Identifying Factors Leading To Gold Losses During The Fabrication Process And Assessing Its Impact On The Smes Jewellery Industry.

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Abstract: This study intended to determine the level of awareness by the Kelantan Jewellers House on how much is the impact of gold losses during the jewelry-making process to their business. The study focuses more on Kelantan State due to their popularity and existence of a chain of small and traditional craftsmen. Most local operators are still preserving the traditional way of fabrication and production techniques, tools, methods whilst maintaining the Malay aesthetic value in all aspects of fabrication. This unique value proposition inherited from their legacy lineage was taught throughout the generations and now adopted by the younger craftsmen in rank. Ironically, the manual process and traditional fabrication techniques were seen as less efficient due to the higher amount of gold scrap as compared to modern techniques.

Hence, this paper aims to ascertain the findings and to validate the assumptions that the manual and traditional technique does indeed contributes to a higher amount of gold losses that adversely affecting the yield and economic returns of the small fabricators in Kelantan, whilst formulating the right action plans to mitigate and resolve the issues effectively.

Index Terms: jewellery manufacturing, gold losses, gold scrap, SMEs.

1. Introduction

A unique and exclusive jewellery item normally fabricated by skillful and professional craftsmen who responsible to identify the suitable best practice techniques, tools, and equipment's in the making process (Kaspin, S. 2013). Jewellery manufacturing process is defined as a first-time transition point of semi-finished or finished jewellery from the gold bullion (World Gold Council, 2019). Chris Baber et: al, (2017), believed jewellery making is an area of human activity in which cognition, creativity and physical performance meet and it is necessary to combine knowledge of metallurgy and gemstones, with craft skills and an ability to create aesthetic designs. Kaspin, S (2008) claimed the most common material used in jewellery production process is gold with various purity referring to the type of design requirements. Jewellery manufacturing process involves precision designs, setting the metal as well as the stones, polishing, filing, grinding and others that will be changed to the physical existence of gold to waste or scrap. Chris Baber et. al; (2017) stated in jewellery

production mistakes can happen and some work can be correct, and some might be categorized as scrap. This scrap will then be mixed with other material from the workbench and floor. The process can cause the quantity and the weight of the raw materials (gold) to be reduced slightly as compared to the original weight measurement (Kaspin, S. 2013; Fergal A. O' Connor et al; (2015), Kaspin, S., & Mohamad, N. (2015). In efficient management, it requires competent knowledge and skills (Norazmi et al., 2019; Norazmi, 2020; Fauziyana et al., 2021; Zaid et al., 2020; Zaid et al., 2021).

C.W. Corti, (2002), Kaspin, S. (2013, April) believed the scrap that was generated from jewellery fabrication process and mixed with other waste can be recovered to extract the pure gold as higher as 999.9 percent purity. Consequently, by neglecting the elements of the gold losses in the jewellery production process obviously will cause a substantial level of loss to the manufacturers indirectly and the action must be taken to contain issues Kaspin, S. (2013), Kaspin, S. (2008). Peter Raw (2000), five major factors contribute to the gold losses in jewellery production, includes poor condition and design of the premises, type of manufacturers, type of jewellery design, condition of machinery and equipment and the management attitude. (Ibid.), believes that if no action is taken to solve and recover this gold particle, the losses of up to 10% of gold can easily be attained. It is clear here that, experience and qualifications in the field of expertise are very helpful in management (Norazmi et al., 2020; Rosnee et al., 2021; Firkhan et al., 2021; Ishak et al., 2021).

2. Background

The craft of gold jewellery design in Malaysia is influenced by the Malay royalty identity and characteristics especially in Kota Bharu, Kuala Terengganu and Kuala Kangsar (Kaspin, S., & Mohamad, N. (2015). Kelantan's goldsmith is admired as it still preserved and produced jewellery by using manual traditional tools, techniques and equipment with the aesthetics Malay motif and values. Based on the total Malaysia's SMEs industry population, Kelantan produced 1,006.661 gram of gold with 5 gold mines in the year 2016 and is known as the second larger gold producer in this country. In 2017, the Gross Domestic Product (GDP) of jewellery business in Kelantan was higher in Malaysia with 9.1% synchronized with the fact of number gold produced by the state (Press Release, Department of Statistics (DOSM), 2018).

