Egyptian Journal of Archaeological and Restoration Studies
An international peer-reviewed journal published bi-annually
www.ejars.sohag-univ.edu.eg

Original article

COMPOSITIONAL STUDY OF SILVER COINS OF SHAMSUDDIN ILYAS SHAH, A SULTAN OF BENGAL (14TH CENTURY CE) USING EDXRF

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Article info.

EJARS – Vol. 12 (2) – Dec. 2022: 197-204

Article history:
Received: 14-9-2022
Accepted: 2-12-2022
Doi: 10.21608/ejars.2022.276165

Keywords:
Silver coin
Copper
Bengal
Shamsuddin Ilyas Shah
EDXRF

***Abstract**:*
In numismatics, coins are considered as a reflection of the economy and culture of a nation or civilization. Relative proportion of major/minor elements in coins provides valuable information on changes in monetary theory, economic conditions, material technologies, political aspect, religion, cultural heritage and art of minting at the time. Ten silver coins issued by Shamsuddin Ilyas Shah, a ruler of the Bengal Sultanate, were selected from the collection of Bangladesh National Museum and analyzed using EDXRF for elemental composition and comparative study. Shamsuddin Iliyas Shah ascended the throne about the end of the year 1342 CE (743 Hijri) and had a reign of 16 years and some months. The main element, silver was estimated along with trace elements copper and gold. Silver was found in all coins and varied between 97% and 99% indicating the better economic condition of the regime of Shamsuddin Ilyas Shah. Moreover, copper was deliberately added to silver during coin fabrication for hardening purposes.

1. Introduction

Coins are the mirror of any nation's economy and culture [1]. Coins are usually found in large numbers in archaeological excavations, because they have high survival rate when compared to other types of metal artefacts. In numismatics, relative proportion of major/minor elements in coins provides valuable information on changes in monetary theory, economic conditions, material technologies, political aspect, religion, cultural heritage and art of minting at the time [2]. Different materials such as silver, gold, copper, bronze etc. were used as raw materials for the fabrication of the old coins. Many nuclear techniques are available for elemental analysis of coins. Among these techniques, EDXRF is of special interest because of non-destructive nature, fast, sensitive and capable of simultaneous multi elemental analysis [3]. The Bangladesh National Museum has been exuberant with an enormous collection of coins with diversified elements and ranges of time [4]. Coins issued by Bengal Sultanate have important contribution to this collection. At present, Bengal comprises modern Bangladesh and West Bengal of India. Little analytical work has been done so far on Bengal Sultanate coins, though it gives valuable information. The research on the determination of elemental composition of these sultanate coins collected in the Bangladesh National Museum of is absolutely inadequate. Ten silver coins issued by Shamsuddin Ilyas Shah, a ruler of the Bengal Sultanate, were selected from the collection of Bangladesh National Museum to put down this scarcity. EDXRF was used to determine the elemental composition and comparative study. Shamsuddin Iliyas Shah ascended the throne about the end of the year 1342 CE (743 H.) [5]. The histories give Shamsuddin Iliyas Shah a reign of 16 years and some months [5]. Coins issued by Ilyas Shah have been rarely collected and recorded in museums or collections. Numismatic research interpreted the social, economic, religious and cultural aspects of this regime of Bengal Sultanate in the last 150 years subject to the mass, size and exterior structure, images, letters, numbers or texts on coins. But, the elemental compositions of all types of coins of Shamsuddin Ilyas Shah have not been determined yet. Remarkably, limited publications on elemental compositions of coins of Shamsuddin Ilyas Shah are only available in which 1-3 coins were taken as sample from private collections. As a result, clear idea or conclusion cannot be put in a place from any published paper regarding the elemental compositions, manufacturing techniques, sources of the metal for coins of Shamsuddin Ilyas Shah. John Deyell published several papers on his personal collection of coins of the Bengal Sultanate and reported that the silver coins issued in Bengal during the regime of Shamsuddin Ilyas Shah were almost pure and contained 97-99% silver [6]. But he did not reveal elemental compositions other than silver present in the coins. Asiatic Society of Bengal was also reported in 1867 CE and in 1929 CE in two publications that the silver composition in the coins issued by Shamsuddin Ilyas Shah was calculated 98-99% with the assessment of specific gravity. Moreover, Monwar Jahan mentioned in his doctoral dissertation that the silver content of Shamsuddin Ilyas Shah's silver coin is 57% [7]. Mohammad Abu Al Hassan reported using XRD technique that the elemental composition of a silver coin issued by Shamsuddin Ilyas Shah was 70.6% [8]. Mohammad Abu Al Hassan et.al also analysed more three silver coins of Ilyas Shah and reported that silver compositions of these coins were 92.6733 %, 91.7396 % and 90.8025 % respectively [9]. All these cases, Hasan took the silver coins from personal collection as sample for analysis [9]. Data published by the Asiatic Society of Bengal and John Deyell significantly differ from that of Jahan and Hasan provided. It is necessary to pick out the adequate compositions since the previous studies stated different results on coins of same ruler and time of the Sultanate period. Analysis of more admissible samples may be a remedy to come an end from this controversy. Determination of the compositions of silver and other metals present in the admissible silver coin of Shamsuddin Ilyas Shah using EDXRF was the aim of this study. Moreover, providing an idea about the source or mining of these silver coins was also another objective.

