5 mg of vitamin C, 0.09 mg of vitamin E, 0.0004 mg of vitamin K1, 0.01 mg of flavonoids, 0.01 mg of anthocyanins, 214.56 mg of phenolic acids, 2.41 mg of hydroxybenzoic acids, 212.15 mg of hydroxycinnamic acids, 0.33 mg of lignans (Rouf Shah and *al)*[45].

2.1.4. Water from cooked maize

Solutions from cooked maize are rich in mineral salts, particularly major macro nutrients (N and K) and minor macro nutrients (Ca, S, and Mg). Concerning the third major macro nutrient, 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 fluids of maize have higher amounts of sodium and chlorides, this joined with a higher electric conductivity. Concerning liquids from cooked beans, they have higher amounts of the different macro nutrients, and a lower electric conductivity. The recycling of end-of cooking fluids 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 (Fopoussi Tuebue)[17].

2.1.5. 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 (Fopoussi Tuebue et *al)*[37].

2.1.6. Area of the studies

The well for domestic use that provided the cooking water is located in 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 (Lawrence and Hornberg)[46]. The average annual rainfall in Yaoundé is 1,600 mm, for an average temperature of 23°C (Lawrence and Hornberg)[46]. The geological substratum is made of embrechites with quartz, garnet, biotite, feldspar, pyroxenes, plagioclase, and hornblende as main minerals (Nzenti)[47]. Soils are of lateritic type (Bachelier) [48]. 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 (Antonakos and Lambrakis)[49].

2.2. Methods

Field and laboratory studies help to reach the targets.

2.2.1. Field work

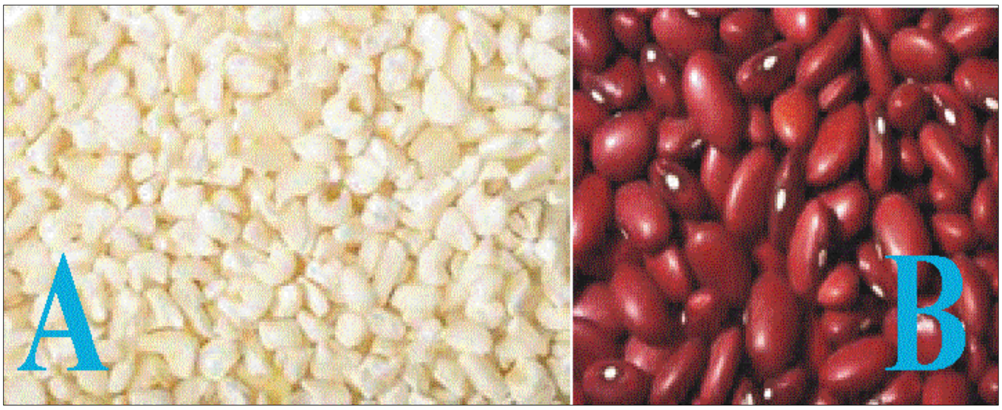

Figure 1 White maize seeds (A) and "Meringue" bean (B) seeds

In the field, it was a question of obtaining the dried maize and bean seeds (Fig. 1) necessary for the production of the end-of-cooking water for these foods. It was also a question of measuring the rate of infiltration of human urine, of the water intended for cooking (control), of the bean end of cooking fluid, and that of the left-over-water from cooked maize. For this, two neighboring plots under natural cover and located at the apex of a hill were selected. They were the subject of morphological characterization and removal of clods of earth. The morphological characterization was made according to the recommendations of (Maignien)[50]. For the infiltration tests, we had a metal cylinder infiltrometer according to the approach of (Roqse)[51]. The aim as in detail to infiltrate respective columns of 11.5 cm of the above fluids. The positions chosen for the infiltration tests were 137 cm apart from each other.

2.2.2. In the laboratory

Manipulation of maize seeds and production of solutions

In the lab, the maize and bean seeds were sorted in order to remove the pebbles. Then followed the weighing phase. Two weighing phases were carried out; for the production of the solutions, 2 kg (MHC = raw bean mass) of maize and beans seeds were respectively taken. Then took place a quick wash to remove dust and any form of impurities. The washed maize and bean seeds were cooked in 8 kg of water, or respectively 1 mass of maize and bean seeds for 4 mass of water. In detail, we started on the basis that 1 liter of water weighs 1 kg according to Lide[52]. Just before placing the pot containing water and maize seeds on the one hand and water and bean seeds on the other hand on the fire, a gauge line was materialized on the rim of the pot to keep the water level intact during cooking. During the cooking phase, the solutions were maintained at the same height by gradually adding water. At the end of the cooking process, four samples of 200ml from each fluids were collected, cooled, and bottled; the different bottles were labeled. These fluids samples were supplemented with a 200 ml sample of control water.

For the infiltration tests, four samples of 902.75 ml each were prepared: human urine sample, control water sample, water from cooked bean sample, and left-over-water from cooked maize sample.

Lab analysis

The four samples of the left-over-water from cooked maize and cooked beans were respectively weighed and their respective mass denoted (Mi). Then they were left to stand for two days following the recommendations of (Fopoussi Tuebue and Tchinda)[18]. At the end of the two days, each of these samples was filtered using white, thick piece of cloth of known dry mass (M1i). The filtrate and the peace of cloth were simultaneously air dried until completely desiccated. A second weighing phase was carried out; it helped to have instantaneously the mass of the peace of cloth and the materials deposited (M2i). The mass of the solid phase resulting from each fluid was obtained by setting $Mi' = M2i - M1i$. For each sample, the proportion of the solid phase (deposit) was obtained by posing $Pi = \frac{Mi'}{Mi} * 100$. In detail, to measure the weight of the different fluids collected, an empty container with known volume was weighted (Mc=mass of the container). After this, the same container full with each fluid respectively was weighted (Mcf=mass of the container full with fluid). The mass of the fluid was then obtained as follow: Mi=Mcf-Mc.

Also, attention was dragged towards the color of the fluids. So, the color of the control water and that of the end of cooking fluid were noticed. In the same vein, the evolution of the color during the stand was emphasized. Moreover, the height of the flocculation was observed in the different cases.

Determination of soils bulk densities and total porosity

To determine the bulk density, a volume of water (Vw) was taken, the mass of which was determined (Mw). Then, we took a clod of earth whose mass was measured (M); its volume was then determined by Archimedes' pushing method (V). The bulk density of the soil was finally determined by setting

$$D=\frac{\rho}{\rho w}, \text{ with } \rho=\frac{M}{V} \text{ and } \rho w=\frac{Mw}{Vw}; \text{ that is, } D=\frac{M*Vw}{V*Mw}.$$

The total porosity of the soils was determined by setting $n= 1-\frac{Da}{Dr}$, Da being the bulk density of the soils and Dr, of 2.7, being the real density of clay particles according to (Bitom)[53].

Determination of the average rate of drawdown of the different columns of fluids

The behavior of the following solutions were investigated: the water provided for cooking the maize (control), human urine, the end-of-cooking fluids for the bean and maize respectively. The average drawdown speed was calculated by setting $V = \frac{11.5ml}{t}$ (t being the column drawdown time of each of the fluids and 11.5 cm being the column height of each of the fluids at the start of the test). The average drawdown speeds were first calculated on an ad hoc basis over time intervals defined by the drawdown curve, then globally, therefore taking into account the entire duration of the drawdown.