The manufacturing sector is defined as the physical or chemical transformation of materials or components into a new product (Bank Negara Malaysia Circulation (BNM/RH/CIR 028-1, (NSDC), 2013). Kelantan jewellers are known for their motif and techniques inherited from the previous legacy techniques. GIT (2017), Malaysian entrepreneurs have been producing products to meet each group of domestic consumers and Malay is the majority consumers with preferences of gold jewelry with flower and leaf motifs or bouquet motifs for brooches, bracelets, and rings. The Malay identity in jewellery can be seen through the techniques used by the craftsmen's such as filigrees, chisels, and others. Kelantan known as one of the popular states produces a unique traditional design concept with reasonable pricing due to its renown "Kelantan gold" is seems lower than industry gold retail prices (Kaspin, S. et.al; 2009). Some countries such as Brunei and UAE have exported jewellery directly from the craftsmen in Kelantan due to the attraction of the Malay motif and quality of the craftsmanship that preserved the Malay culture and identity in their finished product (Ibid.). However, manual techniques and types of design that are applied by many manufacturers in Kelantan have caused higher gold losses and hurting their profit margin. We have identified five (5) major factors that have contributed to gold losses in jewellery production. The factors are poor condition and design of the premises, type of manufacturers, type of jewellery design, condition of machinery and equipment and the lack of management policy and treatment to gold waste (Ibid., 3). From the observation, most of the jewellery premises in Kelantan do not have a good extraction system that led the gold to be inhaled and floated in the air. The conventional method of jewellery making process in Kelantan generates the highest gold scrap compared to the modern method with 1 gram or less at 40.5% followed by 1.5 to 2 grams at 27.8% of gold losses (Ibid.). Mohamad, N. et.al; (2017) mentioned Malaysia's Design Industry is changing for the past three years towards recent years compared to other countries such as the United Kingdom, where they already well developed and operates globally. To achieve that, a proper system or model must be proposed to improve, control, and sustain the jewellery SMEs industry. In facing this problem, experience and qualifications are seen to balance management (Mohd Norazmi et al., 2021; Azlisham et al., 2021; Aminah et al., 2021). Hence, it is being significant to identify and control the losses of gold during the jewellery manufacturing process regarding hold on the economic factors and profit margin of the manufacturers, especially for small and medium scale companies (Nik Nurharlida et al., 2021; Een et al., 2021).

3. Gold scrap: Term and Definition

The jewellery industry is one of the key markets that possess the largest demand for gold (World Gold Council, 2019), the demand world gold demand shows jewellery is a higher demand in 2017 and 2018 (Table 1.) Referring to that, we realize that the traditional or modern technique in jewellery fabrication consistently

produces a scrap in a small workstation or by mass production in the factory. (C.W. Corti, 2002). Gold scrap is produced from many industrial applications such as electronic industry, biomedical, jewellery fabrication and many others. According to World Gold Council (2019), around 90% of recycled gold is of high value and largely produced by the jewellery industry. The rest are from industrial waste such as laptops, mobile phones, circuit boards and others.

Table 1. The Biggest Gold Demand in Jewellery Industry 2019

Tonnes	**Q2 2018**	**Q2 2019**	**y-o-y change**
World Total	520.8	531.7	2 %
India	149.9	168.6	12 %
China	144.1	137.8	-4 %

Gold Demand Trends Q2 2019, 1 August 2019, www.gold.org

All stages in jewellery fabrication process such as alloying and ingot stage, filing, grinding, finishing, soldering at the workbench or in the factory will produce a gold scrap. A discarded material and defective items in the jewellery fabrication process will be categorized as scrap with a high and medium grade of gold purity. Therefore, careful process design, tracking system, identify the root cause are the best practices to be implemented in the workstation such as floors, walls, pieces of equipment, machinery, and others. (Table 2).

