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Use of Waste Banana Peel Ash in Glaze Making*

Atık Muz Kabuğu Külünün Sır Yapımında Kullanımı

Selim Çınar, *Seramik Bölümü, Selçuk Üniversitesi Güzel Sanatlar Fakültesi,* 0000-0002-2380-1818
Ferda Tazeoğlu Filiz, *Seramik Bölümü, Selçuk Üniversitesi, Güzel Sanatlar Fakültesi*, 0000-0002-3411-2575

Abstract

Banana peel waste is a very rich organic source of alkali oxides used in glaze composition. Today, the importance of concepts such as sustainability, recycling, and upcycling has accelerated research into recycling mineral-rich resources such as banana peel, which is considered waste. The use of this mineral-rich resource in the production of ash glaze in the field of ceramic art and the development of new surface suggestions in ceramic art in this context constitute the basis of the research. In this research, the banana peel wastes obtained from Selçuk University dining hall were dried and thermal gravimetric analysis (TGA) was performed. The banana peel ash calcined at 1000°C was analyzed by XRF analyzer on an elemental basis between Na-U and oxide semi-quantitatively. Using the binary system, glaze recipes developed at 1200°C from banana peel ash with potassium, sodium and ulexite additives were prepared and the possibilities of using banana peel ash in glaze were investigated.

The research results show that banana peel ash can be used as the main source for obtaining natural ash glaze, as well as an alternative to alkali oxides in standard transparent glaze composition at 1200°C.

Anahtar Sözcükler: Ceramic, glaze, ash glaze, banana peel, waste

Akademik Disiplin(ler)/Alan(lar): Ceramic, plastic arts, ceramic art, ceramic technologhy, ceramic chemistry, ceramic glazes, artistic glazes, ash glazes.

Özet

Muz kabuğu atığı, sır bileşiminde kullanılan alkali oksitler açısından oldukça zengin bir kaynaktır. Günümüzde sürdürülebilirlik, geri dönüşüm ve ileri dönüşüm gibi kavramların önem kazanması beraberinde atık olarak nitelendirilen muz kabuğu gibi mineral açısından zengin kaynakların yeniden dönüşümüyle ilgili çalışmalara ivme kazandırmıştır. Mineral açısından oldukça zengin olan bu kaynağın seramik sanatı alanında kül sırı yapımında kullanımı ve bu bağlamda seramik sanatında yeni yüzey önerilerinin geliştirilmesi araştırmanın temelini oluşturmaktadır. Yapılan araştırmada Selçuk Üniversitesi yemekhanesinden temin edilen muz kabuğu atıkları kurutularak termal gravimetrik analizi (TGA) yapılmış, daha sonrasında 1000°C'de kalsine edilen muz kabuğu külü XRF analiz cihazı ile Na-U arası elementer bazda ve oksitli yarı kantitatif olarak analiz edilmiştir. İkili sistemden yararlanılarak potasyum, sodyum ve üleksit katkılarıyla muz kabuğu külünden 1200°C'de gelişen sır reçeteleri oluşturulmuş ve sır içerisinde muz kabuğu külünün kullanım olanakları araştırılmıştır.

Araştırma sonucunda muz kabuğu külünün doğal kül sırı elde etmek için ana kaynak olarak kullanılabileceği anlaşılmış olup, bunun yanı sıra 1200°C'de standart şeffaf sır bileşiminde alkali oksitlere alternatif olarak da kullanılabileceği sonucuna ulaşılmıştır.

Keywords: Seramik, sır, kül sırı, muz kabuğu, atık.

Academical Disciplines/Fields: Seramik, plastik sanatlar, seramik sanatı, seramik teknolojisi, seramik kimyası, seramik sırları, artistik sırlar, kül sırları.

