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Food Study of Ceramic Objects from Artisanal Pottery in the City of Katiola in Côte d'Ivoire

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Abstract

In Côte d'Ivoire, there is no regulation regarding the use of traditional ceramics in food. However, their possible impact on human health is not known. Two types of tests must be carried out to study container/content interactions in order to ensure a possible migration of ceramic constituents towards food. The aptitude test of food contact with traditional ceramics intended to come into contact with foodstuffs which determines lead, cadmium, cobalt, arsenic and aluminum release. The migration tests with traditional ceramic food simulants under contact time and temperature conditions are as close as possible to reality. In the aptitude tests of food contact, the utensils comply with French and European regulations concerning the migration of aluminum, cadmium and lead, except that of cobalt. In migration tests with food simulants, the ceramics presented different results. All utensils can be used without danger, except the plates.

Keywords

Food Study, Artisanal Pottery, Ceramics, Food Simulant

1. Introduction

In Côte d'Ivoire, there is no regulation regarding the use of traditional ceramics in food. However, their possible impact on human health is not known. After characterization and identification of clays used in Mangoro pottery by conventional analytical methods to characterize clay minerals, it seems appropriate, in order to protect human health, to assess the health safety of these materials. The ceramic utensils used for eating and drinking such as plates, cups, bowls and other items are fundamental part of many societies since ancient times [1]. Ceramic and glassware can be important source of elements harmful intake to human health such as lead and cadmium [2]-[4]. Besides the well-studied elements lead and cadmium, the migration of other toxic and non-toxic elements such as aluminum, boron, barium, cobalt, chrome, copper, iron, lithium, magnesium, manganese, nickel, antimony, tin, strontium, titanium, vanadium, zinc and zirconium was investigated in order to evaluate their potential health hazards [5] [6]. The migration amount depends on many factors, namely raw materials quality used for production, technological process course, food contact type, and time and temperature contact [3] [7].

Particular risk may be created by products produced on a small scale in the small craft workshops, where good manufacturing practice principles were not applied [4] [8] [9]. This requires a study of container/content interactions in order to ensure a possible migration of ceramic constituents towards food. Food-grade can be defined as material or object's ability to come into contact with foodstuffs while respecting any regulation basic principle relating to Materials intended to come into contact with foodstuffs (MCDA), namely: the inertia principle but also respecting all applicable general and specific requirements. Food quality is therefore not material intrinsic characteristic but depends on the food in contact and use conditions: temperature and duration of contact in particular. Food-safety of materials is also not a universal characteristic but depends on the differences between the regulations in force in the different countries [10].

At the manufactured product stage, the person responsible for the first marketing checks that the inertia criteria are respected, namely for ceramics, the migration of lead, cadmium, aluminum, cobalt and arsenic. Two types of tests are carried out:

- The aptitude test of food contact with traditional ceramics intended to come into contact with foodstuffs. It determines the release of lead, cadmium, cobalt, arsenic and aluminum.
- The migration tests with traditional ceramics food simulants under contact time and temperature conditions as close as possible to reality. To assess the migration of a substance, standardized tests are used to bring materials into contact with liquids simulating food and measure the migrations.

This work aims to assess traditional ceramics compliance with regard to the international regulations in force. To achieve this goal, their ability to come into contact with foodstuffs should be determined and find out the possible migration of ceramic constituents towards food.

2. Materials and Methods

2.1. Sampling

Ceramic samples studied were taken from Katiola in Côte d'Ivoire (GPS coordinates: Altitude 326 m; Latitude N 8˚08'14"; Longitude O 5˚06'03"). Four samples were collected from the ceramic manufacturing site. They consist of pottery made in Katiola:

- C1: plate 1 with a capacity of 600 ml
- C2: plate 2 with a capacity of 600 ml
- C3: soup tureen with a capacity of 1500 ml
- C4: carafe with a capacity of 5000 ml

2.2. Suitability Test for Food Contact of Traditional Ceramics Intended to Come into Contact with Foodstuffs

It consists of determining the yield of lead, cadmium, cobalt, arsenic and aluminum. The ceramics were filled with 4% (V/V) acetic acid to within 1 mm of the overflow point and placed at 22˚C ± 2˚C in a dark room for 24 hours. This migration test was carried out three times successively, the triple repetition corresponds to the usual provisions for testing reusable objects. On the solutions obtained during the first migration, lead and cadmium were assayed by atomic absorption spectrometry (AAS). On the solutions obtained during the third migration, cobalt and arsenic were assayed by AAS and aluminum by spectrophotometry.

