USE OF RICE HUSK AND EUCALYPTUS ASHES IN THE COMPOSITION OF RAW GLAZES

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ABSTRACT

Industrial activities contribute significantly to the environmental imbalance. The tireless search for alternative energy sources and the need to reduce the emission of pollutants in nature have thus brought a further concern for businesses that use biomass as an energy source, especially those that use rice husk and Eucalyptus as an alternative source. The use of biomass as an energy source generates a by-product with higher silica content addressing characteristics that make biomass raw materials of potential interest for application in various branches of the ceramic industry. Thus, the aim of this work was the use of rice husk ash and eucalyptus ash to obtain a raw glaze. A mixture experimental design (DoE) was employed and the factors were the percentages of eucalyptus and rice hull ashes, added to other components such as calcium carbonate, zinc oxide, anhydrous borax, alumina and potassium nitrate. The output variables were the measured properties, hue of the glazes and glaze spread during firing. As a result, despite the need to use other components in the formulation with an added cost, it is feasible to develop raw glazes from biomass because the ashes form 80 wt% of the main formulation.

1. INTRODUCTION

Rice husk is one of the most abundant wastes generated by the agricultural industry. As it is a fibrous material, rice husk degrades with difficulty and it remains unchanged for a long time, causing great harm to the environment. For each ton of rice produced, 23 wt% corresponds to its husk, resulting in 4 wt% of ashes when the husk is burnt. This residue is quite light due to its low density. When the rice husk is stored, it requires large storage areas and spontaneous combustion can occur, resulting in the scattering of ashes throughout the region. Therefore, the use of rice husk as renewable energy source in thermoelectric plants is a viable alternative, but the problem remains with the ashes.

The search for renewable energy is a global trend that has been strengthened in recent years. The European Union stands out in this scenario by setting aggressive targets and incentives for the replacement of fossil fuels with renewable sources in its energy mix. It is estimated that by 2020, 20% of European Union energy will come from renewable sources and the use of wood and husks as energy source is increasing. The rice husk ashes contain over 85 wt% silica in an amorphous state after burning. The burning process of rice husk always results in silica whose colour varies from grey to black, depending on the amount of carbon and inorganic impurities. On the other hand, eucalyptus ashes contain a lower percentage of silica than rice ashes but they also contain other oxides used in the ceramic sector.

Therefore, the present study aimed to characterize the ashes obtained from rice husk and eucalyptus and to develop a raw glaze. Raw glazes are made up of very fine raw materials that are applied as a suspension on the ceramic surface. After firing, the surface melts and adheres to the ceramic body forming the glaze coating on cooling. Generally, this type of glaze is fired at temperatures above 1200°C. The raw glazes are composed of pure components that are mixed during the milling process. In this study, rice husk and eucalyptus ashes were used as raw materials.

2. METHODS

The first step was to prepare the ashes, removing impurities and larger particles by sieving (mesh 12 ASTM). The samples of ashes, without any pre-treatment, were subjected to a thermal treatment in a laboratory oven at 1200°C (rice husk) and 1000 °C (eucalyptus) for 5 hours with a heating rate of 15°C/min. To reduce the particle size, the ashes were milled in eccentric mills (alumina jar and grinding elements) for 4 min (rice ashes) and 7 min (eucalyptus ashes). The chemical composition of the ashes was then determined by X ray fluorescence (XRF).

From the results of chemical analysis, the glaze formulations were prepared by mixing the raw materials in an eccentric mill (alumina jar and grinding elements) with 30 wt% water and additives for 4 min. The ceramic suspension was poured into rings (1 cm height x 1 cm diameter) on monoporosa substrates forming buttons. The assembly was dried (100°C for 24 h) and fired in a laboratory roller kiln at 1200°C for 60 min. The spread of the buttons after firing was measured in order to determine the glaze viscosity during firing. Finally, the lightness (L*) of the glaze formulations was analyzed by colorimetry (d8, spherical geometry, 400 to 700 nm, specular included). The larger the L* value, the clearer the sample.

3. RESULTS

The most common compound present in the rice husk ash is silica, among other components, Table 1. In the eucalyptus ash, the most common compounds are calcium, potassium, aluminium, iron, and magnesium oxides, as well as a high percentage of silica, which may vary depending on the blend obtained.

Ash (wt%)	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	MgO	CaO	MnO	TiO_2	P_2O_5	LoI
Rice husk	94.7	0.2	0.1	1.2	0.1	0.5	0.8	0.2	0.1	0.4	0.1
Eucalyptus	37.4	9.5	2.6	6.3	1.4	4.5	25.1	0.9	0.4	2.5	5.3

Table 1. Chemical analyses of the rice husk and eucalyptus ashes (XRF).