Table 2. Stage in jewellery production creates waste.

STAGE	**REMARKS**
During design stage	Work that can be proactively avoided can be decided at this stage so that practices
During planning stage	Planning and scheduling can be done in a manner that prevents loss of time, fewer inventories and so on.
During operations stage	This is reactive as compared to the earlier actions and is to be addressed after the process is in place

Source: K. Chandrasekaran, Solitaire International, 2011

4. Sources of Scraps and Wastes in Jewelry Manufacturing

As discussed earlier, all stages in jewellery fabrication whether by machine or handmade will contribute to the scrap. Eventually, this scrap that yields through cutting, grinding, finishing, soldering, polishing and buffing process will change to the airborne particles that fall off and dropped to the floor, workbench, pipes, clothes, or may even be vented to the outside and lost. Any cleaning and machine finishing operations can occur with the gold-bearing material being washed down when draining process and this includes all gold-containing solutions from electroplating, acid stripping and others. Referred to an example of gold scrap that occurred from both traditional workshop and factory situations (Ibid.). The figure of gold scrap sources is shown in Table 2.

Table 3. Typical sources of wastes in gold jewellery manufacturer

Process stages	**Sources**
Melting and casting	• Crucibles, molds, casting dies • Slag's, fluxes, splashes and dirt • Cooling water from graining • Residues from ingot dressing • Investment casting
Working operation	• **Sheet and strip:** -edge cracks and alligatoring • blister, laps • Rod rolling – fins. • Wire drawing • Lubricating oils • Stamping and blanking • Chain making • Annealing and soldering in a belt furnace • Cleaning rags

Assembly, cleaning and finishing	• Cutting, filing, sawing, soldering • Grinding and polishing • Diamond milling and faceting • Cleaning fluids • Spent electroplating solutions. • Rinse water in electroplating, • Acid pickling baths, bombing solutions. Cleaning rags, tissues, brushes,
Workers and workplace	• Clothes, skin, hair, feet • Floors, walls, ledges, lights, benches • Skins and drains • Equipment, extraction system, fans
Test samples	• Test specimens for analysis, etc.

Source: Recovery gold scrap from waste (2002), World Gold Council

5. Tracking of Gold Losses

A proper system must be included in the making process to identify, analyze, improve, and control the potential of gold losses in jewellery fabrication process. According to Dr. Christopher W. Corti (1996) and Peter Raw (2000) tracking is a routine procedure by regular weighing of the input and output in each stage during the fabrication of jewellery to identify the sources of gold losses and action can be taken to improve the system and minimize the losses. The formula is as follows:

F = gold at last inventory + gold taken in – gold *shipped out*

Concerning the formula, the importance of tracking the gold losses in every stage of the jewellery fabrication process can be applied to enhance the gold scrap collecting procedure and minimize the losses. Inventory is an important part of the tracking system to determine and monitor the stock level. The fabrication area and equipment such as drain, walls, floors, exhaust system and working clothes must be cleaned to recover the gold losses. According to Dr. Peter M Raw (2000), the gold scrap that has been changed into dust can be spread in the worker's clothes, floors, workstation and walls and sometimes can be found in skin and hair. Michael T. Gervais, (1998), the ounces of loss must be identified and divide by the number of ounces that have been used in manufacturing in the same period is another way to analyze the shrink ounces and percentages lost to (1) determine if the losses fall within the parameters outlined in your company's business plan, and (2) see if the losses fall in line with those of similar manufacturers. Any system of controls must begin with the establishment of good inventory procedures. Kittichok Nithisathian et; al (2012), have claimed that the Thai fine gold jewellery industry is lack research and development in terms of production, as they still rely on traditional jewellery crafting technique and this mystify way of management make it difficult to develop and manage. Thai fine gold jewellery needs to improve its IT systems, processes, advanced management methods, and fresh ideas should be added into these companies to follow the economic development such as customer orientation, information management system, flexible operational process, and others to sustain. (Ibid.) Chris Corti, (2014), expected old technologies to rise again with new developments in 2024. The motivation will continue to be increased efficiency in both uses of materials and yields, leading to a reduction in costs, widening of design opportunities and the customizing of design.