The devices used are:

- THERMO SCIENTIFIC ICE 3000 AA05164104 atomic absorption spectrophotometer equipped with coded lamps of cobalt 15 mA, lead 12 mA, cadmium 10 mA, arsenic 12 mA and an oven with temperature ranges from 100 to 2500˚C (for the determination of cadmium, lead and cobalt) and 100 to 2700˚C (for the determination of arsenic). The characteristics and settings for yield determinations of lead, cadmium, cobalt, arsenic, and aluminum are detailed in Table 1.
- HACH DR 3900 spectrophotometer.

Table 1. Characteristics of lead, cadmium, cobalt, arsenic and aluminum yield determinations.

SETTINGS	DEVICE	WAVE LENGTH (nm)	DETECTION LIMIT
Cadmium	AAS-OVEN	228.8	0.02 µg/L
Arsenic	AAS-OVEN	193.7	0.53 µg/L
Lead	AAS-OVEN	217.0	0.11 µg/L
Cobalt	AAS-FLAME	240.7	0.01 mg/L
Aluminum	Spectrophotometer	522	0.008 mg/L

2.3. Migration Tests with Food Simulants of Traditional Ceramics

To assess the migration of a substance, standardized tests were used to bring materials into contact with liquids simulating food and measure the migrations. These conditions are recommended by European directives 85/572/EEC and 97/48/EC. Directive 85/572 sets the list of simulants to be used depending on the type of food selected.

The types of food and food simulants used in this study are contained in the following Table 2:

Table 2. Food simulant according to the type of food.

Type of food	Food simulant
Watery foods (pH > 4.5)	Ultrapure water
Acidic or alcoholic foods containing less than 5% (pH ≤ 4.5)	10% Ethanol
Alcoholic foods	15% Ethanol
Fatty foods	Refined olive oil

3. Results and Discussion

3.1. Suitability Test for Food Contact of Traditional Ceramics Intended to Come into Contact with Foodstuffs

In the aptitude tests for food contact, the utensils (plates 1 and 2, carafe and soup tureen) have residual arsenic concentrations equal to 0, the standard being equal to 0.0002 mg/kg. Residual cobalt concentrations in utensils are above the standard (0.02 mg/kg). Residual aluminum concentrations are less than 1 mg/kg (standard value). Residual cadmium concentrations in all utensils are below the standard value (0.1 mg/l). Residual lead concentrations in all utensils are below the standard value (1.5 mg/l) (**Figure 1**).

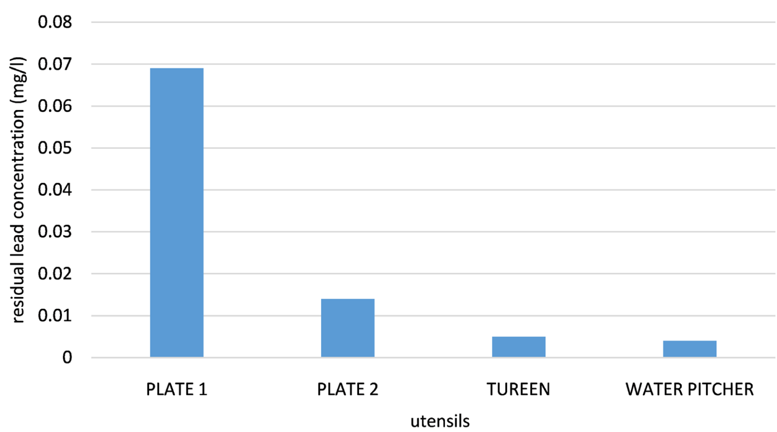

Figure 1. Residual lead concentration according to utensils.

The levels of lead and cadmium released did not exceed the standard limits (0.1 mg/l for cadmium and 1.5 mg/l for lead) (**Figure 2**). Aderemi *et al* observed the same result [2]. However, an investigation by the Norwegian Food Control Authority in Oslo in 2003 revealed that several ceramic items tested had shown lead migration levels above the migration limit [8].