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- **Corresponding Author:** Ferda Tazeoğlu Filiz, Seramik Bölümü, Selçuk Üniversitesi Güzel Sanatlar Fakültesi.
- **Address:** Selçuk Üniversitesi Alaeddin Keykubat Kampüsü Güzel Sanatlar Fakültesi Seramik Bölümü Selçuklu/Konya, 42130.
- **E-mail:** ferdatazeoglu@gmail.com
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1. Introduction

Glaze is a glassy coating material used in ceramics that covers the surface of the form and gives various properties to the surface. Historically, the association of glass with glaze and the attribution of a glassy characteristic to glaze is due to the silisium oxide contained in both materials (Yıdırım & Tazeoğlu Filiz, 2023). Silisium is a raw material with a high melting temperature (1410°C). Since this temperature requires a very high cost and technical infrastructure even in the industry-based production process, certain amounts of melter are added to silisium oxide to reduce this temperature in the industries. Similarly, feldspars such as sodium and potassium are used in glaze compositions to lower the melting temperature of the glaze. Pegmatites, aplites, feldspar phyllons and nepheline syenite are rock types used as commercial feldspar sources. They are used as melting agents in ceramic bodies and glazes.

Adding ashes of organics such as wood and plants to the materials included in the glaze component dates back to ancient times. It is the Chinese who discovered that the wood ash spread in kiln using wood as fuel adheres to the surface of ceramics at high temperatures, creating mottled and fluid surfaces. Ashes contain in a fine state of division large proportions of silica some potassium and sodium salts, alkaline earths, iron and often phosphate salts. The amounts and varieties of these minerals vary considerably from plant to plant, soil to soil and, with the same plant, season to season. The colour of ashes, either before or after washing, varies from white to grey brown and black, and while some of this colour is due to fine particles of charcoal (carbon), which burns out from the glaze, some is due to the presence of iron, which affects the colour of the glaze, though some potters think that small quantities of copper may be present in certain ashes. When combined with feldspar or clay, wood or plant ash will form richly textured and coloured glazes at temperatures about I200°C. The romantic appeal of using ash makes it a favourite material for the stoneware potter. Various analyses of ashes have been carried out but are relevant only for that particular batch. The same sort of wood grown on different ground will inevitably yield a different analysis (Cooper & Royle, 1978).

The use of melting agents such as potassium and sodium from organic compounds in glaze making dates back to 1500 BC. (Genç, 2013). Ash glazes are among the oldest glazes known in history. They were discovered during the Shang Dynasty and were first used on ceramic surfaces by Chinese craftsmen. These glazes were created accidentally when the ashes that flew through the air during firing in wood-fired kilns fell on the surface of the pots (Çalışkan Güneş, 2017). Very soon new approaches to decoration began to evolve that took advantage of the flowing, pooling characteristics of the high-lime ash glazes. Many of those decorative elements were also to perform a functional role in that they prevented the often over-fluid glazes from running too far down the side of a pot. Witness the prominent ridges that restrict the effects of gravity on the Han dynasty proto-porcelain jars. In the first instance, however, these ‘glazes' were produced accidentally, the product of white-hot wood ash being carried through the kiln with the draught of the fire and falling onto the pots. As soon as the temperature reached around 1170°C the ash reacted with the silica and alumina in the surface of the clay to form a crude, often runny glaze. The build-up of these flashed areas did not rely upon the falling wood ash particles alone to form the glaze. In burning the wood fuel at such high temperatures the oxides of potassium and calcium are liberated as volatile gases which react with the silica in a clay in much the same way as the sodium in a salt firing. This form of vapour glazing accounts for the well-glazed areas that occur on the vertical walls of pots where ash alone is unable to settle except in relatively small amounts when, as the temperature increases, the clay becomes ‘tacky’ as it vitrifies (Rogers, 2003). As ceramic kilns were developed in Chinese ceramic culture, the firing temperature also increased. The increase in temperature has made ceramics non-porous and durable and has made the melting of the materials used more effective. During Zhou dynasty (1155-255 BC) it was discovered that a simple glaze could be made by dusting a mineral like feldspar or wood ash on to the shoulder of the pots. At temperatures around 1200 C, it will combine with the surface of the pot to form a mottled and attravtive glaze. This technique seems to have contiuned intermittedntly until its use became more widespread in the Han dynasty. Simple glazes of the mineral feldspar and wood ash produced thin olive-green glazes which enhanced the form, though were unnecessary from a practical point of view as stoneware is impervious to liquid (Cooper, 1988).

