

Tea-Colour Effect of Ash Leachates: Causes and Prevention

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ABSTRACT:

The causes of dark brown leachates from ashes, especially those from ashes of cocoa pod husk, were investigated. Those of ashes obtained at ashing temperatures above 650 °C were attributed to the formation of hexahydroxy-ferrates of the type $M_3 [Fe(OH)_6]$. However, colorations in the leachates of ashes obtained at temperatures below 600 °C have been found to come from soot. This soot forms colloidal carbons in the leachates which is responsible for the coloration. The colloidal carbon owes its stability to the adsorbed oxygen on them which makes them hydrolyzed in the aqueous environment and exchange anions in the electrolyte. To prevent this tea coloration of the leachates, it is necessary to further calcine the ash to temperatures within 600-650 °C before leaching in order to burn off the colloidal carbons.

Keywords: Agricultural waste, Tea-colour, Cocoa pod husk, Ashes, Leachates, Soot

I. INTRODUCTION

Potash from organic sources, mainly from agricultural wastes, is highly valued for its freedom from toxic heavy metals such as Arsenic, Lead and Cadmium which are usually associated with mined potash, and it is usually referred to as “Organic Potash”. They therefore have great potential application in the food and pharmaceutical industries.

One major use of such potash in the food industry is for the alkalization of cocoa paste in chocolates formulation. In the pharmaceutical, it is critically needed for the formulation of hypertensive drugs.

A set back to the wider usage of the organic potash from ashes has been its brown coloration which tends to depreciate its commercial value.

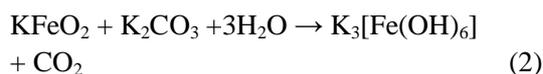
In our previous work [1], it was shown that the yield and quality of potash from agricultural wastes depend very much on the ashing temperature and that the optimal ashing temperature, with respect to potash yield, occurs at 800 °C ± 50 °C. Below and above this optimum temperature range, potash yield falls and the browning coloration of the final products intensifies.

It was found [2] that the cause of this browning at temperature higher than 650 °C was due to the formation of potassium ferrates which forms from K_2CO_3 and Fe_2O_3 when the ashing temperature exceeds 650 °C.



Indeed, it was also noticed that the ferric oxide also acted as a flux to reduce the decomposition temperature of K_2CO_3 which normally, alone, started decomposing from 890 °C.

Browning in the leachates at the higher temperature was then attributed to the potassium oxy-ferrates, which in water hydrolyses to form very stable brownish hexahydroxyl ferrate ions and subsequently, crystalline salts.



Sublimation of the K_2CO_3 at the higher temperature also accounted for poor ash yield and poorer potassium content of the ash.

This work, therefore, seeks to investigate the source of coloration found in ash leachates at temperatures lower than the optimal (600 °C).

II. MATERIALS AND METHODS

2.1. Drying of the pod husk

Fresh cocoa pod husks (the Amelenado variety) from the farm were washed to remove dirt, cut into smaller pieces, weighed and dried in an electric oven at 120 °C to constant weight. An average moisture content of 81% was recorded for the fresh cocoa pod husks after several runs.

2.2. Ashing of the dried husk

The dried husks were further size-reduced to about 2 cm characteristic length by hand. Weighed quantities were then ashed batchwise in crucibles, starting from 350 °C to 600 °C at intervals of 50 °C. Ashing time was six hours for each chosen temperature. The visual characteristics of the ashes were noted and the

percentage yield of ash with respect to the dried husk calculated.

2.3. Experimental procedure

The procedure followed in this investigation was described in our previous work [1].

2.4. Chemical analysis of the ash

The resultant ash as well as the leachate was physically examined and chemically analysed. Two instrumental methods were used in the chemical analysis of the ash namely; the flame photometric method, and the Atomic Adsorption Spectroscopic method (AAS). Detailed description of the procedure was presented in Woode and Hammond [1].

III. RESULTS AND DISCUSSION

The results of the study are presented in Tables 1, 2 and 3. The graphical representation of the results is shown in Figures 1, 2, and 3.

Table 1: Mineral composition of ash from cocoa pod husk, obtained at 600 °C

Elements	Ca	Mg	K	P	Fe	Na	Mn
% in Ash	4.00	3.90	43.70	1.50	0.035	0.15	0.0064

Table 2: Variation of cocoa husk ash yield and characteristics with temperature

Temperature °C	Percent Yield Ash/husk	Observation
350	8.88	Crucible was soothed, Ash was blackish
400	7.93	Crucible was soothed, Charcoal was less in the ash
450	7.60	Ash was white at the surface but blackish underneath
500	7.30	Ash was homogenously white and smooth
550	7.20	Ash was white and smooth
600	7.20	Ash was white and smooth
650	7.20	Ash was smooth but with a taint of yellowish green
700	6.75	Ash looked crystalline and fused and yellowish green at the surface. Underneath was quite blackish

750	6.10	Ash was crystalline and pale green at the top
800	4.42	Ash was greenish, crystalline, brittle with black spots

Table 3: Variation of potassium yield per ash and per dried husk with ashing temperature

Temp.(°C)	350	400	450	500	550	600	650	700	750	800
K in Ash (%)	26.0	29.0	34.0	37.0	40.0	43.6	41.0	38.0	31.0	19.0
K in Dried Husk (%)	2.31	2.30	2.58	2.70	2.88	3.14	2.95	2.57	1.89	0.84

Physical examination showed that soot content of the ash diminished from 350 to 500 °C where the ash yield from the cocoa pod husk remained constant and 7.2 % as the ash colour also became white (Table 2). The leachates also changed colour from deep tea-colour to colourless. Chemical analysis also shows that metal ions that could feature in the leachates in appreciable amounts are, K^+ , Ca^{2+} , Mg^{2+} , Na^+ (Table 1). Iron (Fe) in the oxides states are practically insoluble in the distilled water used for leaching. The brown leachates (tea-effect) could therefore be attributed to the soot only (in its colloidal state) which is the only parameter whose magnitude changed with temperature in this range of experiments (Table 2). The maximum percentage of potassium in the husk and the ash occurred at 600 °C (Fig.2 and 3).