6. Research Methodology

The purpose of this paper is to identify the action taken by the jewellery manufacturer toward the gold scrap in jewellery making process based on the following research questions:

Q1: Does the manufacturer is aware of the gold missing during the jewellery fabrication process?
Q2: What are the action plans taken by the manufacturer toward the missing gold?
Q3: How much of the gold has been missing along the way of the jewellery fabrication process?

The questionnaire method has been used for this study because of its flexibility in gathering relevant information on a wide range of topics and sample sizes. It also represents an efficient data collection mechanism where the researcher understands the requirements and measurements of the variables. Besides, each of the

questionnaires has been carefully validated together with face-to-face interviews by the researcher during the questioning process. The interviews were conducted to ensure legitimate measurement of valid data is used in this research. The questionnaires were divided into four sections. Section 1 was intended to collect information about the respondents, while section 2, 3, and 4 was meant to collect information for analysis. (Table 4)

Table 4. Section divided in the survey as tabulated below.

Section	Objectives
Section 1	Demographic – identify the information about the respondent and companies
Section 2	Customers Information- identify the customer's preference on types of material, design
Section 3	Operation Information's-identify how regularly the manufacturing process has been managed.
Section 4	Scrap Management – identify how the manufacturers managed the scrap during the making process.

Each section refers to the respondent's knowledge about gold scrap and methods used in jewellery fabrication. The data is then analyzed and undergone a tight process with close monitoring, structured testing and data tracking through SPSS for Interview/Questionnaires result. The set of questionnaires was randomly distributed to 139 Jeweler's House in 9 districts in Kelantan state.

7. Finding Analysis

Figure 5. Awareness of the gold losses during the fabrication stage

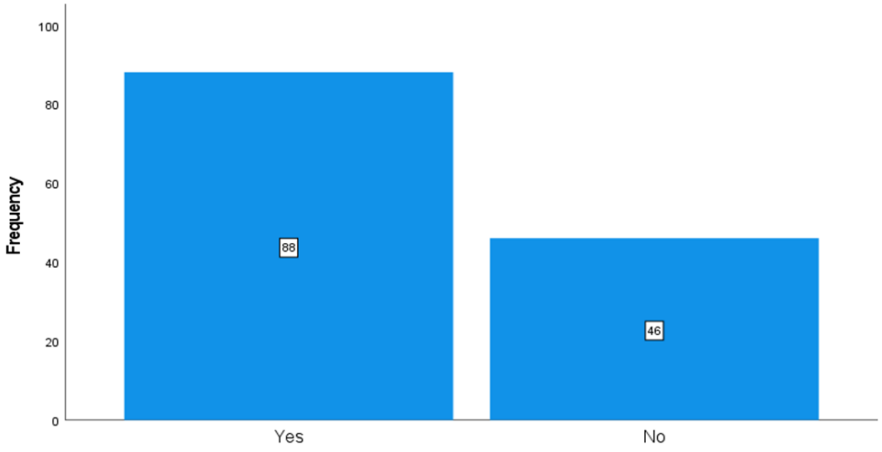

Table 5. Awareness of the gold losses during the fabrication stage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	88	63.3	65.7	65.7
	No	46	33.1	34.3	100.0
	Total	134	96.4	100.0	
Missing	99	5	3.6		
Total		139	100.0		

Based on the survey in Table 5 and Figure 5, we can see the level of awareness of gold losses during the fabrication stage produced in the premises by the owners. The valid status for this question is 134 cases out of 139 with 100.0 percent. Whereas missing status is 5 cases with 3.6 cents. From the table, the highest awareness of respondents on gold losses during the fabrication process is 'Yes' with 63.3 percent. The frequency for Yes is 88 cases out of 139. Whereas, for 'No', the frequency is 46 cases out of 139 with 33.1 percent.