2. Materials and Methods

2.1. *Documentation of coins before conservation treatment*

In this work, ten silver coins of Shamsuddin Ilyas Shah were selected from the collection of Bangladesh National Museum to conduct the study. All the studied coins were in good condition with a well-built metal core and with very little surface deterioration. The coins were secured accession number in Bangladesh national museum (the then Dacca Museum) on 24 August 1968 CE. The place of finding of these coins was Chapainawabganj district of Bangladesh. Chapainawabganj was a part of Gaur, one of the largest medieval ruin cites in the Indian subcontinent. In accordance with the registration data in the museum, the period of these silver coins is from 1342 to 1358 CE. Prior to the conservation treatment, the mass and other relevant information of these coins including photographs were recorded. They are circular in shape with irregular diameter. The photos of coins of the analysed set are shown in fig. (1). The weight, average diameter and average thickness of these coins against their accession number are also mentioned in tab. (1).

Figure (1) Shows accession number; **a.** E-66.55, **b.** E-66.56, **c.** E-66.59,**d.** E-66.60, **e.** E-66.62, **f.** E-66.70,**g.** E-66.71, **h.** E-66.72, **i.** E-66.74, **j.** E-66.75,

Table (1) weight, average diameter and average thickness of the coins.

Accession no.	Weight (gm)	Diameter (mm) (ave.)	Thickness (mm) (ave.)
E-66.55	10.56	26.10	2.60
E-66.56	10.10	25.33	2.61
E-66.59	10.69	24.50	2.70
E-66.60	10.60	24.20	2.75
E-66.62	10.44	25.80	2.62
E-66.70	10.23	26.00	2.42
E-66.71	10.44	24.50	2.85
E-66.72	10.19	24.50	2.80
E-66.74	10.56	26.36	2.50
E-66.75	10.49	24.50	2.70

2.2. *EDXRF analyses and conservation treatment*

EDXRF measurement produced a fluorescence spectrum showing the presence of different elements. In this study, analyses were carried out using the EDXRF model (*XRF-W9, Korea*). The x-rays only penetrate about 20 microns for which this is considered as a surface analytical technique [10]. Therefore, it must be expected that the volume (area×depth) analyzed is repressentative of the whole object [10]. However, Beck, et al. [11] have revealed that there is a full agreement between surface and bulk methods for the silver content greater than 92% and although some surface aggregate of dirt was found on the some of the coins [10]. On the other hand, coins with a copper content of less than 3% can be considered massive and not enriched with silver on the surface. In accordance with the general objectives of this study and being mindful of the limitations of the technique, the study endeavoured to determine the type of alloy used for the coins and to investigate if any groups demonstrated homogenous characters concerning metal composition which would suggest a common ore source [3]. In this regard, the dirt and other substances deposited on the surfaces of coins were suitably removed before determining the compositions of silver and other metals. After that, the coins were washed with acetone and then air-dried. Subsequently, the coins were immersed in 10% formic acid solution for 24 hours and then dried in the oven [2]. The calibration of the EDXRF system was obtained through direct measurements of a standards and a program based on the method. The coins were then placed in the exact place of EDXRF chamber where the position was ensured with the assistance of a camera connected to monitor. Then, the samples were irradiated with x-ray and data processed by interactive software were also collected. Two measurements, on the obverse side and on the reverse side, were performed on the coins and the reported concentrations represent the average values of both measurements [12]. This technique was applied owing to the superficial structures and the lack of homogeneousness of the samples in order to consider the irregularity and understand the composition variability from point to point [12]. From these data, the compositions of silver and other metals in the coins under investigation are shown in tab. (2). Silver coins were then coated with 5% paraloid B-72 solution to prevent future deterioration. Finally, photographs were taken for documentation.

