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A Preliminary Quality Survey of Gold Jewellery Sold in Trinidad and Tobago

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Abstract

Due to the absence of mandatory hallmarking and assaying requirements for gold containing jewellery as well as limited published literature on the quality of gold based jewellery traded in Trinidad and Tobago, there exists the possibility of underkarating either accidental or intentional for material gain. A preliminary survey evaluating the gold content in jewellery products as well as the other alloying elements of silver, copper and zinc was therefore conducted. The results showed that of the sixteen (16) samples analysed for gold content, thirteen (13) samples representing 81.25 % of the samples contained % gold content less than the expected or reference values. Statistical evaluation at the 95 % confidence level revealed that for 56.25 % of the samples analysed, the % gold obtained was significantly different from the reference or expected values as advertised by retailers. The overall average total composition % of the jewellery samples (gold, copper, zinc and silver) for all sixteen (16) samples was 75.67 % suggesting the samples analysed contained a significant level of extraneous material. The results clearly suggest that there is a definite need for quality control protocols such as assaying and hallmarking to be implemented in the gold product trade in Trinidad and Tobago to protect consumers and traders alike.

Keywords: Flame Atomic Absorption Spectroscopy, jewellery, hallmarking, assaying, gold.

INTRODUCTION

Gold is a transition metal and is in the same periodic table column as silver and copper. This group is referred to as the coinage metal group since its elements are frequently used to produce money. Gold is one of the first metals known to mankind as gold artifacts found at the Nahal Kana cave cemetery are considered the earliest find (Chalcolithic or copper age) from the Levant [1]. Gold artifacts obtained in the Balkans dates back to the 4th millennium BC [2]. Over time, jewellery has evolved from the religious symbols and objects of power and royalty to universal fashion.

The value of gold based jewellery is sold on the basis of its gold content and thus gold content is quantified in terms of its Fineness (in parts per thousand gold) or Karatage (where 24 karat represents pure gold); the latter being the most widely known measure of gold content. The karat is based on the ratio of fine gold to total metal present (by weight) [3]. In this method, the total metal present is divided into 24 parts, each karat being 1/24 (by weight) of the whole representing 4.17% or 41.7 ppt. Based on this calculation, Table 1 shows typical karat values and its equivalent measures in parts gold to alloy, percentage and fineness.

Table 1: Gold Karat Grade

Karat	Parts Gold to Alloy	Percentage	Fineness
10K	10/24	41.67%	417
12K	12/24	50.00%	500
14K	14/24	58.33%	583
16K	16/24	66.67%	667
18K	18/24	75.00%	750
22K	22/24	91.66%	917

Pure (24k) gold is very soft and as a result it is usually alloyed with other metals for use in jewellery such as copper, silver and zinc, altering physical properties such as its hardness and ductility, melting point, colour and other properties. Copper is the most commonly used alloying metal and gives rise to a generally redder colour [4]. Gold jewellery is traded based on the content of gold within the alloy. Certain jurisdictions have laws governing the actual karatages of jewellery that can be sold and the corresponding allowable tolerances on the gold content. The requirement for assaying or hallmarking is usually conducted by independent quality control and standards laboratories to show the purity of gold in a piece of gold jewellery. Usually the product has the mark of the assaying office that certified the purity and the fineness or karatage of the gold product [5]. Since the value of the jewellery is determined by the karat, the incidence of fraudulent underkarating can occur [6].

In the United Kingdom, it is a requirement that all gold products, except for products weighing less than 1 gram, be hallmarked. In the United States however the fineness is used to describe purity and does not have to be marked but must be identified by independent signage close to the jewellery item or relayed verbally. Other countries, including Switzerland, Italy, India and China, jewellery hallmarking is not mandatory. In order to standardize the quality of precious metals, European nations signed the Vienna Convention on the Control of the Fineness and the Hallmarking of Precious Metal Objects in 1972 where a Common Control Mark (CCM) was introduced that allowed goods marked with the CCM mark to be imported without further testing and marking if the goods met the quality standards in the domestic market [4].