Figure 6. Any action has been taken to minimize the losses.

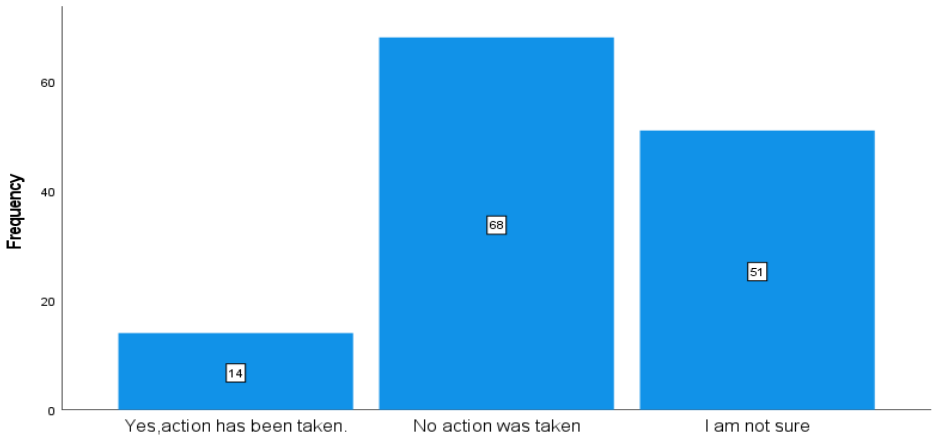

Table 6. Any action has been taken to minimize the losses.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, action has been taken.	14	10.1	10.5	10.5
	No action was taken	68	48.9	51.1	61.7
	I am not sure	51	36.7	38.3	100.0
	Total	133	95.7	100.0	
Missing	99	6	4.3		
Total		139	100.0		

Based on the survey in Table 6 and Figure 6, the result shows the respondents respond towards the gold losses during the jewellery making process. The answer is divided into 3 which are 'Do action', 'Non-Action' and 'I am not sure'. From the table, the results show that the valid answer is 133 cases out of 139 with 100.0 valid percent. Whereas the missing status is 6 cases with 4.3 percent. The highest response is 'I am not sure' with 68 cases out of 139 whereby the valid percentage is 48.9 percent. Meanwhile, "No action was taken" in 68 cases with 48.9 percent. The lowest response is 'Yes, action has been taken' with 14 cases out of 139 with 3.1 percent.

Figure 7. Action against waste and scrap on the goldsmith's desk and other workstation