Table (2) Composition of metals in silver coins (wt%)

Accession no.	Silver (Ag)	Copper (Cu)	Gold (Au)
E-66.55	98.9678	1.0322	0.0000
E-66.56	98.8850	1.1150	0.0000
E-66.59	99.0313	0.9687	0.0000
E-66.60	98.5942	1.2089	0.1969
E-66.62	98.9176	0.6978	0.3847
E-66.70	98.2479	0.7837	0.9684
E-66.71	97.2262	1.6806	1.0931
E-66.72	98.2201	1.5105	0.2694
E-66.74	97.6175	1.3598	1.0227
E-66.75	98.6604	1.1522	0.1874

3. Results

3.1. *Visual observation*

All the studied coins were in good condition with a well-built metal core and with very little surface deterioration as shown in fig. (1). The coins tended to bend with slight pressure during conservation treatment. Moreover, the weight, average diameter and average thickness of the coins under examination were found between 10.10 to 10.69 grams, 24.20 to 26.36 mm. and 2.42 to 2.85 mm respectively, tab. (1).

3.2. *EDXRF analyses*

In the analyses of the coins, the detected elements were silver, copper and gold. The concentration of the elements Ag, Cu and Au of the analyzed coins are presented in tab. (2). Each coin has Ag concentration in the range 97-99% whereas Cu concentration in the range 0.70- 1.68%. Trace amounts of Au were found in the range 0.19-1.09% in seven coins among ten studied coins. Other elements like zinc, nickel, lead and tine were not detected in the present study.

3.3. *Correlation among Ag and Au with Cu*

Correlation among of silver and gold with copper were calculated and presented in tab. (3). According to this table, copper was negatively and significantly correlated with silver but positively and non-significantly correlated with gold.

Table (3) The relationship (r value) of copper (Cu) with silver (Ag) and gold (Au)

Element	Ag	Au
Cu	-0.722*	0.303^{ns}

Ns: *Not significant,* ****:*** *5% level of significant*

4. Discussion

The earliest observation to be made concerns the silver and copper contents of the coins. The results show that all the coins are made of a similar silver-copper alloy and each coin has silver concentration in the range 97-99%. That is, high quality silver was produced by purification process and subsequently almost pure silver was used to these coins. It also indicates that metalworker of Bengal had a high capacity to refine silver. The average concentrations of silver and copper in each coin are very close to each other and, respectively, around 98.45% for silver and around 1.15% for copper. Several studies have shown that copper contents above 0.5-1 wt.% indicate deliberate additions, most probably to increase the strength and wear resistance in high-silver alloys, and also in larger amounts to make lower-quality artifacts and coins [13]. In this study, copper was detected above the range. Copper additions appear to have been conducted since about 3000 BCE [14] whereas studied coins fabricated in 14th century. Moreover, the strong negative correlation between silver and copper is an indication that copper was deliberately added to silver fig. (2) & tab. (3) [3] rather than an impure alloying agent. In addition, the absence of lead in the silver artefact means that silver was not produced by cupellation [15]. Similarly, absence of zinc, nickel and tin indicating the copper was added as pure metal not as copper alloy. It seems that the slight addition of copper was not related with debasement but rather monetary policy or economic necessity [3]. However, the presence of some small quantity of copper also suggests that it was added for hardening purposes [3].

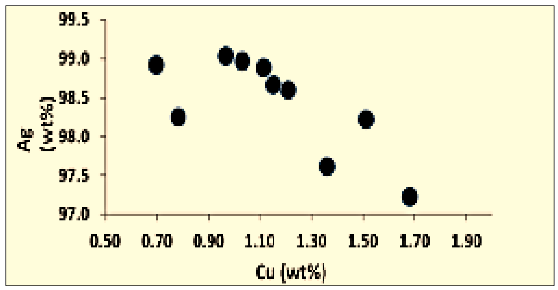

Figure (2) Shows the relationship between copper (Cu) and silver (Ag) contents in the studied coins.