Gold testing techniques such as fire assay, touchstone testing and hydrostatic weighing have been used historically [7, 8]. Analytical detection of minute quantities for mining purposes has also been evaluated [9]. Analytical techniques such as X-ray transmission, Compton scattering, neutron activation analysis, inelastic scattering, atomic absorption, and particle-induced X-ray emission though experimentally complex and expensive are accurate [10-12].

He absence of legislation and laws governing the hallmarking and assaying of gold and precious metal content of jewellery traded by the hundreds of jewellery retailers in Trinidad and Tobago has allowed for the possibility of the misrepresentation of gold content or underkarating, either accidental or intentional, for material gain. Additionally a review of the published literature has revealed limited information of the assaying of jewellery in Trinidad and Tobago verifying the integrity of the precious metal for the protection of retailers and consumers. The objective of this study is to conduct a survey evaluating gold jewellery products for possible underkarating. The assaying will be conducted using the Flame Atomic Absorption technique for the metals gold, silver, copper and zinc.

EXPERIMENTAL

Materials

Sixteen (16) jewellery samples were obtained from various retailers in Trinidad and Tobago. BDH, SpectrosoL® 1000 μgmL^{-1} certified metal standard solutions of gold, silver, copper and zinc were obtained from the Trinidad Bureau of Standards (TTBS).

Material Characterization

The analytical procedure was executed according to the flow chart presented in Figure 1 below.