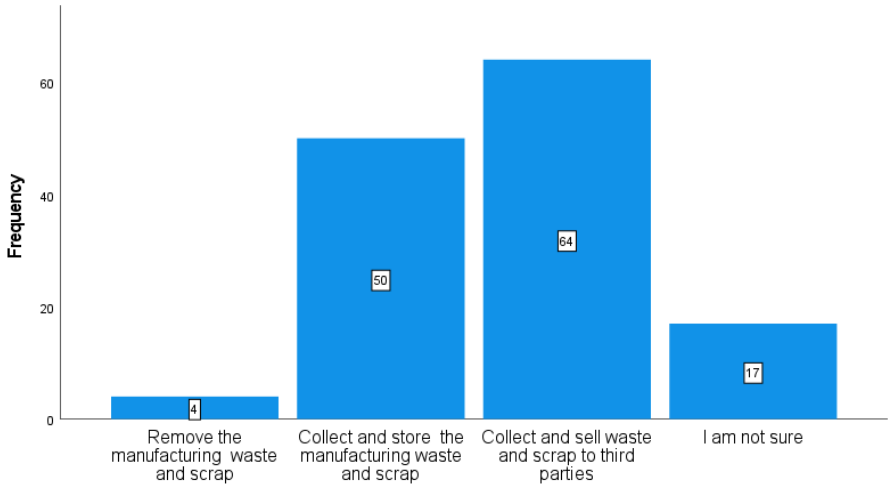

Table 7. Action against waste and scrap on the goldsmith's desk and other workstation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Remove the manufacturing waste and scrap	4	2.9	3.0	3.0
	Collect and store the manufacturing waste and scrap	50	36.0	37.0	40.0
	Collect and sell waste and scrap to third parties	64	46.0	47.4	87.4
	I am not sure	17	12.2	12.6	100.0
	Total	135	97.1	100.0	
Missing	99	4	2.9		
Total		139	100.0		

Based on the survey in Table 7 and Figure7, we can see the number of gold losses after the jewellery fabrication process. The answer is divided by 3 which are 'Remove the manufacturing waste and scrap', 'Collect and store the manufacturing waste and scrap', 'Collect and sell waste and scrap to third parties and 'I am not sure'. The valid percent for this question is 135 case out of 139 with percent cent. Whereas missing status is 4 cases with 2.9 per cent. The highest action taken toward the waste and scrap is ‘Collect and sell waste and scrap to the third parties’ with 46.0 percent and 64 cases. The second highest is ‘Collect and store the manufacturing waste and scrap with 50 cases out of 139. The percentage of ‘Collect and store the manufacturing waste and scrap’ is 36.0%percenteas the third highest is ‘I am not sure’ with 12.2 per cent and 17 cases. Meanwhile, “Remove the manufacturing waste and scrap frequency is only 4 cases with 2.9 percent.

Figure 8. The amount of gold used to produce the jewellery product in a week.

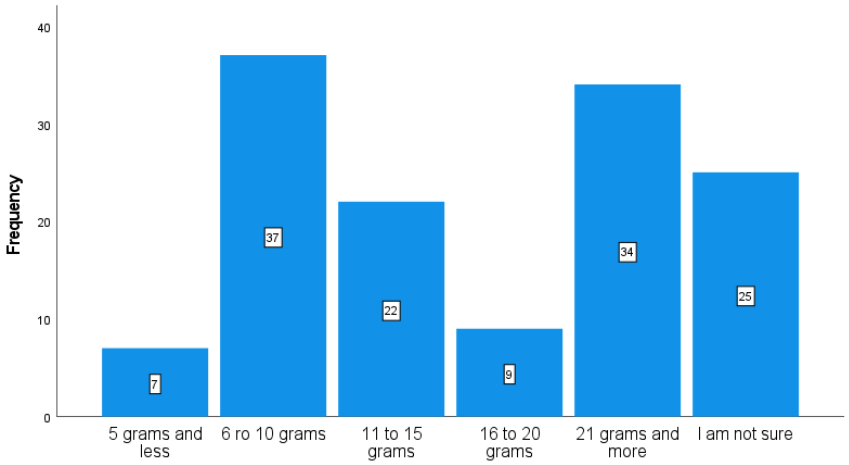

Table 8. The amount of gold used to produce the jewellery product in a week.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 grams and less	7	5.0	5.2	5.2
	6 to 10 grams	37	26.6	27.6	32.8
	11 to 15 grams	22	15.8	16.4	49.3
	16 to 20 grams	9	6.5	6.7	56.0
	21 grams and more	34	24.5	25.4	81.3
	I am not sure	25	18.0	18.7	100.0
	Total	134	96.4	100.0	
Missing	99	5	3.6		
Total		139	100.0		

Based on the survey in Table 8 and Figure 8, the result shows the quantity of gold used to produce the jewellery product in a week. The answer is divided into 6 groups which are ‘5 gram and less’, ‘6 to 10 grams’,

'11 to 15 grams', '16 to 20 grams', '21 grams and more' and 'I am not sure'. The table and figure show that the highest quantity of gold used to produce a product a week is '6 to 10 grams' with 26.6 percent. The frequency for '6 to 10 grams' is 37 cases out of 139. The second rank is '21 grams and more' with 34 cases equivalent to 24.5 percent. The percentage for 'I am not sure' is 18.0 percent with 25 cases. The fourth rank is '11 to 15 grams' with 15.8 percent. The frequency for '11 to 5 grams is 22 cases out of 139. Meanwhile, '16 to 20 grams' is only 9 cases with 6.5 percent. The lowest quantity of gold used in a week for jewellery making is 5 grams and less with 5.0 percent. The frequency for '5 grams and less is only 7 10 cases out of 139.