Residual aluminum concentrations in utensils are less than 1 mg/kg (standard) (**Figure 3**).

The utensils (plates 1 and 2, carafe and soup tureen) have residual arsenic concentrations equal to 0 (**Figure 4**), the standard being equal to 0.0002 mg/kg. However, Henden *et al.* reported that a large amount of arsenic was released from earthenware pottery [11]. In addition, some authors in Nigeria detected relatively high levels of arsenic in all samples studied [2].

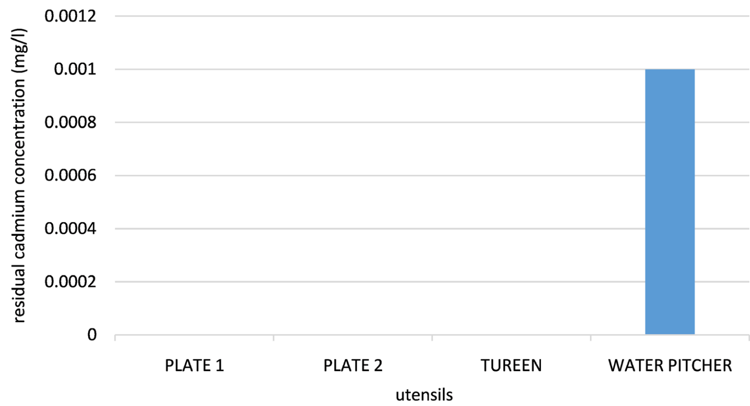

Figure 2. Residual cadmium concentration according to utensils.

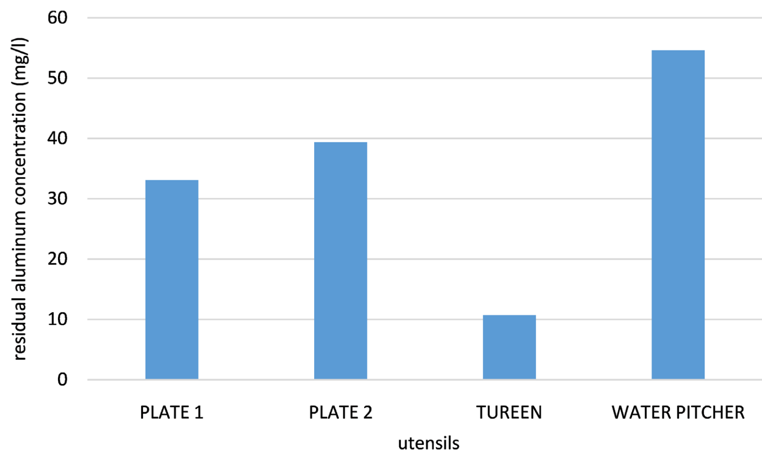

Figure 3. Residual aluminum concentration according to utensils.

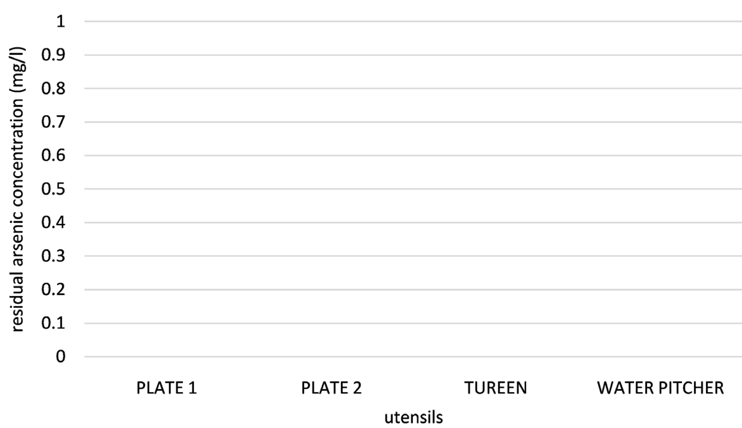

Figure 4. Residual arsenic concentration according to utensils.

The residual concentrations of cobalt in the utensils are higher than the standard (0.02 mg/kg) (**Figure 5**). To manage non-conformity and achieve quality objectives, it is important to implement corrective and preventive measures with a view to eliminating the potential causes of non-conformity [12]. Thus in the case of non-conformity of the migration of cobalt it will be a question of knowing whether the presence of cobalt comes from the raw material used to make the utensil or from the elements used for ornamentation [13].