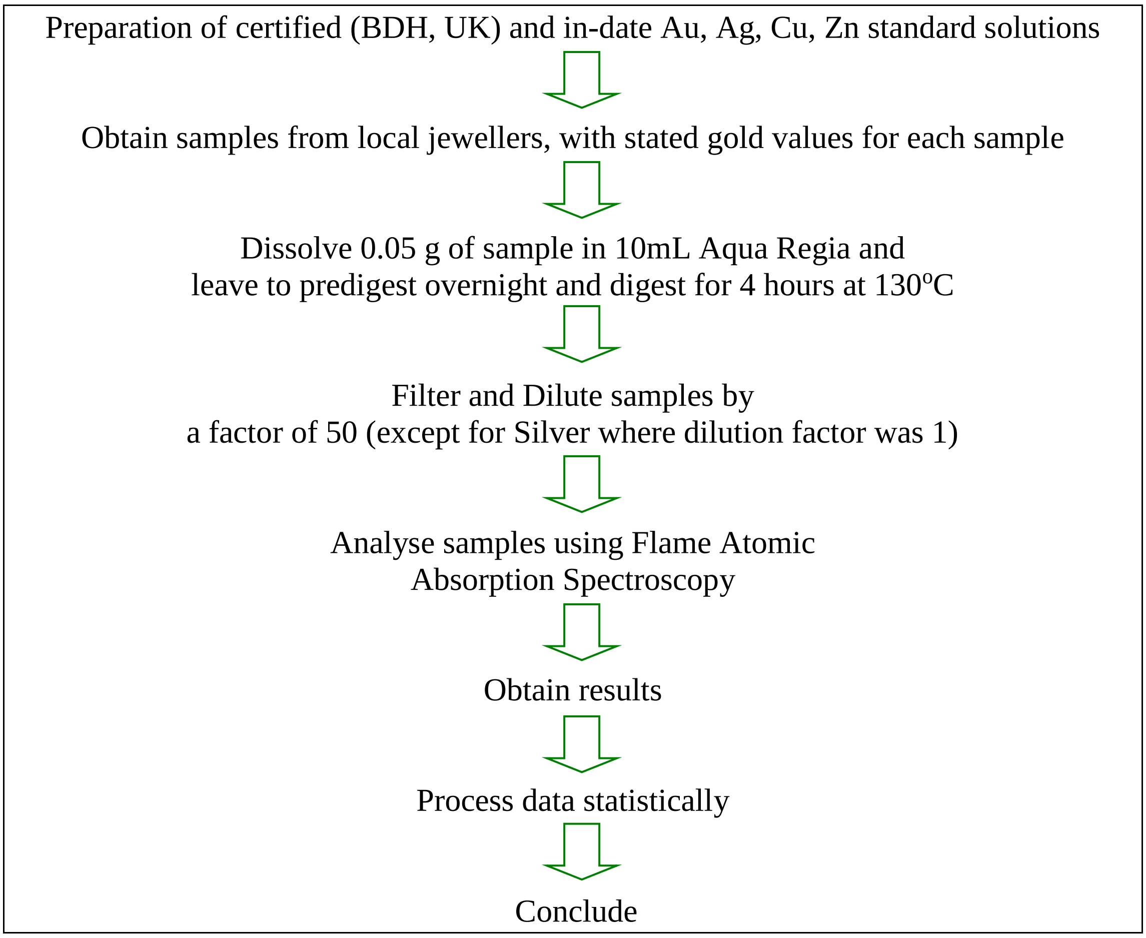

Figure 1: The analytical procedure employed in study.

The certified metal standard solutions (gold, silver, copper and zinc) were obtained from the Trinidad and Tobago Bureau of Standards (TTBS) and an eight-point calibration curve within the range 0.5-20 μgmL^{-1} generated for each metal. The jewellery samples obtained were melted using a goldsmith's blow torch in separate graphite crucibles and then casted. They were also individually milled to minimize cross-contamination before analysis. This process was carried out to reduce the sample to a form in which it could be easily dissolved in aqua regia, a mixture of analytical grade hydrochloric and nitric acids (3:1 v/v). Approximately 0.05 g of each gold sample was weighed out in triplicate on an analytical balance and each aliquot placed in a boiling tube, to which 10 mL of aqua regia was added. The tubes were covered with a clean glass plate to allow escape of vapours and to prevent aerial contamination and samples allowed to pre-digest at room temperature overnight. The samples were completely digested on a dry heating block for four hours at 130^{o}C. After cooling, the samples were filtered through Whatman #542 filters, diluted appropriately with distilled and de-ionized water and then analysed by Flame Atomic Absorption Spectroscopy using a Varian SpectrAA 880 instrument [13]. The gold, silver and copper concentration in each sample replicate was calculated and converted to wt. % and the means and standard deviations (SD) determined for each sample.

Statistical Analysis

Paired t-tests were performed to compare analytical means of gold in each sample, with the gold values provided by jewellers for each sample, using a 95% confidence level (p.05) to determine significance of means [14].

RESULT

The results of analysis of the samples for gold content, as well as the statistical comparison of the % gold obtained with the expected % of gold as provided by jewellers, are shown in Table 2

Table 2: Results of analysis of gold content in jewellery samples.

Sample	**% Gold (Mean±SD)**	Expected % Gold (reference)	**Results of pair data Analysis ($p < 0.05$)**
A	38.70 ± 0.33	41.67 (10K)*	**Significantly Different from Reference**
B	60.30 ± 4.46	58.33 (14K)	No Significant Difference
C	38.40 ± 0.87	41.67 (10K)*	**Significantly Different from Reference**
D	31.70 ± 2.41	41.67 (10K)*	**Significantly Different from Reference**
E	40.00 ± 1.31	41.67 (10K)	No Significant Difference
F	16.80 ± 3.60	41.67 (10K)*	**Significantly Different from Reference**
G	50.90 ± 0.29	50.00 (12K)	No Significant Difference
H	68.40 ± 1.85	75.00 (18K)*	**Significantly Different from Reference**
I	64.90 ± 2.68	66.67 (16K)	No Significant Difference
J	26.10 ± 0.48	41.67 (10K)*	**Significantly Different from Reference**
K	27.00 ± 0.88	41.67 (10K)*	**Significantly Different from Reference**
L	24.90 ± 0.54	41.67 (10K)*	**Significantly Different from**