In the 8th and 9th centuries, ash glazes were applied to an iron oxide-containing slip and fired at low temperatures. The surfaces of these pots and wares, unique to Tongguan and Qlonlai, are decorated with brushwork using iron and copper oxide, resulting in soft lines. In the 13th century, ash from rice straw was used for two special glaze effect. First one, in the northern province of Henan, the siliceous content of rice straw ash was used to obtain opaque glazes with different shades of blue. The second one was the technique of overlaying a layer rice straw ash onto a tenmoku to create a mottled pattern. Known as Jizhou ware this was sometimes done by simply splashing on the ash and at other times by using a sophisticated stencil system or possibly a resist. It took 2000 years for the kiln technology to reach the Japanese, which allows wood ash in the kiln atmosphere to precipitate and adhere to the ceramic surface. The ceramics called "Sucki" by the Japanese had a process of sprinkling wood ash on the ceramic surface before firing, like the Chinese Han Dynasty jars. The Japanese followed a sophisticated and intuitive path, unlike the Chinese, who developed glazes consisting of various ash-clay combinations. Instead of covering the surface with wood or plant ash before firing, the Japanese preferred the improvised glaze effect achieved by settling the ash flying in the kiln atmosphere onto the surface of the ceramics. The Japanese also acted intuitively while placing the ceramics into the kiln and observed the movement of ash on the ceramic surfaces. These firings are still done today (Rogers, 2003).

In addition to features such as firing technologies, clay diversity, clay shaping techniques, the use of wood or plant ashes alone or mixed with various materials played a central role in the development of Far Eastern ceramic culture. Following the Chinese, the Japanese also incorporated the use of ash into their ceramic culture. Thanks to geographical proximity and commercial relations, Korea, Thailand and Islamic countries have also started to use wood and plant ashes. The Western world turned its face towards the east in terms of ceramics in the late 19th century, and ashes of organics such as wood and plants began to be used in western ceramic culture from the beginning of the 20th century.

Bernard Leach received his ceramics training from Shoji Hamada in Japan and returned to England in the 1920s. Leach, who returned to England with Hamada, has a deep admiration for the Far East as well as important knowledge of ceramics. His ceramics are a synthesis; he synthesized clay, shaping, decoration and firing cultures of Far Eastern origin with European ceramic culture. He used the glazes he saw in Japan and Korea faithfully to the original, and preferred glazes with high ash content in jugs and vases. When Leach's explanations about his works are examined, it is understood that he adopted in detail how the ashes of organics such as wood and plants are used. The most comprehensive research on the behavior of various wood and plant ashes was first conducted by Katherine Pleydell-Bouveri, a student of Bernard Leach. Katherine has conducted systematic testing and research on the ashes of organics such as many different plants, shrubs and trees, and these studies have become the primary source and inspiration for the work of ceramic artists and potters around the world (Rogers, 2003).

Ash glazes are categorized as natural, synthetic, and false ash glazes based how the ash is obtained. Natural ash glazes are made with ash from organic materials such as wood, straw, shrubs, fruit peels and various plants. These materials must have their chemical structures intact. Ash can be used by sprinkling, spraying or adding it to the glaze mixture (Şölenay, 2011).

> Ashes can be classified by several means. The useful classification is hard, soft and medium ashes. A more precise classification identifies each ash by its name. Generally speaking, the quicker the growth, the higher the proportion of silica and the harder the ash. The longer the growth, the softer the ash; as a result the hard woods, which have taken many years to grow, yield low silica and high flux content, such as potassium and calcium, and give soft ash. Quickly grown plants, such as bracken, give ash with a high silica content and a hard ash. However, the silica content of ash is often intimately combined with the other ingredients and does not act as a refractory material in the way that flint or quartz acts. Classical combinations of materials in glazes with ash include feldspar, clay and flint. Small quantities of calcium carbonate (whiting) or dolomite are often added. Ash is usually considered to be a fluxing material falling into group one materials. (Cooper & Royle, 1978)

Many scientific studies have been conducted on the effects of ash on glaze. These studies have found that many organic materials such as pomegranate, olive tree, hazelnut shells (Genç, 2013), hops (Savaş, 2021), potatoes (Şölenay & Turan, 2020), chestnut shells (Kubat, 2020), eggplant branches (Tizgöl & Gündeşlioğlu, 2016), rose pulp (Ünal & Akgeyik, 2020), and olive seeds (Divitcioğlu & Karagül, 2021) beech wood, pine tree, oak tree, apple tree, hornbeam tree, poplar tree, cherry tree, walnut tree, olive wood (Çalışkan Güneş, 2014) have been used in the production of ash.