The analyses also show that seven coins comprises trace amount of gold except the accession number E-66.55, E-66.56 and E-66.59 respectively, tab. (2). The presence and absence of gold in the coins suggests that these were of two groups. That is, the ores used to prepare two groups of metallic silver coins were collected from different sources. Each group is categorized in the study to easy interpretation as group 1: coins comprising gold and group 2: coins not comprising gold. However, the quantity of gold in group 1 can also be considered as impurities or as a gangue element of the primary ore, because in ancient times it could not be easily removed from main component [16]. Although, it is expected to identify gold at trace amounts within the composition of historical silver objects, it could also likely be used to determine the ores used to prepare metallic silver [17]. Moreover, gold is a noble metal and is not removed during the smelting or cupellation process, meaning that it can be used as a fingerprint for ore mining [18]. The data obtained in this study suggests that the gold composition is below 1wt.% for group 1, tab. (1). So, the silver was made from cerussite because the amount of residual gold was detected between 0.2 and 1.5 wt.% within the coins [19]. Moreover, the quantity of gold does not change during the smelting and cupellation processes suggest that ores extracted from the galena mines were not used [20]. Meyers also believes that this amount of gold in old silver objects indicate the use of cerussite ore [21]. The observation can also be considered that the coins tended to bend with slight pressure during conservation treatment. This physical property aligns with that of highly pure silver alloy with copper. The results of the EDXRF examination are also reasonably similar to that of published by the Asiatic Society of Bengal and John Deyell. In some cases, personal collections do not provide authentic sample for historical research. In this study, the samples for this examination were selected from more admissible and authentic source that is Bangladesh National Museum. Moreover, modern technology was applied to conduct these analyses. Therefore, it can be concluded that compositions of silver coins of Shamsuddin Ilyas Shah are 97-99% and simultaneously indicating a better economic condition of the regime. Moreover, the presence of copper and the absence of zinc and nickel will make an advantage for identification of Ilyas Shah's coins because it is quite difficult to fabricate a trace element from metal ore or to remove any metal at all. In addition, the weight of the coins under examination is between 10.10 to10.69 grams. Several numismatic studies also reveal that the weight of the Ilyas Shah's silver coins is almost 10.5 grams as well which is similar to the present data. Historians take account of the Gaur as the most influential region of Ilyas Shah from where the coins under investigation were also collected. In the period of Ilyas Shah, there was no native source of silver in Bengal for the minting and other uses of silver [7]. In other words, Bengal was totally dependent on imports for the use of silver. Siberia, Manchuria, Hunan, Yunnan and Japan were the Asian sources of silver on that time. In contrast to the other sources, only Yunnan in China is relatively close to Bengal. Many historical studies have shown that Bengal had an established communication system with this region and had trade relations during the reign of Shamsuddin Ilyas Shah [7]. That is why it may be borne in mind that silver was imported to Bengal from this region. In modern techniques, isotope analysis can lead to a crystal-clear conclusion on provenance study which requires further research.

5. Conclusion

Results of this study improved our knowledge of the metallurgical technology in Shamsuddin Ilyas Shah's era in Bengal. The high purity of silver in the coins clearly points to metalworker of Bengal had a high capacity to refining and extracting silver at that time. The high silver content (>90 wt%) in all coins indicates the precise and controlled application of refining process of silver and separation of other impurities from the primary ores. On other hand, the high content of silver in coins also indicates an economically and politically powerful regime. Results of this study concerning elemental analysis of samples will provide a credible evidence or reference for validation of the authenticity of Shamsuddin Ilyas Shah's silver coin.

Acknowledgements

The authors are thankful to Bangladesh National Museum authority for providing the opportunity to conduct this research. The authors are also especially thankful to Mr. Mohammad Monirul Hoque, Deputy Keeper and in charge of coin cabinets of Bangladesh National Museum for providing the sample coins.

References

[1] Kumar, R., Rani, A. & Singh, R. (2014). Elemental analysis of one rupee Indian coins by using EDXRF technique, *J. of Integrated Science and Technology*, Vol. 2 (1), pp. 1-4.

[2] Rautray, T., Nayak, S., Tripathy, B., et al. (2011). Analysis of ancient Indian silver punch-marked coins by external PIXE, *Applied Radiation and Isotopes*, Vol. 69, (10), pp. 1385-1389.

[3] Civici, N., Gjongecaj, Sh., Stamati, F., et al. (2007). Compositional study of IIIrd century BC silver coins from Kreshpan hoard (Albania) using EDXRF spectrometry, *Nuclear Instruments and Methods in Physics Research, B,* Vol. 258, pp. 414-420.