Determination of the volumetric mass and the density of the different fluids

The volumetric mass was calculated using the following formula:

$$\rho=\frac{M}{V} \text{ (}\rho\text{: volumetric mass;}$$

M: mass of the fluid; V: volume of the fluid). The density was calculated by setting $D=\frac{\rho}{\rho w}$. Since $\rho w=\frac{Mw}{Vw}$ (ρw: volumetric mass of a given type of water; Mw: mass of a given type of water; Vw: volume of a given type of water) and $\rho=\frac{M}{V}$, $D=\frac{M*Vw}{V*Mw}$ finally. The percentage of the flakes was obtained by dividing their mass by the mass of the fluid containing them as follow: Percentage= $\frac{Mf}{Ml}$x100 (Mf: mass of flakes; Ml: mass of liquid).

3. Results

3.1. Maize, water for the cooking process, and left-over-water from cooking processes

The cooking process of the maize is longer than that of the beans. In detail, while the dried beans seeds take about 2 hours to get well done, the dried maize seeds for their one takes longer, about 6 hours.

The water used for the cooking process is translucent (Fig. 2A). As the maize cooks, the color of the seeds remains quite the same up to the end of the cooking process. Concerning the left-over-water from cooked maize, at the end of the cooking process, it is whitish (Fig. 2B); but as the cooling process evolves, the whitish color is progressively replaced by the yellowish color (Fig. 2C).

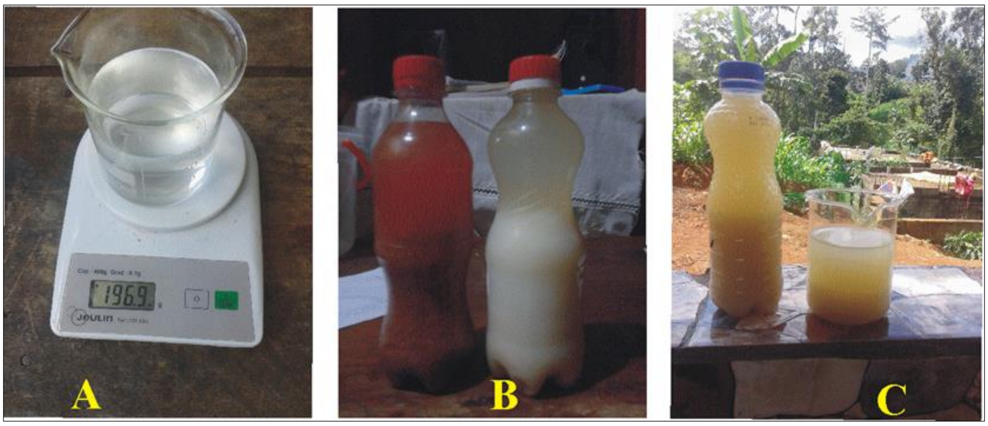

Figure 2 Aspect of the water used for the cooking process (A), water from the cooking process of Beans (left side of the **Figure** 2B) and maize (wright side of the Figure 2B), and that of the left-over-water from cooked maize alone (C)

In contact with the fingers, the corn end-of-cooking fluid is slippery. This liquid, on cooling, forms a translucent film on its surface (Fig. 3A). Its thickness is about 1mm. Its surface easily reflects light (Fig. 3A). Out of the fluid, this film forms a kind of veil on the hand (Fig. 3B). It opposes its destruction under the pressure of the fingers. After two days of storing the water from the end of corn cooking in a hermetically sealed bottle, you can easily hear a noise similar to the one you hear when opening a bottle of carbonated juice.

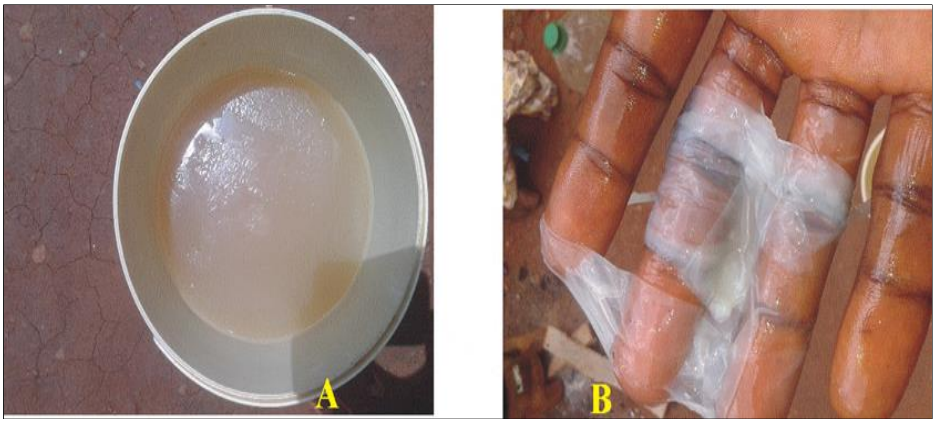

Figure 3 Respective aspects of the surface of the left-over-water from cooked maize (A) and the film formed at the surface of the same fluid during cooling (B)

3.2. Flocculation Study

At rest, the corn end-of-cooking fluid settles, favoring the formation of two slices (photograph 2B). The lower slice has an overall milky appearance, individualized into numerous millimetric and subspherical particles, lining the basal part of the container (Fig. 4). As for the upper slice, it is also distinguished by its yellowish appearance, but less dark than that of the basal part (Fig. 2B).

Figure 4 Presence of the millimetric roundish particles within the left-over-water from cooked maize

The passage of this fluid through a piece of fine-knit fabric made it possible to retain the flocculated phase formed on the surface of the piece of clothing (Fig. 5B and 5H). The flocculate-piece of cloth set, laid out for draining, made it possible to identify a few facts.

During the first day of draining, the coagulate from the water at the end of corn cooking has a pasty appearance with a smooth surface (Fig. 5I). As for the one from the water after the beans have been cooked, it has many bubbles on its surface, generating a foam (Fig. 5B). The smell that emanates is repulsive for the coagulate from the water after the beans have been cooked; for the coagulate from the water at the end of corn cooking, however, it is bearable. Towards the end of the first day of drying, the presence of numerous subspherical vacuoles of millimetric size can be observed on the surface of the coagulate resulting from the water at the end of the bean's cooking. Both coagulates attract many red fruit flies. We can also observe the presence of many pupae. Moreover, some samples of flakes have completely or partially disappeared. At the same time, many faecal cylinders of millimetric size, with rounded ends, as well as marks of small incisors, were found on the piece of cloth bearing these flocculates.