			Reference
M	38.80 ± 1.73	41.67 (10K)	No Significant Difference
N	24.20 ± 0.47	41.67 (10K)*	**Significantly Different from Reference**
O	36.90 ± 0.00	41.67 (10K)	No Significant Difference
P	60.30 ± 0.42	58.33 (14K)	No Significant Difference

The results show that of the sixteen (16) samples analysed for gold content, thirteen (13) samples or 81.25 % of the samples contained less % gold than the expected values. However, nine samples or 56.25 % of samples contained % gold content significantly less ($p<.05$) than the expected or reference values. Of these nine samples, eight were 10K samples, while the other was an 18K sample. Of the other samples with statistically similar ($p>.05$) gold contents, three were 10K, one 12K, two 14K and one 16K. While the differences were more significant for the lower 10K karatages, the 18K sample also failed to meet the gold target. This suggests that underkarating may occur in gold jewellery sold to unsuspecting customers in Trinidad.

The results of analysis for the % silver and copper composition of samples are shown in Table 3, while zinc in samples were all below the detection limit of the method and not included. While the total mass percentages of gold, silver and copper in samples were expected to be close to 100 %, this was not the case for any of the samples analysed. In fact the overall average total mass % of gold, silver and copper for all sixteen samples was only 75.67 %. This showed that the samples analysed contained significant levels of other metals, some of which could be potential irritants (metals + refs) or toxic (metals and refs) to skin exposed to such jewellery. The need thus exists for a listing of such diluent metals in jewellery, in addition to their gold contents.

Table 3: Percentage gold, silver and copper and total Au, Ag and Cu of the samples analysed.

Sample	% Gold ± SD	% Silver ± SD	% Copper ± SD	Total % Au, Ag, Cu
A	38.70 ± 0.33	0.41 ± 0.02	44.9 ± 2.82	84.01
B	60.30 ± 4.46	0.35 ± 0.02	28.0 ± 3.57	88.65
C	38.40 ± 0.87	0.39 ± 0.03	40.0 ± 1.10	78.79

D	31.70 ± 2.41	0.43 ± 0.01	33.5 ± 2.54	65.63
E	40.00 ± 1.31	1.06 ± 0.06	42.2 ± 3.84	83.26
F	16.80 ± 3.60	0.18 ± 0.08	13.5 ± 1.53	30.48
G	50.90 ± 0.29	0.11 ± 0.04	23.1 ± 1.50	74.11
H	68.40 ± 1.85	0.21 ± 0.08	17.7 ± 0.58	86.31
I	64.90 ± 2.68	0.17 ± 0.02	26.8 ± 0.78	91.87
J	26.10 ± 0.48	0.15 ± 0.01	36.1 ± 1.31	62.35
K	27.00 ± 0.88	0.17 ± 0.04	37.9 ± 0.77	65.07
L	24.90 ± 0.54	0.20 ± 0.04	51.8 ± 1.42	76.90
M	38.80 ± 1.73	0.18 ± 0.04	43.8 ± 1.67	82.78
N	24.20 ± 0.47	0.23 ± 0.03	50.6 ± 0.66	75.03
O	36.90 ± 0.00	0.20 ± 0.02	41.7 ± 0.82	78.80
P	60.30 ± 0.42	0.24 ± 0.04	26.2 ± 0.16	86.74

CONCLUSION

The results clearly demonstrated that there is a need to for quality control protocols such as assaying and hallmarking to be implemented in the gold product trade in Trinidad and Tobago, to protect consumers. Not only was the gold contents of the majority samples less than the expected values, but varying percentages of silver, copper and other unknown diluent metals were also present in the jewellery analysed. Further studies are required in the determination of such metals, as well as a wider study of gold jewellery, to enhance consumer protection.

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