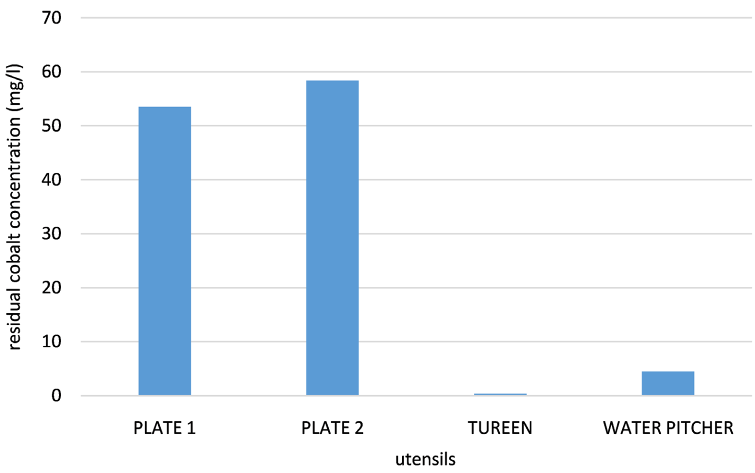

Figure 5. Residual cobalt concentration according to utensils.

3.2. Migration Tests with Food Simulants of Traditional Ceramics

In migration tests with food simulants, the ceramics presented the following results with regard to French and European regulations:

*Aqueous foods

- The residual aluminum concentration of plates 1 and 2 is lower than the standard concentration which is equal to 1 mg/kg of foodstuff. That of the tureen is 2 mg/kg
- The residual arsenic concentration is 0 mg/kg of foodstuff, the standard one is equal to 1 mg/kg of foodstuff
- The residual cobalt concentration of the utensils is higher than the standard value 0.02 mg/kg of foodstuff (**Figure 6**)
- The residual lead concentration is equal to 0, the standard concentration is 1.5 mg/l of foodstuff

*Acidic or alcoholic foods containing less than 5% (pH ≤ 4.5)

- The residual lead concentration is lower than the standard (1.5 mg/l of foodstuff)
- The residual aluminum concentration is lower than the standard (1 mg/kg of foodstuff) (**Figure 7**)
- The residual arsenic concentration is equal to 0, the standard being 0.002 mg/kg of foodstuff
- The residual cobalt concentration of plates 1 and 2 are higher than the standard while that of the soup tureen is lower than the standard (0.02 mg/kg of foodstuff)

Overall, clay potteries are not inert and various elements, particularly aluminum do migrate into acidic food simulants [14].

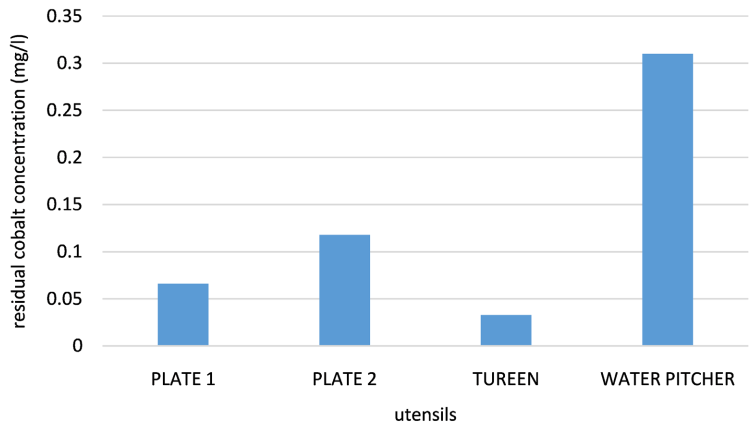

Figure 6. Residual cobalt concentration of utensils (pure water).