Figure 9. Quantity of gold losses after every fabrication stage

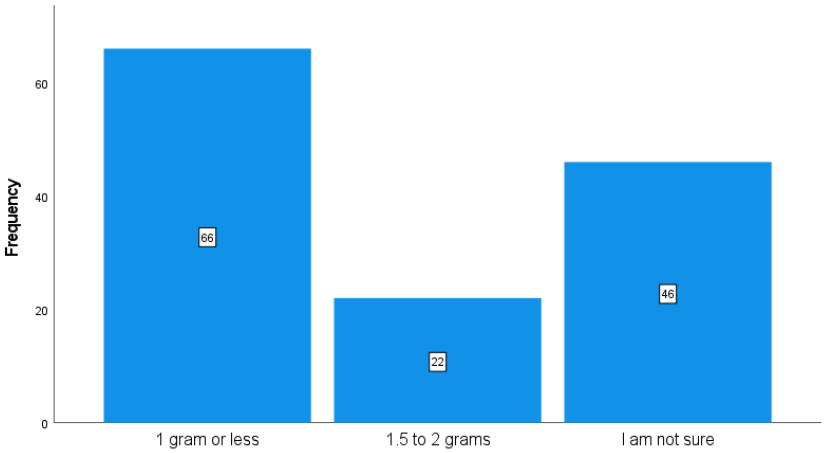

Table 9. Quantity of gold losses after every fabrication stage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 gram or less	66	47.5	49.3	49.3
	1.5 to 2 grams	22	15.8	16.4	65.7
	I am not sure	46	33.1	34.3	100.0
	Total	134	96.4	100.0	
Missing	99	5	3.6		
Total		139	100.0		

Based on the survey of Table 9 and Figure 9, the result shows the number of gold losses after the fabrication process. The answer is divided by 3 which is 1 gram or less and 1.5 to 2 grams and 'I am not sure'. The valid result for this question is 134 cases out of 139 with 100.0 percent. Whereas missing status is 5 cases with 3.6 percent. The highest quantity of gold losses after fabrication processes a week is 1 gram and less with 47.5 percent. The frequency of 1 gram and less is 66 cases out of 139. Whereas the second highest of gold losses is 'I am not sure' a week with 33.1per cent and 46 cases. On the other hand, 1.5 to 2 grams frequency is 22 cases with 15.8 percent.

8. Discussion and Conclusion

The good systems and procedures implemented in the workplace will significantly reduce the loss of gold in the long run for the manufacturers. Generally, when dealing with gold, some manufacturers habitually aware of the value of the materials but the action is taken does not meet the standards. Rarely, data of the material used before and after the making process is being documented and analyzed systematically and precisely in small and medium scale companies as the process involves high cost and expertise to run. However, in ensuring the stability and sustainability of the company the manufacturers must start to evolve with the new system, technology, and procedures in dealing with gold losses. From the results, we can see the number frequency of 'unknown' action to solve the minimize the gold losses, the action was taken against the waste and gold scrap, and the number of gold losses during the fabrication process is quite high. We can conclude the fabricator not following the procedures on gold collecting scrap as the frequency of gold losses is high.

A model to identify the right root cause, analysis and how to improve the process of gold collecting procedure in the jewellery fabrication process must be developed to ensure the gold losses can be control and improve. The results and analysis through the investigation will be documented and enhanced with the development of standard operation procedures (SOP) specifically in scrap collecting procedures to be suggested and followed by the jewellery fabricators.

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