In this study, natural ash glaze recipes were prepared using banana peel ash, which is very rich in potassium. The possibilities of using ash in glaze-making at 1200°C with potassium feldspar, sodium feldspar and ulexite additives added to the glaze mixture using the binary system were investigated. In addition, the effect of ash in transparent glaze composition was studied by substituting banana peel ash for feldspars in a standard transparent glaze recipe.

2. Experimental Studies

Bananas are organic and consist of the peel and the fruit. The peel makes up about 40% of the banana. When bananas are consumed, the flesh is usually eaten, and the peel is discarded. Studies have shown that the potassium content of the banana peel is as high as that of the fruit. These studies have spurred research into the recycling and upcycling of this mineral-rich resource (Muslu, 2022).

The banana peel used in the ceramic glaze composition was obtained from the Central Dining Hall of Selçuk University. As a result of the negotiations with the Central Dining Hall Administration, the banana peels were separated by the garbage separation method and used as a waste source on the day when bananas were served on the lunch menu.

32 kg of banana peel waste from the dining hall of Selçuk University was dried in the open air for 15 days. As seen in Figure 1, after drying the banana peel waste, the first stage of the calcination process was carried out in the open air. With this process, the volatile substances were removed from the body. The reason why the first stage of the process is carried out in the open air is that the carbon monoxide that the body will release into the environment during the first stage of combustion will be released into the open air. Ethyl alcohol was used as the fuel to maintain the purity of the dried banana peels. The incineration process was carried out in uncoated metal cans.

Figure 1. Banana peel collection, drying and incineration processes.

The ashes obtained after the first incineration step were calcined at 1000°C. The result is in Figure 2a. Then it was fired at 1200°C on a porcelain plate. The calcined ash used on the porcelain plate without additives penetrated into the structure at 1200°C, affecting the structural properties of the structure and deforming the shape. The result is in Figure 2b.

Figure 2a. Image of ash after calcination at 1000°C **2b.** Image of calcined ash fired at 1200°C on porcelain plate.

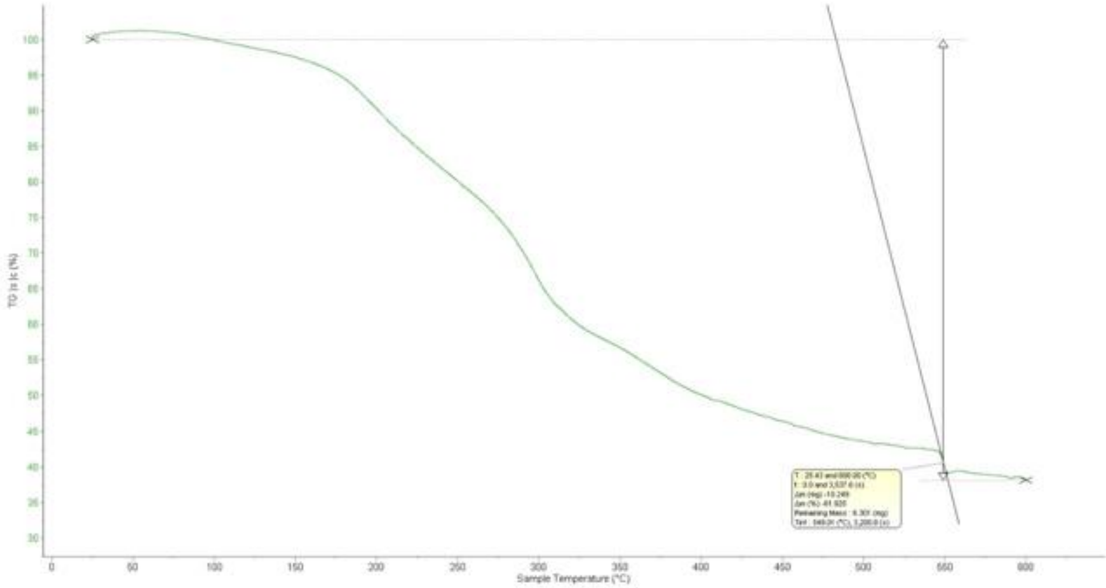
Thermal Gravimetric Analysis (TGA) of dried banana peel and elemental oxide analysis of ash sample calcined at 1000°C were performed at Necmettin Erbakan University BİTAM Central Laboratory.