[4] National Museum of Bangladesh. (2012). *Exhibition catalogue on coins and paper notes of Bengal*, Bangladesh National Museum, Dhaka (pub. in Bangla lang.).

[5] Bhattasali, N. (1922). *Coins and chronology of the early independent sultans of Bengal*, Hbpper, W. & Sons, Cambridge, England.

[6] Deyell, J. (2010-11). New metallic assay of Bengal sultan Tankas, *J. of Research in Numismatic Studies*, Vol. 34 (7), pp. 119-135.

[7] Chattopadhyay, P., Datta, P., Vijayan, V., et al. (2010). Punch marked coins of Bengal, in: Seragudin, A., Islam, N., Shafee, S., et al. (eds.). *Centenary Commemorative Volume (1913- 2013) Bangladesh National Museum*, Centre for Archaeological and Heritage Research, Dhaka, pp. 82-109.

[8] Abu Al Hasan, M., Kurny, A. & Ahsan, S. (2019). Political changes reflected in the coins of Sunargaon mint: An archaeometallurgical attempt to reexamine the history of 14th Century Bengal, *J. of the Oriental Numismatic Society*, Vol. 238, pp. 24-36.

[9] Abu Al Hasan, M. & Kurny, A. (2019). Archaeometallurgical analysis of four silver coins from different mint of independent sultan of Bengal, archeologist and museum: Dialogue about eternal Kazan, *Arkheologiya Evraziyskikh stepey*, Vol. 5, pp. 251-260.

[10] Notis, M., Shugar, A. & Herman, D., et al. (2007). Chemical composition of the Isfiya and Qumran coin hoard, Ch. 14, in: Glascock, M., Speakman, R. & Popelka-Filcoff, R. (eds.) *Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation*, American Chemical Society Symp. Series, pp. 258-274.

[11] Beck, L., Bosonnet, S., Reveillon, S., et al. (2004). Silver surface enrichment of silver-copper alloys: A limitation for the analysis of ancient silver coins by surface techniques, *Nuclear Instruments and Methods in Physics Research B,* Vol., 226, pp. 153-162.

[12] Brocchieria, J; Vitaleb, R. & Sabbarese, C. (2020). Characterization of the incuse coins of the Museo Campano in Capua (Southern Italy) by X-ray fluorescence and numismatic analysis, *Nuclear Instruments and Methods in Physics Research Section B,* Vol. 479, pp. 93-101.

[13] Oudbashi, O. & Wanhill, R. (2021). Long-term embrittlement of ancient copper and silver alloys, *Heritage*, Vol. 4 (3), pp. 2287-2319.

[14] Gale, N. & Stos-Gale, Z. (1981). Ancient Egyptian silver, *J. of Egyptian. Archaeology,* Vol. 67, pp. 103-115.

[15] Guerra, M. (2000). The study of the characterisation and provenance of coins and other metal work using XRF, PIXE and Activation Analysis, in: Creagh, D. Bradley, D. (eds.) *Radiation in Art and Archaeometry*, Elsevier, pp. 378-415.

[16] Guerra, M. (1998). Analysis of archaeological metals. The place of XRF and PIXE in the determination of technology and provenance, X-Ray *Spectrom*, Vol. 27, pp. 73-80.

[17] Tayyari, J., Emami, M. & Agha-Aligol, D. (2021). Identification of microstructure and chemical composition of a silver object from Shahrak-e Firouzeh, Nishapur, Iran (~2nd millennium BC), *Surfaces and Interfaces*, Vol. 25, doi: 10.1016/j.surfin.2021.101168

[18] Uzonyi, I., Bugoi, R., Sasianu, A., et al. (2000). Characterization of Dyrrhachium silver coins by micro-PIXE method, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, Vol. 161-163, pp. 748-752.

[19] Sodaei, B., Khak, P. & Khazaie, M. (2013). A study of Sasanian silver coins employing the XRF technique, *Interdisciplinaria Archaeologica (Natural Science Archaeology)*, Vol. IV (2), pp. 211-215.

[20] Mortazavi, M., Naghavi, S., Khanjari, R. et al. (2018). Metallurgical study on some Sasanian silver coins in Sistan Museum, *Archaeological and Anthropological Sciences*, Vol. 10, pp. 1831- 1840.

[21] Meyers, P., Van Zelst, L. & Sayre, E. (1973). Determination of major components and trace elements in ancient silver by thermal neutron activation analysis, *J. of Radioanalytical Chemistry*. Vol. 16. pp. 67-78.