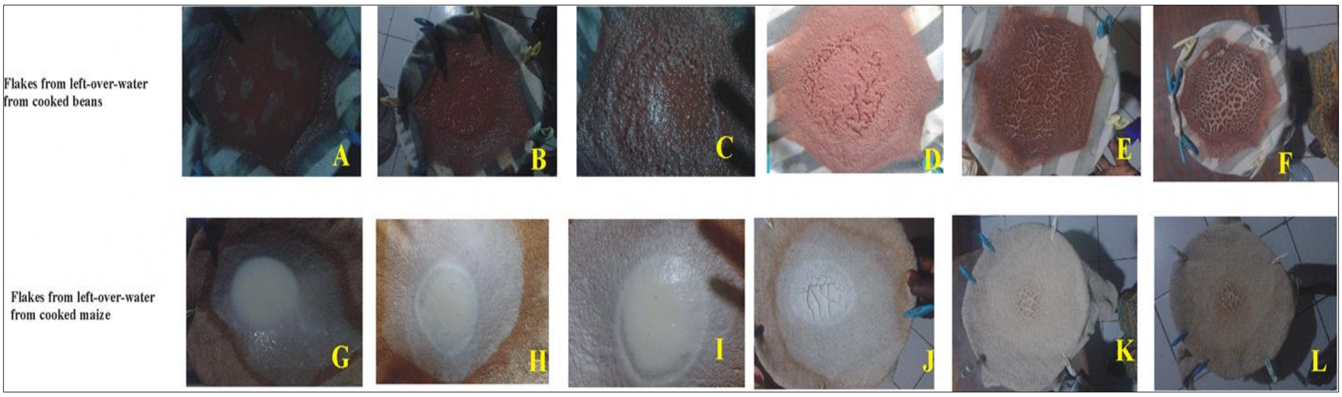

Figure 5 Evolution of the flakes during drying

On the second day of drying, many cracks appeared on both sides. Only, they are more numerous within the coagulate resulting from the water of end of cooking of the bean where they are contiguous. We can then observe many polygons of varying sizes. In the coagulate from the water at the end of corn cooking, the cracks are much more isolated; however, a few polygons are detectable. In detail, the size of the polygons is larger and larger when moving from the periphery to the center of the coagulate (Fig. 5D and 5J); we can then measure here lengths of up to 7cm on the long axis in the coagulate from the water at the end of the bean's cooking, but a little less, around 4.5 cm, in the coagulate from the water end of corn cooking. Areas of the piece of cloth used for filtering are somewhat harder than areas of the same piece of cloth that have not been in contact with this substance.

At the end of the third day of drying, the coagulates are completely fragmented by large cracks whose opening locally reaches 10cm in the central zone and much less in the periphery (Fig. 5E and 5K). The polygons, of varying sizes, remain present and abundant. The areas of the piece of cloth used for sieving are much harder than before. Polygons based on coagulate from corn end-of-cooking water are harder and harder than those based on coagulate from bean end-of-cooking water. In both cases, we note that the polygons become concave upwards (Fig. 5F and 5L).

Table 1 Some physical characteristics of the fluids considered in this study

		Left-over-water from cooked beans	Left-over-water from cooked maize	Water used for the cooking process
Mass (g)		211.1	203.5	196.9
Volume (ml)		200	200	200
Volumetric mass (g/ml)		1.0555	1.0175	0.9845
Density		1.039	1.001	1
Flake	mass (g)	16.2	3.8	0
	Percentage	7.67%	1.87%	0

For the same volume of the different fluids, the masses are as follow: 211.1 g for the fluid from beans cooking; 203.5 g from the fluid from maize cooking; 196.9 g for the water used for the cooking process as showed in Table 1 and Fig. 6.

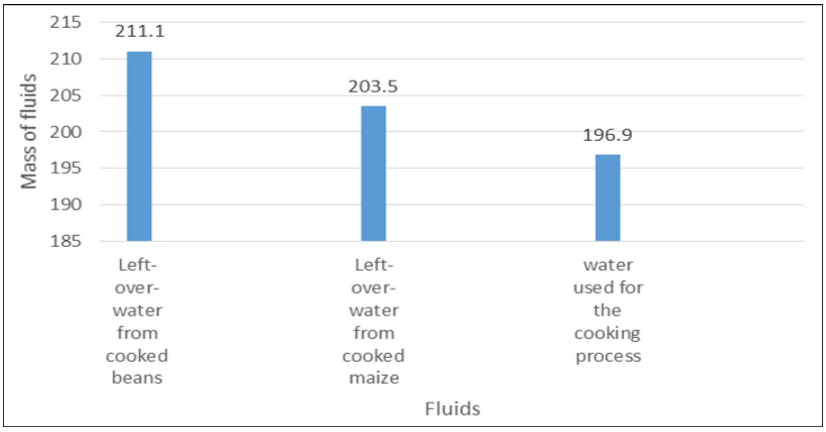

Figure 6 The different masses of the studied fluids

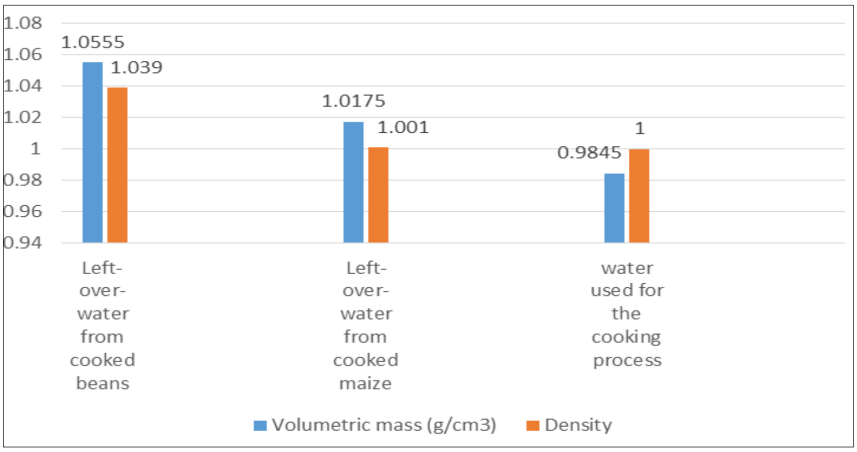

Figure 7 The different volumetric mass of the studied fluids

Regarding the volumetric mass and the density, Table 1 and Figure 2 show the behavior. In fact, the water used for the cooking process has a volumetric mass of 0.9845 g/ml and a density of 1. Concerning the fluid resulting from the maize cooking, its volumetric mass is 1.0175 g/ml for and its density is 1.001. The liquid resulting from the bean cooking for his own has a volumetric mass of 1.0555 g/ml and a density of 1.039.

Concerning the flakes, their quantities in the different fluids are presented in Table 1 and Fig. 8. In detail, for the 200 ml of the different fluids respectively collected, the left-over-water from cooked bean weighs 211.1 g. 7.67% of that mass is occupied by flakes, this is to say 16.2 g. Concerning the fluid from cooked maize, it weighs 203.5 g. 1.87% of that mass represent that of flakes (3.8 g). Regarding the water used for the cooking process, it weighs 196.9 g; no flakes were found.