Thermal Gravimetric analysis (TGA) of dried banana peel was performed with Setaram LABSYS EVO brand model thermal analyzer under nitrogen gas at a heating rate of 10 degrees/minute by heating from room temperature of 25°C to 600°C.

In the graph in Table 1, the amount of substance lost with heating (% Mass Loss) and the temperature value of the dry banana peel sample is given. Accordingly, it can be seen that the sample defined as "Banana Peel Ash" contains volatile components that can be separated from the structure up to 600°C and these volatile components constitute approximately 82% of the initial mass by mass.

Table 1. Amount of material lost by heating (% Mass Loss) and temperature value of banana peel ash sample.

Sample	Gas Atmosphere	Heating Speed	Heat (°C)	Mass loss %	Mass Loss Initial Temperature
Banana Peel Ash	Nitrogen (N_2)	10^{C}/min	25-600 C	81.925	75 C



1000°C calcined banana peel ash sample was analyzed for elemental oxides using a Rigaku - NEX-CG model XRF analyzer. The sample was analyzed semi-quantitatively on an elemental basis between Na-U and oxide and the mass % distribution is given in Table 2.

Table 2. X-ray fluorescence spectrometry (xrf) result of calcined banana peel ash sample.

Element	Unit	Banana Peel Ash	Statistical error	Detection limit	Quantitation limit
K	mass%	31.9	0.0529	0.0028	0.0084
Na	mass%	3.87	0.179	0.418	1.25
Si	mass%	3.69	0.0104	0.0033	0.0099
Ca	mass%	3.22	0.0242	0.0179	0.0537
Cl	mass%	2.55	0.0028	0.0017	0.005
Mg	mass%	1.39	0.022	0.0247	0.074
P	mass%	0.485	0.0023	0.0032	0.0097
Al	mass%	0.373	0.0059	0.0081	0.0242
Zr	mass%	0.256	0.0026	0.0005	0.0016
S	mass%	0.153	0.0015	0.0034	0.0103
K_2O	mass%	33.7	0.0484	0.003	0.009
SiO_2	mass%	7.61	0.0208	0.004	0.0121
CaO	mass%	4.44	0.0315	0.0252	0.0757
Na_2O	mass%	3.93	0.238	0.603	1.81
MgO	mass%	2.36	0.0351	0.0314	0.0941
P_2O_5	mass%	1.09	0.005	0.0067	0.0202
Al_2O_3	mass%	0.669	0.0105	0.014	0.042
SO_3	mass%	0.421	0.0038	0.0086	0.0258
ZrO_2	mass%	0.304	0.0031	0.0006	0.0019
Fe_2O_3	mass%	0.112	0.0022	0.0028	0.0085

3. Discussion

According to X-ray fluorescence spectrometry (XRF) results, the amount of coloring oxide in the calcined banana peel ash sample is less than 1%, while K and K_2O, which are used as melting agents in glaze making, constitute 65% of the mass. Therefore, it is predicted that the glazes that can be obtained from this ash are beige in color and have high fusibility.

Based on the results, glaze recipes (5 gr) were prepared by combining sodium feldspar, potassium feldspar and ulexite, which are used as melting agents in ceramic glaze composition, with banana peel ash in binary system. Table 2, Table 3 and Table 4 below show the changing values of sodium feldspar, potassium feldspar, ulexite and banana peel ash in binary system. In the research, the recipes containing sodium feldspar and ash are given with the code SK, the recipes containing potassium feldspar and ash are given with the code PK, and the recipes containing ulexite and ash are given with the code UK. To increase the stability of the glaze and ensure adhesion to the surface, 2% kaolin was added to each recipe.

Table 3. Glaze recipes with sodium feldspar and banana peel ash.

Materials	**Recipes**								
%	**SK1**	**SK2**	**SK3**	**SK4**	**SK5**	**SK6**	**SK7**	**SK8**	**SK9**
Sodium Feldspar	10	20	30	40	50	60	70	80	90
Banana Peel Ash	90	80	70	60	50	40	30	20	10

Table 4. Glaze recipes with potassium feldspar and banana peel ash.