From the chemical analyses results, Table 1, the glaze compositions were formulated by mixture design, Table 2. Anhydrous borax and sodium nitrate were used as raw materials besides rice husk and eucalyptus ashes. The amount of raw materials was selected to cover the formulations typically used for raw glazes. Table 2 also shows the results for button spread (in mm) and lightness (L*).

Glaze	Eucalyptus Ash (%)	Rice Ash (%)	Borax (%)	Sodium (%)	Spread (mm)	L* (Judd)
1	50	30	10	10	10.8	47.2
2	45	30	20	5	11.5	68.6
3	40	30	20	10	15.4	72.3
4	45	40	10	5	9.2	67.3
5	40	40	10	10	9.2	54.2
6	40	35	20	5	10.8	67.0
7	40	40	15	5	8.5	60.2
8	50	30	15	5	10.8	67.4
9	50	35	10	5	10.0	66.6
10	44.5	34.4	14.4	6.7	10.8	72.8

Table 2. Compositions of raw glazes obtained by mixture design and results for button spread (in mm) and lightness (Judds).

Table 3 shows the analysis of variance for the lightness of the samples, L*. The lightness shows statistical significance (F) for the quadratic model, with intermediate reliability (p) of the results, around 75%, Table 3. The results for the lightness of the compositions are plotted as a function of the raw materials, Figure 1.

Model	SS	dF	MS	F	p
Linear	276	3	91.9	1.71	0.263
Quadratic	316	5	63.1	9.85	0.237
Error	6.41	1	6.41		
Total adjusted	598	9	66.4		

Table 3. ANOVA for the lightness (Judd) of the samples after firing.

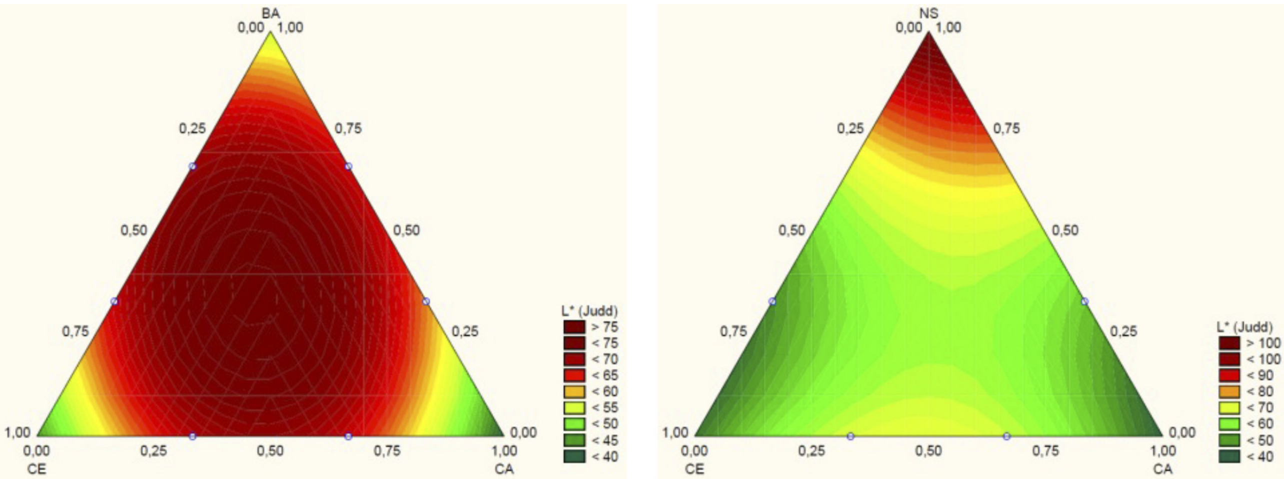

Figure 1. Contours for the lightness of the glazes. CE= eucalyptus ash, CA= rice husk ash, BA= anhydrous borax, OZ= zinc oxide (R^2=0.99 for the quadratic model).

The contour plots given by the response surfaces for the effect of the raw materials on the lightness of the glazes (L*), Figure 1, show the effect of sodium nitrate in increasing the brightness of the glazes. Both ashes tend to decrease the brightness due to contamination, mainly Fe_2O_3, Table 1.

4. CONCLUSIONS

Despite the need to use other components in the formulation of the raw glazes, which automatically increases the cost of the glazes, the final value is feasible because the major raw materials for the formulation of the raw glazes are the eucalyptus and rice ashes, with 80 to 90% of the total weight. The ancillary components make up only 10 to 20% by weight of the compositions.