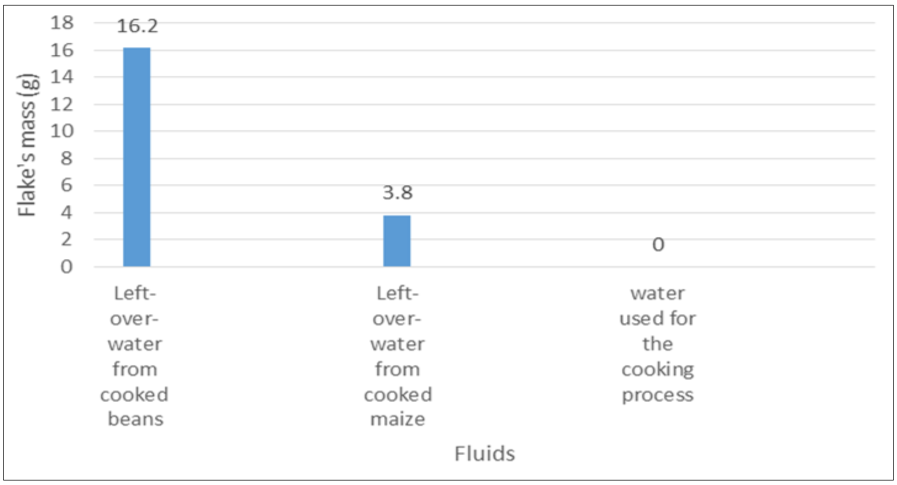

Figure 8 Masses of flakes within the different fluids

A study of correlations was made between the mass of the flakes, the mass, the volumetric mass and the density of the different fluids. In the various cases, it is positive as shown in Figs 9, 10, 11, 12, 13, and 14. In detail, however, some changing emerge depending on the case. Concerning the correlation between the volumetric mass of fluids and the mass of the flakes (Fig 9), it is highlighted by a positive bond; the dots are differentially positioned around the average line. It has a correlation coefficient of 0.9675 (Table 2). The induced cloud reveals three groups of dots: the blue dot for the first group, the red dot for the second group, and the yellow dot for the third group. The formed groups are very distant from each other. But, the dots of the third group is bore by the average line.

Table 2 Correlation matrix

	Mass of flakes	**Density of fluids**	**Volumetric mass of fluids**	**Mass of fluids**
Mass of flakes	1			
Density of fluids	0.9771	1		
Volumetric mass of fluids	0.9675	0.9996	1	
Mass of fluids	0.9672	0.999	1	1

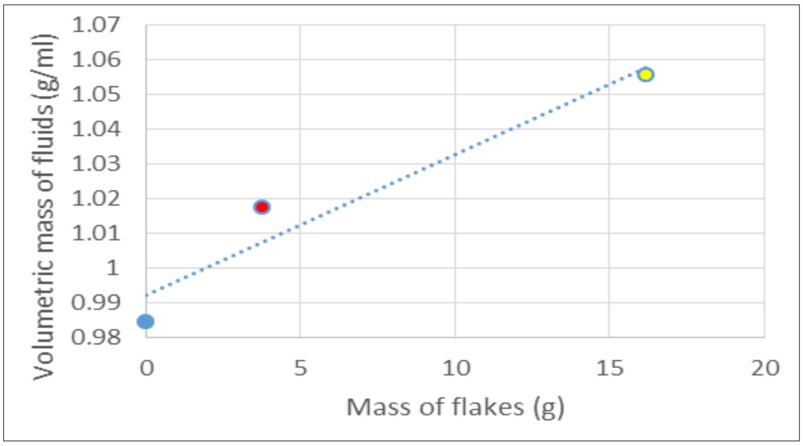

Figure 9 Correlation between the volumetric mass of fluids and the mass of flakes

The correlation between the volumetric mass and the density of solutions is positive, linear, and nearly perfect (Fig. 10). Its correlation index is 0.9996 (Table 2). As shown in Fig. 11, the dots of the cloud are distant from each other, revealing three groups of dots, quite completely positioned along the average line. Those groups are as follow: the blue dot for the first group, the red dot for the second group, and the yellow dot for the third group.