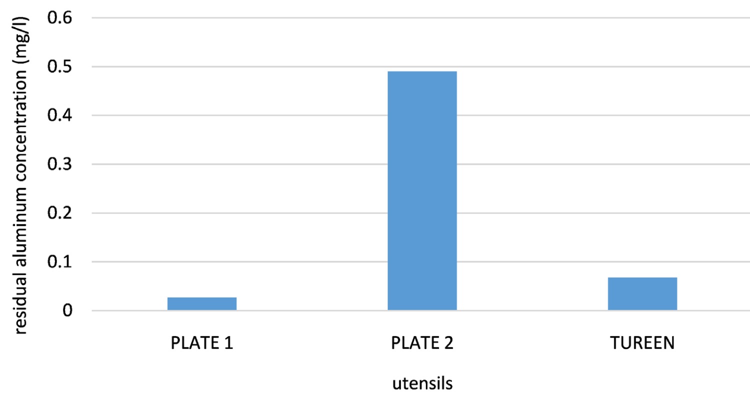

Figure 7. Residual aluminum concentration of utensils (ethanol 10˚).

*Alcoholic foods

- The residual aluminum concentration of the utensils is lower than the standard (1 mg/kg of foodstuff)
- The residual arsenic concentration of the utensils is equal to 0, it is therefore lower than the standard (0.002 mg/kg of foodstuff)
- The residual cobalt concentration of the tureen is equal to 0, those of plates 1 and 2 are higher than the standard (0.02 mg/kg of foodstuff)
- The residual lead concentration of the utensils is equal to 0 below the standard (1.5 mg/l of foodstuff)

*Fatty foods

- The residual aluminum concentration of the utensils is equal to 0 less than the standard 1 mg/kg of foodstuff
- The residual arsenic concentration of the utensils is equal to 0 less than the standard 0.002 mg/kg of foodstuff
- The residual cobalt concentration of the utensils is equal to 0 less than the standard 0.02 mg/kg of foodstuff
- The residual lead concentration in utensils is lower than the standard (1.5 mg/l of foodstuff) (**Figure 8**)

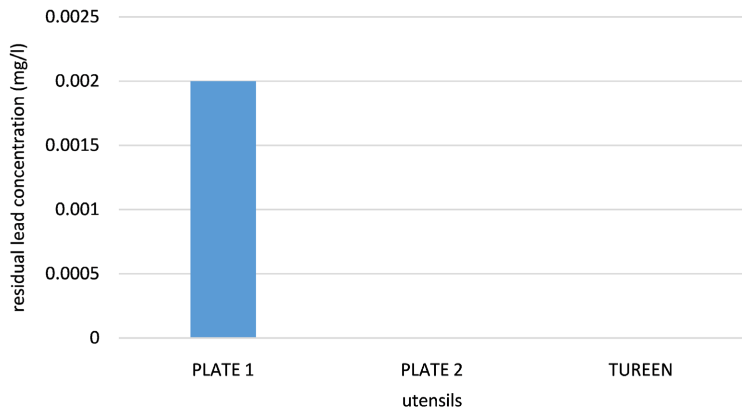

Figure 8. Residual lead concentration of utensils (olive oil).

4. Conclusion

The aptitude tests for food contact and the migration tests with food simulants were carried out on four traditional ceramics from the artisanal pottery of Katiola City. The utensils are suitable for food contact in view of French and European regulations concerning the migration of lead, cadmium, aluminum and arsenic, while they are non-compliant concerning the migration of cobalt.

Tests with food simulants reveal that:

- For aqueous foods, plates 1 and 2 are compliant regarding the migration of aluminum away from the soup tureen, the migration of arsenic is compliant for all utensils. Cobalt is not consistent with the migration of lead.
- For acidic or alcoholic foods containing less than 5% ($pH \leq 4.5$), the utensils are compliant with regard to the migration of lead, aluminum and arsenic. Only plates 1 and 2 are non-compliant regarding cobalt migration.
- For alcoholic foods, non-compliance is present for all utensils concerning the migration of aluminium, arsenic and lead. Only the soup tureen meets the standard for cobalt migration.
- For fatty foods, plates 1 and 2 are compliant regarding the migration of aluminium, arsenic, cobalt and lead.

In conclusion, only fatty foods should be put in the utensils so that aluminum, arsenic, cobalt and lead do not migrate easily. Furthermore, the amount of heavy metal migration will not decrease as the quantity of utensils used increases because it depends on the quantity of heavy metals present in the utensils used, not the quantity of utensils.

When using utensils, you didn't store food in the bowl for long periods. Look for a warning label. If the pottery was manufactured for use only as a decorative item, it may have a warning stamped onto the clay bottom such as "Not for Food Use—May Poison Food". Do not use items with this type of warning for cooking, serving, or storing food or drinks.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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