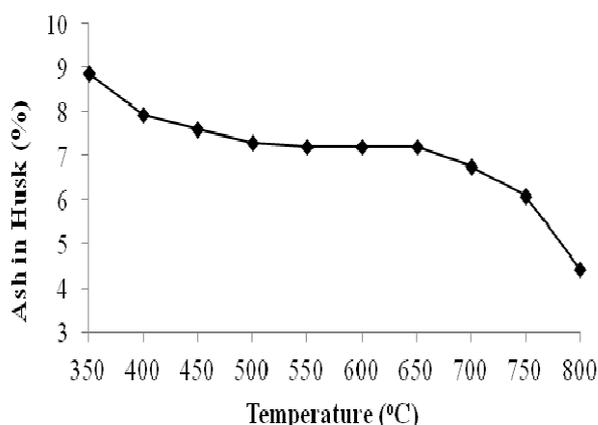


Figure 1: Percentage ash in dried husk as a function of temperature

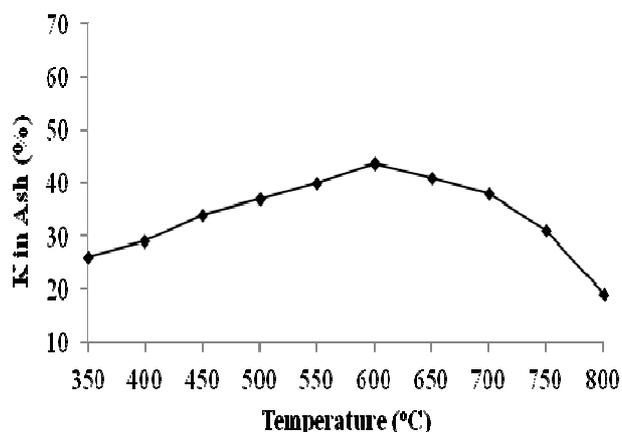


Figure 2: Percentage potassium in ash as a function of temperature

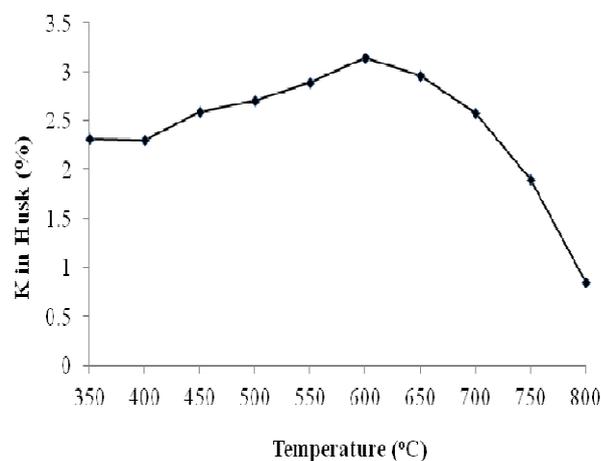


Figure 3: Percentage potassium in dried husk at various temperatures

It is a fact that colloidal sols are capable of effecting colour changes in solution and crystals (Tyndall effect) through light scattering and absorption. However, it is the stability of such sols, found in the leachates under consideration, which needs to be proven. Normally it would have been expected that the soot particles would eventually coalesce and settle out of the solution. According to S. Voyutsky [3], colloidal particles fall within range of 1–100 μM and soot, depending on their origin, have size range of 30 – 90 μM . Soot particle on whose surface oxygen is adsorbed, as pertains during the ashing process,

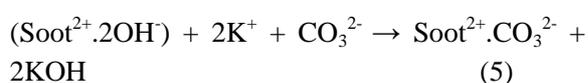
behaves as an electron donor in water, while the oxygen atoms acts as electron acceptors (Eq. 3):



The very absorbed O^{2-} ions immediately react with water forming hydroxyl ions (Eq.4):



In a solution of an electrolyte, such soot or coal particle behaves as a basic adsorbent which exchanges the hydroxyl ions for any anion: – in our case CO_3^{2-} (Eq.5):



By this interaction of oxygen-adsorbed soot particle with water, the colloidal carbon is stabilised, producing the brown or tea-colour effect.

IV. CONCLUSION

The brown or tea-coloration observed in leachates from ashes was due to colloidal carbon in the ash as a result of incomplete ashing or combustion. These colloidal carbon particles (soot), by virtue of adsorbed oxygen, are able to stabilise themselves into the leachates and create the colours observed through Tyndall effect. When such ash is calcined at higher temperatures, their corresponding soot burn off the leachates and their corresponding crystals become colourless. Essentially, leachates of these ashes, when calcined at 600 °C, became colourless.

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