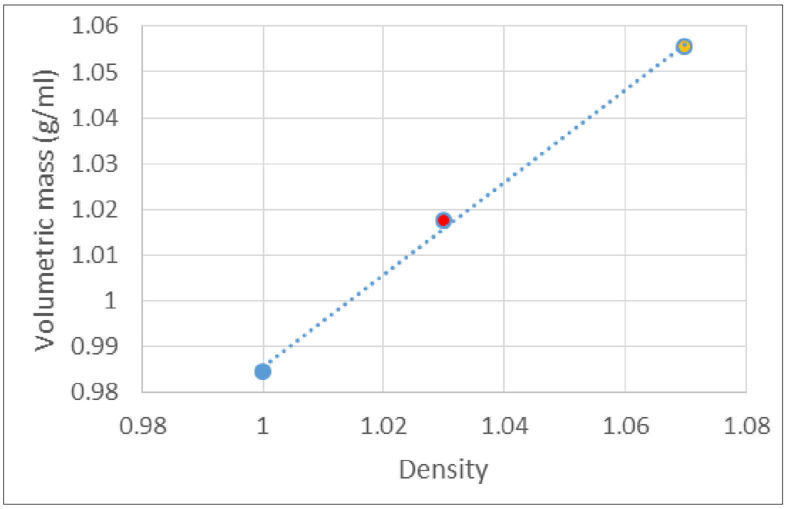

Figure 10 Correlation between the density and the volumetric mass of fluids

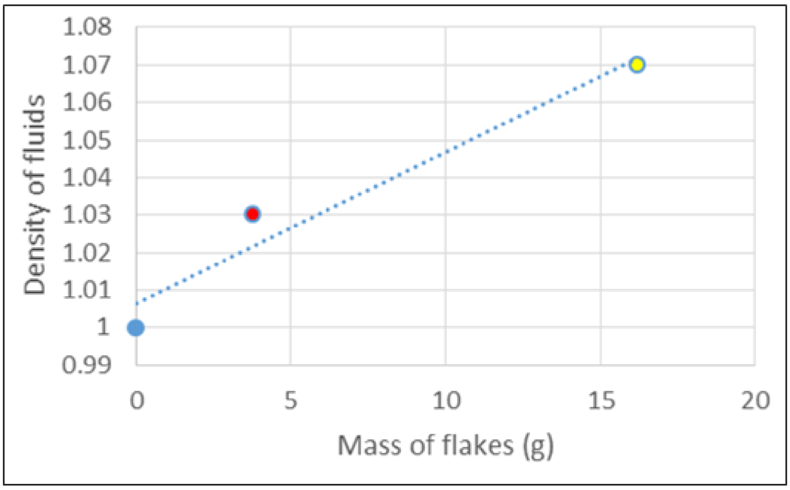

Figure 11 Correlation between the density of fluids and the mass of flakes

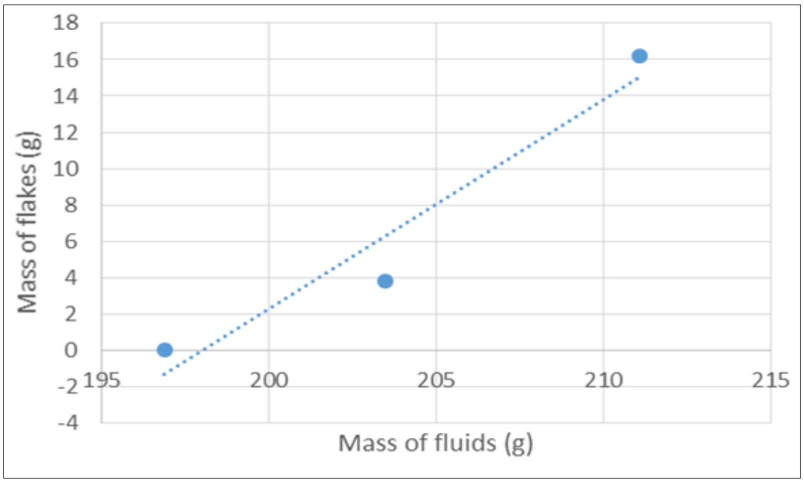

Figure 12 Correlation between the mass of fluids and the mass of flakes

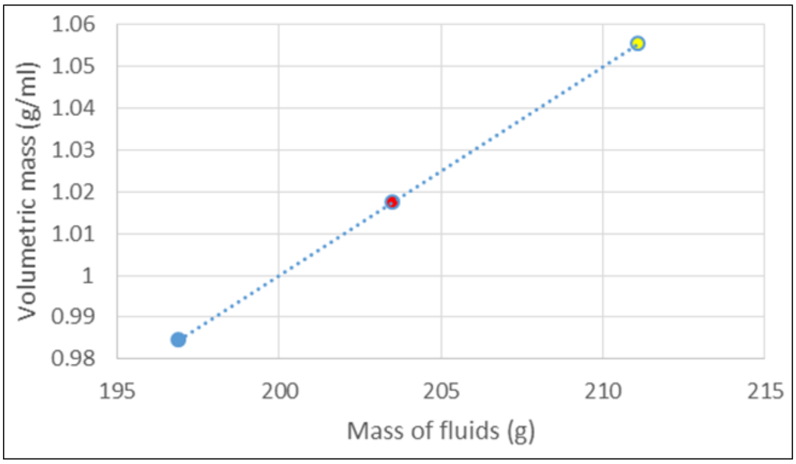

Figure 13 Correlation between the volumetric mass and the mass of fluids

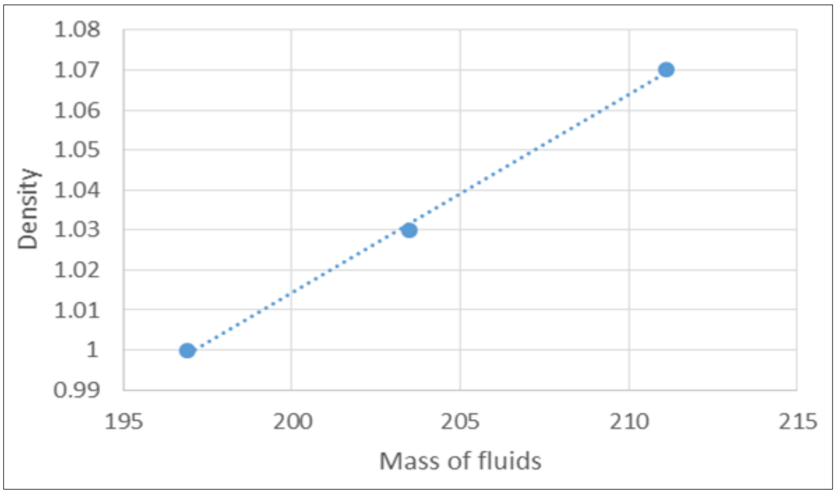

Figure 14 Correlation between the density and the mass of fluids

The correlation between the mass of the flakes and the density of solutions (Fig. 11) is identical in the distribution of dots of the cloud to the correlation established between the volumetric mass of solutions and the mass of flakes (Fig. 9). Here however, the Pearson correlation coefficient is 0.9771 (Table 2).

The correlation established between the mass of fluids and the mass of flakes (Fig. 7) tends to be a little bit linear. None of the dots of the generated cloud is bore by the average line. As above, those dots remain distant from each other. The three groups of dots observed in the previous cases are present here. The correlation index is 0.9672 (Table 2).

The correlation between the volumetric mass and the mass of fluids (Fig. 13) on the one hand and that between the density and the mass of fluids (Figure 9) on the other hand are quite identical. The dots in those two cases are lined and bore by the average line. The three groups of dots as observed above remain existent here: the blue dot, the red dot, and the yellow dot. The correlation coefficient is respectively 1 and 0.999 in the second case (Table 2).

3.3. Characterization of Soils

The soils characterization relates to two neighboring plots under natural cover. In both cases, we limited ourselves to their cultural profile. It is 15cm thick, moist, quite dense and compact, reddish brown (7.5YR4 / 6). The structure, of polyhedral type, is well developed and the texture is clayey. A few biological and structural holes are observed. Biological voids are essentially rare scattered galleries of burrowing animals. Regarding structural voids, these are voids that outline the contours of the aggregates.

The apparent density of the soils is 1.64 for a total porosity of 39.32%.

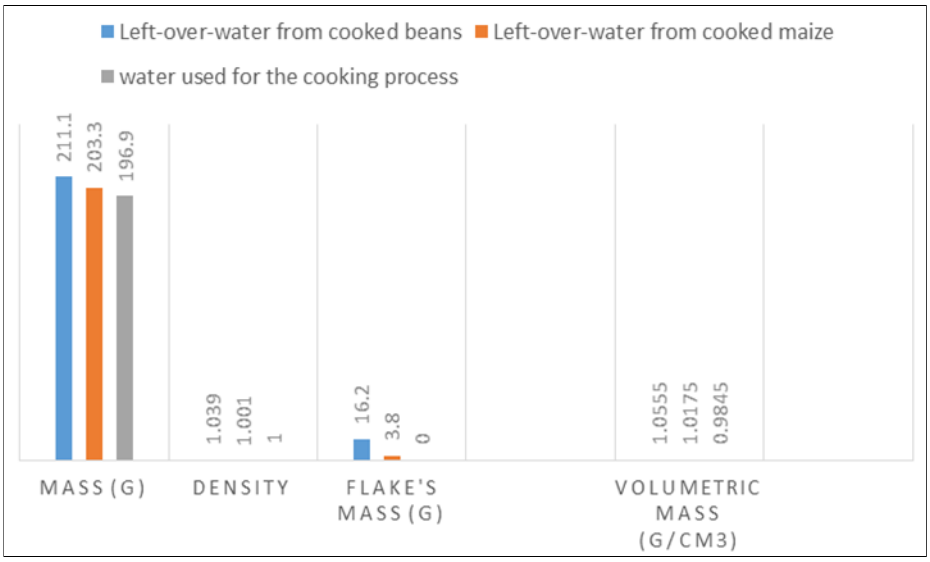

Figure 15 Synthetic approach of the different quantifiable parameters studied

3.3.1. Comparison between the respective rates of infiltration of human urine, left over water from cooked beans and maize, and water used for the cooking process of beans and maize

The column of the three fluids whose drawdown monitoring is in question here is 11.5cm. From Fig.16, we see that the drawdown curves of the bean and maize end-of-cooking fluids have a linear tendency. In detail, however, a level aspect of said curves is observed in watermark. Thus, we first have a region of greatest decrease for these fluids; the tangent of the angle of inclination is then 0.0625, or an inclination of 6.25%. This portion is then followed by 7 steps of increasing length. The first three steps of the seven have comparable lengths. The fourth tier is approximately double each of the first three tiers. The fifth tier is approximately double the fourth tier. The sixth level is approximately double the fifth. Regarding the last level, the longest, it is a little more than 2.5 times the sixth level. After two hours (120 minutes) of observation, only 1.2cm in height of this solution draw downed; this then reflects a general average drawdown speed of 0.01 cm / minute after 120 minutes of monitoring. During the drawdown of the present fluids, there is concomitantly a significant clarification of the upper frank of the liquids. Along the portions of the drawdown curves of these fluids established after 120 minutes of monitoring, the different point average speeds are: 0.0375cm / minute in the oblique portion, 0.017cm / minute in the first level, 0.017cm / minute in the second step, 0.017cm / minute in the third step, 0.01cm / minute in the fourth step, 0.007cm / minute in the fifth step, 0.004cm / minute in the sixth, 0.002cm / minute in the seventh step. These fluids were however left in their respective cylinder. 24 hours after the start of the drawdown, the height of the solution dropped from 11.5cm at the start to 9cm, implying a drop of 2.5cm in 1440 minutes.