Materials	**Recipes**								
%	**PK1**	**PK2**	**PK3**	**PK4**	**PK5**	**PK6**	**PK7**	**PK8**	**PK9**
Potassium Feldspar	10	20	30	40	50	60	70	80	90
Banana Peel Ash	90	80	70	60	50	40	30	20	10

Table 5. Glaze recipes made with ulexite and banana peel ash.

Materials	**Recipes**								
%	**UK1**	**UK2**	**UK3**	**UK4**	**UK5**	**UK6**	**UK7**	**UK8**	**UK9**
Ulexite	10	20	30	40	50	60	70	80	90
Banana Peel Ash	90	80	70	60	50	40	30	20	10

All recipes were applied to biscuit fired porcelain plates at 1000°C by preparing samples of 5 grams each. The sample of glaze-applied porcelain plates was fired at 1200°C in the Nabertherm kiln. The results obtained after firing are displayed in Table 6, Table 7, and Table 8.

Table 6. Glaze recipes with sodium feldspar and banana peel ash.

SK1	**SK2**	**SK3**	**SK4**	**SK5**
				
SK6	**SK7**	**SK8**	**SK9**	
				

Table 7. Glaze recipes with potassium feldspar and banana peel ash.

PK1	**PK2**	**PK3**	**PK4**	**PK5**
				
PK6	**PK7**	**PK8**	**PK9**	
				

Table 8. Glaze recipes made with ulexite and banana peel ash.

UK1	UK2	UK3	UK4	UK5
				
UK6	**UK7**	**UK8**	**UK9**	
				

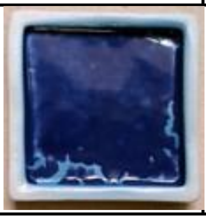
Transparent and semi-matt glazes in cream-beige tones were obtained in all recipes. It was observed that in all recipes where sodium feldspar was used above 50%, cracks started to form due to surface tension. In recipes containing 10% and 20% sodium feldspar (SK1-SK2), the tendency of the glaze to clump increased as the sodium content decreased. Therefore, the optimum value at which sodium feldspar and ash can be used was determined to be recipe SK3.

The groups of recipes in which potassium feldspar and banana peel ash were used together produced semi-matt, opaque, cream-colored glazes with a tendency to agglomerate. Since agglomeration tendency was observed in the recipes (PK1-PK2) where potassium feldspar was used at 10% and 20% ratios, the maximum and optimum use of ash was determined to be recipe numbered PK3.

It was found that the glazing and fluxure were higher in the groups of recipes where ulexite and banana peel ash were used together, especially in the recipes where ulexite was used more than 30%. Glassy transparent glaze recipes were obtained in the samples of this group, and the recipe numbered UK1 was selected as the optimum value where ash can be used.

In all three melting groups, optimum proportions of ash were determined, and the selected recipes were colored by adding three different amounts of cobalt oxide between 1 % and 10 %. The coloring process was carried out on horizontal biscuit plates and the applications were fired at 1200°C. The colored surface images of SK3 (70% ash-30% sodium feldspar) from the sodium feldspar group, PK3 (70% ash-30% potassium feldspar) from the potassium feldspar group, and UK1 (90% ash-10% ulexite) from the ulexite group are shown below. The results are in Table 9.

Table 9. Cobalt oxide-colored surface images of SK3, PK3 and UK1 coded recipes.

Recipe	Cobalt Oxide %				
	1	3	5	7	10
SK3					
PK3					
UK1					

Increasing the amount of cobalt oxide in the SK3-coded glaze recipe with sodium feldspar and ash components only affected the color properties of the glaze. Increasing the amount of cobalt oxide resulted in the recipe of colors ranging from bluish purple to red/pink purple in the glaze.

In the PK3 glaze recipe with potassium feldspar and ash component, the amount of cobalt oxide increased the dulling tendency of the glaze and caused a color change from blue-violet to red-violet in the hues. Adding 1 - 3 % cobalt did not change the glaze's structure, while using more than 3 % cobalt oxide caused the glaze to become dull.