Seven days, that is to say 10,080 minutes after the start of handling, the bean and maize end-of-cooking fluids are completely infiltrated into the soil. This makes it possible to observe on the infiltration surface the presence of a layers as shown in Fig. 17. The layer formed from the left over water from cooked beans has two main colors: a superficial whitish color and an underlying dark color. When viewed up close, the whitish areas resemble a film of mold growing on the surface of the dark area. The layer gives off a strong odor. The layer formed from the left over water from cooked maize has a greyish color. The two layers attract many small flies. There are many small maggots as well as many pupae within them. Their respective thickness is about 3mm.

Regarding the human urine drawdown curve, it can be subdivided into two branches. The first branch goes from t = o to t = 8minutes, for a height drop of 11.5cm-6.3cm, or 5.2cm. The average drawdown speed related to this branch is 0.65cm / minute. The tangent of the angle of inclination of this branch is 0.65, or an inclination of 65%. The second branch goes from t = 8minutes to t = 48minutes, for a drop in height from 6.3cm to 0cm, or 6.3cm. The average drawdown speed associated with this branch is 0.1575cm / minute. The tangent of the bank angle is 0.1575, or 15.75%. The overall average speed is 0.24cm / minute. The column completely infiltrates in 48 minutes. The ratio between these two average speeds shows that the infiltration in the first branch is 4.13 times faster than in the second branch.

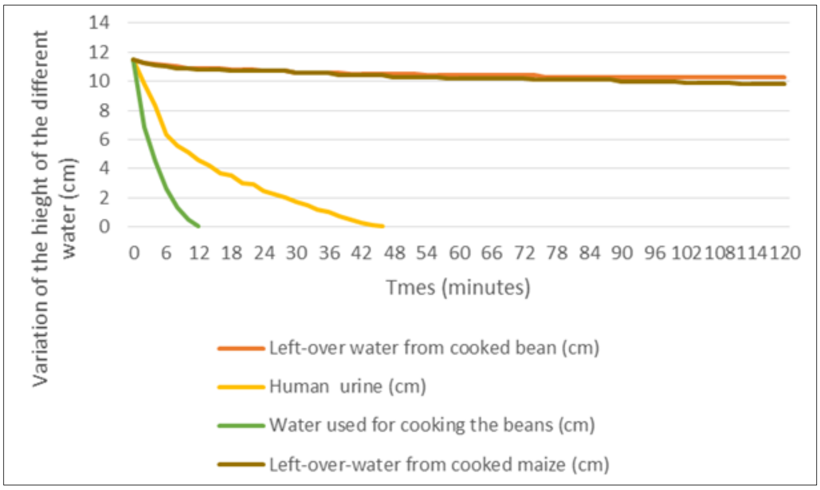

Figure 16 Behaviour of the different fluids during infiltration tests

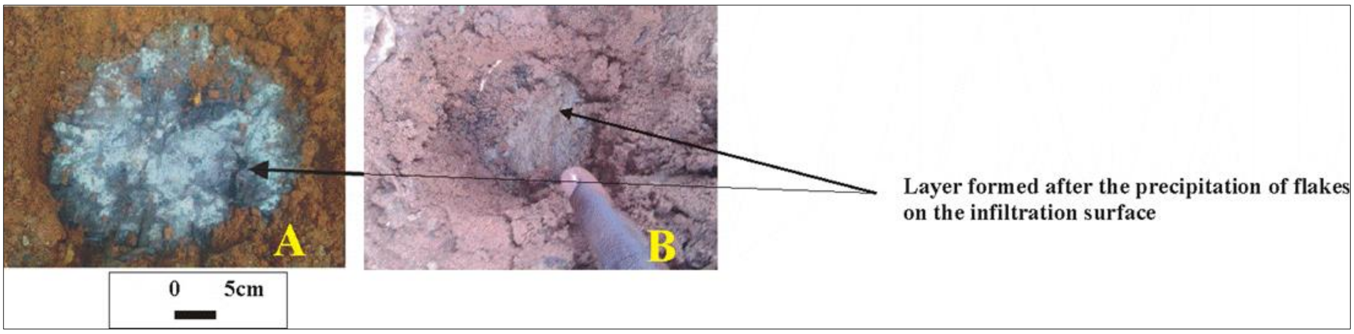

Figure 17 The respective layers formed on the infiltration surface of the fluid from cooked beans (A) and that of the cooked maize (B)

Regarding the control water drawdown curve, it is almost vertical. In detail, we can note a slight inflection towards the downstream part of the drawdown curve of the water column. The column of water infiltrates completely in 12 minutes. The average infiltration rate here is 0.96cm / minute.

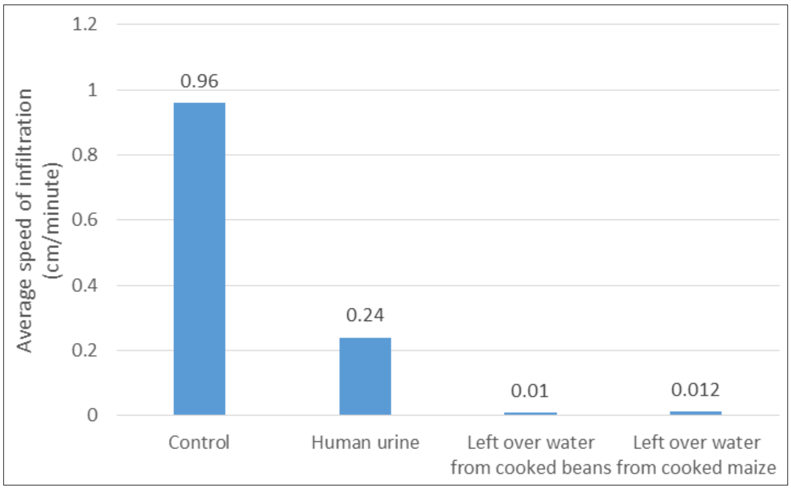

Figure 18 Comparison between the general drawdown speeds of the different fluids

For the different solutions, the general average rate of infiltration into the soil in situ is compared in Fig. 18 and Table 3. Thus, the control water has the fastest drawdown (0.96cm / minute), followed by far by human urine (0.24cm / minute), then from far away by the end of cooking solution of the maize (0.012cm/min), then end of cooking solution from cooked bean (0.01cm / minute) (Table 3, Fig. 18).

Table 3 Average drawdown speed of fluids from cooked beans and maize, water intended for the cooking tests, and human urine

Average speed of infiltration (cm/minute)	
Control	0.96
Human urine	0.24
Left over water from cooked beans	0.01
Left over water from cooked maize	0.012

4. Discussion

4.1. Soils Characterization

The cultural profile is 15cm thick. According to Bitom[53] and Monnier[54], this thickness is low. The texture of the soils is clayey. It agrees with the results of Bachelier[48]. The structure is polyhedral. This type of soil particle organization is common in clayey textured soils as shown by Duchaufour[55] and Bonneau and Souchier [56]. The bulk density is 1.64. For Memento de l'agronome[57], it is strong. It therefore fits perfectly with compactness such as manually evaluating in the field. Voids, biological and structural, are rare. This corroborates the value of the total porosity (39.26%); in fact, the classification chart for the total porosity of soils proposed by Memento de l'agronome [57] qualifies it as low.

4.2. Color, flocculation, mass, volumetric mass, and density of fluids resulting from the cooking processes of bean and maize seeds

From the water used for cooking to the fluid resulting from cooking the seeds, changing in color can be noticed. In the case of the bean seeds, the reddish followed by the brownish coloration can be observed. The reddish coloration is the consequence of the loss of sensitive material by the bean seeds during the beginning of the cooking process; these observations agree with the observations of Fopoussi Tuebue and Tchinda[18]. It is important to mention that at that stage, things evolve as we were in the situation of soaking according to Fopoussi Tuebue and *al*[37]. The intensification of the reddening becomes sharply accentuated before giving way to a completely brown color. This increased reddening is the consequence of the increasing of the temperature in response to the cooking process. In this sense, David[58] notes that temperature has the characteristic of accentuating the dissolution of solid compounds when they come into contact with water. This theory is comfort by the observations of Lide[52]. The change from dark red color to brown color as cooking progresses is a consequence of the transformation of the previously red pigments from the seed by the increase in temperature. Such changes in the characteristics of matter are commonly observed during metamorphism. This is a geological phenomenon that involves the intervention of temperature when modifying materials. In this sense, it has been showed that the degree of implication of temperature varies with the type of metamorphism if we refer to the work of Nzenti[47]; this is consistent with the different stages of cooking of the bean as used in the context of this study. In the case of the maize seeds, the color of the water at the end of the cooking process is whitish; this is also the consequence of the loose of matters by the seeds because of getting in contact with water during the cooking process. As the cooling process evolves, the whitish color is progressively replaced by the yellowish coloration; this changing can be justified by the modification of carotenoids released within the cooking fluids. In this sense, Muzhingi and *al*[59] reveals that the evolution of the cooking process of maize enriches the matter with carotenoids. In detail, for the two types of seeds, the lost elements can be organized into pigments among which we can mention anthocianins, mineral salts, and organic derivatives after Fopoussi Tuebue and Tchinda[18], Fopoussi Tuebue and *al* [37], Fopoussi Tuebue and Tchinda[38] and Lao and *al*[42]. However, only the pigments are responsible for the gradual coloring observed.

The intensity of the flocculation is different when one moves from the water used for the cooking process to the different water from the cooking processes. Globally, according to the amount of the flakes, the different fluids concerned can be classified as follow: water used for the cooking process < left over water from cooked maize < left over water from cooked beans. So, the mass of the flakes is 0 g in 200 ml of the water used for the cooking process, 3.8 g in 200 ml of fluids resulting from maize cooking, 16.2 g in 200 ml of fluids from beans cooking. The increase in the mass of the deposits from the water used for the cooking process is in agreement with the increase in the mass, the density, and the volumetric mass of the respective fluids. This is commonly observed when the mass of a solution increases without variation in volume as shown by Lide[52]. In addition, it can be noticed that the quantity of flakes noted in the fluids from cooking the bean is 4.26 times the quantity of the flakes within the fluids from cooking the maize. This situation is in perfect agreement with the duration of the cooking process of those different seeds. Moreover, one can think that the components of the maize seeds could be resistant to dissolution and motion compared to the habit of the component from bean seeds. This agrees with the observations made by many housewives in Cameroon.

4.3. The Behavior of the Different Fluids during the Drawdown

For the respective end-of-cooking bean and maize fluids, the oblique branch of the drawdown curve indicates the period during which the drawdown speed is highest. Indeed, during the corresponding time slot, the pores of the soil are still free, thereby allowing easier but brief infiltration of these fluids. The brief character noted here is in perfect harmony with the poor total porosity of the soils. The terraced landings, for their part, reveal the drawdown levels at the same speed of the column of bean and maize end-of-cooking solutions, that is to say less and less. This drop in speed is the consequence either of the saturation of the pores if we refer to the work of Gonzalez-Merchan[60], or then quite simply the consequence of their clogging. The soil pore clogging processes have been regularly discussed by Antonakos and Lambrakis [49]. This clogging was undoubtedly caused by the deposit of particles in suspension in the bean and maize end-of-cooking solutions as shown by Fopoussi and Tchinda[18]. One week after the start of the infiltration tests, the bean and maize end-of-cooking solutions were completely infiltrated. On the infiltration surfaces, we notice layers with a dark matrix above which we have a whitish domain on layers from left over water from cooked beans. This layer covering the infiltration surface is undoubtedly the consequence of the precipitation of the abundant flakes in the bean and maize end-of-cooking solutions. Such a vision is reinforced by the clarification of the upper frank of these fluids which thus recalls the phenomenon of settling as shown by Fopoussi and Tchinda [18]. According to the work of the same author, this deposit is initially brown for the left over water from beans, but first of all whitish then yellowish for the left-over water from cooked maize. The dark color noted in the matrix can reflect the decomposition of the layer. In this sense, Bru-Adan and *al*[61] describes the product resulting from the decomposition of organic matter, still seen from the angle of compost, emphasizing its dark color. The whitish screen present on the surface of the dark matrix suggests a layer made of *Aspergillus L.* according to the investigations of Fopoussi Tuebue and *al*[15]. This observation is in accordance with the findings of Bru-Adan and *al* [61].

For the urine solution, the first limb, with a 65% incline, shows the speed at which the urine column is drawn down the highest. Indeed, the pores at this time are still more or less free, and thus even to facilitate the gravity flow of human urine tested here. This is in agreement with the observations made by Gonzalez-Merchan [60]. The second branch, with a 17.75% incline, reveals the level at lower infiltration speed. We can link this drop in the drawdown speed to two facts. At first glance, this may be the consequence of the gradual saturation of soil pores if we take the studies of Gonzalez-Merchan[60]. On the other hand, it can be the clogging of these same pores by the precipitation of urinary compounds. In this second case, [60] observed the ability of urinary compounds to precipitate and block the pipes during the use of pipes through soil fertilization with human urine.

For the control solution (water used for cooking processes), the water drawdown curve is almost vertical. This reveals a very high drawdown speed according to Gonzalez-Merchan[60]. But, towards the base of the curve, there is a slight inflection. This demonstrates a significant decrease in the speed of drawing said fluid into the soil. Such a thought is in agreement with the hypothesis of a progressive saturation of the pores of the soil following the progressive infiltration of water according to Gonzalez-Merchan[60] on the one hand, and to the lack of flakes in the control solution on the second hand. It is further reinforced by the total poor porosity.

The water used for the cooking processes (control) has the fastest drawdown (0.96 cm/minute), followed by far by human urine (0.24 cm/minute), then very far by the fluids from cooked maize (0.012 cm/minute) and bean (0.01 cm/minute) respectively. Thus, the control water enters into the soil 4 times faster than human urine and at least 96 times faster than the bean and maize end-of-cooking solutions. As for human urine, it enters into the soil 24 times faster than the bean and maize end-of-cooking solutions. These observations closely match the content of the various solutions in flocculent materials. This content is in fact very high in the solution from cooked beans and quite absent in the water used for the cooking processes according to Fopoussi Tuebue and Tchinda[18].