The amount of cobalt oxide in the glaze recipe coded UK1, which consists of ulexite and ash, caused the glaze to become dull and artistic effects similar to the formation of crystals on the surface. As the amount of cobalt increased, the glaze color changed from cobalt blue to petrol blue.

The test flowability glaze recipes containing 1 % and 10 % cobalt oxide additives were compared with uncolored forms of SK3, PK3 and UK1. The results are in Table 10.

Table 10. Surface images of SK3-, PK3- and UK1-coded recipes in raw form and applied to the vertical surface with 1-10% cobalt oxide additive.

Recipe	Uncolored	Cobalt Oxide %	
		%1	%10
SK3			
PK3			
UK1			

As a result of the research, as seen in Table 10, the recipe groups coded SK3, PK3 and UK1 were visually very close to each other, and it was understood that they did not have fluid properties.

In order to more closely observe the effect of banana ash on the glaze in a glaze recipe developed at 1200°C, a transparent glaze recipe was developed and banana peel ash was added to the formulation in place of feldspar. In Table 11, the standard transparent glaze recipe is shown as R1 and the recipes in which ash was used instead of feldspars are shown as R2 and R3.

Table 11. R1, R2 and R3 coded recipe compositions and surface images after firing at 1200°C.

Materials %	R1	R2	R3
Sodium Feldspar	20	20	-
Potassium Feldpar	25	-	-
Ulexite	25	15	15
Kaolin	10	10	10
Quart	20	20	20
Banana Peel Ash	-	35	55
	Surface Image after firing 1200°C	Surface Image after firing 1200°C	Surface Image after firing 1200°C
			

As shown in Table 11, glaze recipe R2 was prepared by removing potassium feldspar and 10% ulexite from transparent glaze recipe R1, and glaze recipe R3 was prepared by removing all feldspars and adding 10% ulexite. As can be seen, the appearance of all three-recipes after firing at 1200°C is very similar. The results obtained show that banana peel ash, which has a high feldspar content, can be used as an alternative material to feldspars in a transparent glaze composition. Recipe code R3, using 55% ash, was dyed with 5% copper oxide, applied to the vertical surface and fired at 1200°C. The result is shown in Figure 3.

Figure 3. R3 coded glaze recipe colored with 5% copper oxide, 1200°C.

Figure 4 shows Selim Çınar's artworks titled "Blue Personas". Layers and holes were made by applying paraffin decoration technique on the surface of the pieces formed with porcelain clay molds. After 1000°C biscuit firing, 1200°C glaze firing was applied. They were glazed according to the UK1-coded recipe with the addition of banana peel ash, which was developed during the research. The glazes, which were selected by considering the artistic effects, supported and emphasized the formal and superficial features of the artworks, and this situation shows that the glazes with banana peel ash additives can be an alternative glaze for artistic ceramics.

Figure 4. Selim Çınar, *Blue Personas*, Stoneware, Slip Casting, Water Etching, Banana Ash Glaze, 1200°C, 2023.

Conclusion

Banana peel is a very rich organic source of alkali metals. During the research, this source was converted to ash and used in two ways to obtain a natural ash glaze and as a glaze ingredient in a transparent glaze composition. No cracking, foaming or glaze defects were observed in the SK3, PK3 and UK1 recipes from the ash glaze trials. Therefore, it can be said that the potential of using banana peel waste ash for glaze development in industrial and artistic production is quite high. The results show that this source, rich in potassium content, can be used as an alternative material to alkalis in transparent glaze composition. Since no glaze defects were observed in the recipes containing potassium and sodium as melting agents, it was concluded that both industrial and artistic applications would be compatible; however, due to the artistic effects observed in the recipes containing ulexite, it was decided to be more suitable for artistic use only. The optimum amount of cobalt oxide that can be used as a colorant in all groups of glazes was determined to be 1% to 3%. It was found that the use of cobalt oxide above 3% caused haze and opacity in transparent glazes. The scope of the study can be expanded in future studies by focusing on the effects of banana peel ash on matte glaze composition, colorants other than cobalt oxide, different structures, and the development of low-grade glazes. Raw material resources are becoming increasingly depleted due to natural destruction. By improving recycling awareness, organic waste can be used as a raw material source in ceramic production.

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