4.4. The behavior of the different fluids during resting, sieving, and drying

In contact with the fingers, the corn end-of-cooking fluid is slippery. This fact is commonly observed with post-cooking liquids of carbohydrate-rich materials. This liquid, on cooling, forms a translucent film on its surface. On the surface of foodstuffs with a pasty or fluid tendency from cereals, this phenomenon is regularly observed. Its surface easily reflects light. This observation can be justified by the glassy appearance of this veil as shown by Deferne[62] when speaking about Muscovites. Released from the fluid, this film forms a kind of veil on the hand which opposes its destruction under the pressure of the fingers. Indeed, this hardness is common in corn flour dishes. This is the case with cooled corn couscous which, as it cools, generates hard and sometimes spicy parts.

The passage of this fluid through a piece of fine mesh fabric made it possible to retain the flocculated phase formed on the surface of the piece of clothing. This is consistent with the presence of flakes in the fluid as showed by Fopoussi Tuebue and Tchinda [18].

During the first day of draining, coagulate from the water at the end of corn cooking has a pasty appearance with a smooth surface. This fact would be the consequence of the size of the colloids constituting the paste. As for the one from the water at the end of the bean's cooking, it has many bubbles on its surface, generating a foam. This foam reflects the degassing of the material. Indeed, beans, which are particularly rich in protein, easily release sulfur and nitrogen gases. This is consistent with the flatulence highlighted by Roger Fenwick and *al* [34] and Winham and Hutchins[35]. The smell that emanates is repulsive for the coagulate from the water after the beans have been cooked; for the coagulate from the water at the end of corn cooking, however, it is bearable. Such an observation corroborates the presence of foam on the surface of the end-of-cooking fluid of the bean, as well as the richness of the bean in nitrogen and sulfur. Towards the end of the first day of drying, the presence of numerous subspherical vacuoles of millimeter size can be observed on the surface of the coagulate resulting from the water at the end of the bean's cooking; these would be gas escape routes. Both coagulates attract many red fruit flies; in fact, this coagulate represents for them a source of food and an excellent place for laying eggs. This is in perfect agreement with the presence of numerous pupae observed in the samples. Moreover, some samples of flakes have completely or partially disappeared. At the same time, many fecal cylinders of millimetric size, with rounded ends, as well as marks of small incisors, were found on the piece of cloth bearing these flocculates. The cylinders are reminiscent of mouse faecal pellets. This opinion is in agreement with the traces of incisors observed. We can therefore correlate the disappearance of certain flocculates from the end-of-cooking corn solution with the nutrition of a few mice that would have stayed there. In this sense, Cruz and *al*[63] highlights the strong attraction of corn to mice.

On the second day of drying, the areas of the piece of fabric used for sieving are much harder than before. Such a situation is common with materials with a pasty or fluid tendency rich in carbohydrates as previously announced. Polygons based on coagulate from corn end-of-cooking water are harder than those based on coagulate from bean end-of-cooking water. In both cases, we note that the polygons become concave upwards. Such figures are commonly observed during the dewatering of deposits composed of very fine particles, the size of clays. Commenting upon these facts, Berger[64] speaks about desquamation figures.

4.5. Correlations Study

All correlations are positive, with Pearson's coefficient of at least 0.9672. According to the work of Rakotomalala[65], the various correlated parameters are strongly related. But, the point clouds are organized in detail in sometimes very distant groups as is the case for the correlation between the volumetric mass of the solutions and the mass of the flakes.

This indicates the existence of a third parameter not taken into account within the framework of the present correlation as responsible for the noted behaviors. This is in agreement with the observations of Rakotomalala[65]. Such a fact is then justified by the absence or the presence of flakes in very small quantities in the control solutions, but in very high quantities in the solutions resulting from cooking. This thinking is consistent with the studies of Fopoussi Tuebue and Tchinda[39] and Memento de l'agronome[57], from which the bean end-of-cooking solution is a source of organic matter for soils. The correlation between the volumetric mass and the density of the solutions is positive, linear, and almost perfect, with a correlation index of 0.9996. This is quite normal as these are two closely related parameters; Memento de l'agronome[57] highlights in this vein a formula which takes into account these two quantities; the variation of one will therefore consequently induce that of the other.

4.6. Comparison between the left over water from the cooked beans, left over water from cooked maize, human urine, and water used for the cooking process

From the present study and from the previous ones, comparisons can be done between the fluids concerned here and human urine. So, on the physical point of view, there are differences and resemblances existing between the left over water from the cooked beans, left over water from cooked maize, human urine, and water used for the cooking processes. Those facts are summarized within the table 4 below.

Table 4 Comparison between the left over water from the cooked beans, left over water from cooked maize, human urine, and water used for the cooking process

		Left over water from the cooked beans	**Left over water from cooked maize**	**Water used for the cooking process**	**Human urine***
Color		Brown	Yellowish	Translucent	Light yellowish
Volume taken (ml)		200	200	200	200
Mass (g)		211.1	203.5	196.9	196.58
Density		1.039	1.001	1	0.9829
Volumetric mass		1.0555	1.0175	0.9845	0.9829
Flakes	Presence	Yes	Yes	No	Yes**
	Color	Brown	Yellowish	-	Whitish
	Behavior when get drying	Polygonation, strong smell, presence of voids	Polygonation, light smell, presence of voids	-	-
	Action on mice	No	Yes		
	Action on flies	Yes	Yes		
	Mass (g)	16.2	3.8		
	Percentage	7.67%	1.87%		
Drawdown speed (cm/min)		0.01	0.012	0.96	0.24
Formation of seal on the infiltration surface		Yes	Yes	-	No
Spreading of odor		Strong odor	Light odor	-	Strong odor
Decanting		Yes	Yes	-	Yes
Formation of a film at rest at the surface		No	Yes	-	-
Gas emanation when kept in bottles		Yes	Yes	-	Yes

*[36] ** [66]

5. Conclusion

The color of the water used for the cooking process is translucent. Concerning solutions from cooking, those from cooked beans are brown while those from cooked maize are whitish to yellowish. Fluids from cooked beans contained greater quantities of flakes compared to those from cooked maize. From the water used for the cooking processes to the end of the different cooking fluids, the mass, the volumetric mass, and the density increase. The infiltration tests made show that the infiltration rate of the water from cooked beans is low compared to that of the water from cooked maize, and very low compared to that of human urine and water used for the cooking processes respectively. The total infiltration of solution of the end of cooking the bean and the maize reveals on the infiltration surface the presence of a film of a material bearing molds, generated by the progressive settling of this solution. Odor risen from fluids from cooked beans is stronger compared to that from fluids from cooked maize. The repulsive character of the odor from human urine is effective; however, the subjectivity of that character cannot really help to identify which among odor from liquid from cooked bean and human urine is more repulsive. At rest, one can find formed at the surface of the water from cooked maize the presence of a film. Settling occurs at rest within the fluids from cooked maize and cooked beans at rest. Flakes from cooked beans and cooked maize fluids both attract flies; but only those from cooked maize attract also mice. The correlations established between the different parameters followed up here are highly positive. But in detail, the influence of an under laid parameter, known here as temperature, has been identified as being the responsible of the questioned behavior of the parameters taken in peers in the case of correlation studies made.

Recommendation

In the case of the use of the solution from cooked beans and cooked maize as fertilizer, it is important to keep it within the soils in other to make its organic part to undergo decomposition and therefore, provide the tillable land with humic components, necessary in the improvement of soils in the nutrients and water retention, as substrate for soils microorganisms, as soils structuring factor, and so on.

Compliance with ethical standards

Acknowledgments

Mrs Fopoussi Tuebue provided us with left over water from cooked beans and maize. We appreciate it.

Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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