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BUREAU OF INDIAN STANDARDS

(New Delhi)

AGENDA

Silk and Silk Products Sectional Committee, TXD 28 **18th Meeting**

Date/Day	Time	Venue
12th December, 2024 (Thursday)	1100 h	Through Video Conferencing

Chairperson: Dr S. Periyasamy
Director (CSTRI), Bangalore

Member Secretary: Ms. Shikha Yadav
Scientist B, BIS

Item 0 WELCOME AND INTRODUCTORY REMARKS BY THE CHAIRMAN

Item 1 CONFIRMATION OF THE MINUTES OF THE PREVIOUS MEETING

1.1 The minutes of the 17th meeting of the committee held on 1st August 2024 (Tuesday) were circulated vide BIS DG letter No. TXD 28/A2.17 dated 19 September 2024. No comments were received.

1.1.1 The Committee may **APPROVE** the minutes as circulated.

Item 2 COMPOSITION AND SCOPE OF TXD 28

2.1 The present composition and scope of TXD 28 are given in **Annex 1 (Page 4 to 5).**

2.1.1 The committee may **NOTE and REVIEW.**

Item 3 ISSUES ARISING OUT OF THE PREVIOUS MEETING

3.1 A summary of actions taken on the various decisions of the 17th meeting of TXD 28 is given in **Annex 2 (Page 6).**

3.1.1 The committee may **NOTE.**

Item 4 FORMULATION OF INDIAN STANDARDS ON NEW SUBJECTS

4.1 A new work item proposal has been received on **'**Computerized Zari Testing Protocol' from Dr. S. Periyasamy, CSTRI, Bangalore to formulate an Indian standard on the subject. The technical inputs as received from CSTRI, Bangalore on the aforementioned subject is given at **Annex 3 (Pages 7 - 27).**

4.1.1 The committee may **DELIBERATE** and **DECIDE.**

4.1.2 As per the directions of the competent authority, the working group should be formed for the effective and expeditious preparation of P-drafts on the new work item proposals. In view of the above, the following list of members has been proposed based on their active contribution and valuable technical inputs on the **'**Computerized Zari Testing Protocol' during our recent committee meetings.

Working group name - **Computerized Zari Testing Protocol**

Sl. No.	Organization	Member Name
1.	Central Silk Technological Research Institute, Bengaluru	Dr. S. Nivedita and Dr. Brojeswari Das (Convenor)
2.	The Bombay Textile Research Association, Mumbai	Shri Amol Thite
3.	Karnataka State Sericulture Development Institute, Thalaghattapura	Shri A Jambunath
4.	Chamundi Textiles Silk Mills Limited, Bengaluru	Shri Venugopal
5.	Bureau of Indian Standards, New Delhi	Ms. Shikha Yadav (Member Secretary)

4.1.3 The committee may **DECIDE**.

4.2 In the last meeting of TXD 28 held on 01/08/2024, The Committee considered the new subject "**Spun Silk Grading — Method of testing for Commercial silk varieties"** for the formulation of Indian standards under the domain of TXD 28, and further decided that the technical inputs on the same shall be sought from CSTRI Bangalore, after the completion of research project for the preparation of the working draft.

The technical inputs are still awaited.

4.2.1 The committee may **DECIDE.**

4.3 In the 14th meeting of TXD 28 held on 04/01/2023, The Committee identified the new subject "Silk fabrics from highly twisted yarn" for the formulation of Indian standards under the domain of TXD 28, and further decided that the inputs on the same shall be sought from CSTRI, Bangalore for the preparation of working draft.

Properties and performance of "**Silk Chiffon Fabrics"** submitted by the BIS intern Shri. Harshit Gangwar who visited the CSTRI, Bangalore on the 30th and 31st July, 2024 is given in **Annex 4 (Pages 28 - 29).**

4.3.1 The committee may **DECIDE.**

Item 5 DATE AND PLACE OF NEXT MEETING

Item 6 ANY OTHER BUSINESS

ANNEX 1

(*Item 2.1****)***

Scope & Composition of Silk and Silk Products Sectional Committee, TXD 28

Scope: To formulate Indian Standards on terminology, methods of test, grading, specifications and packaging of all varieties of raw silk, degummed silk, silk byproducts and weighted silk including silk yarns and fabrics.

Meeting Held	**Date**
15th meeting	27/06/23 through WebEx video conference
16th meeting	14/11/23 through WebEx video conference
17th meeting	01/08/24 through WebEx video conference

S.L. No	**Organization represented**	**Name of representative Principal/Alternate**	**ATTENDANCE**
1.	Central Silk Board, Bangalore	Dr. S. Periyasamy Director, CSTRI (*Chairperson*)	3/3
2.	Anwar Silk Industries, Sidlaghatta, Karnataka	Shri Irshad Ahmed	2/3
3.	Central Silk Technological Research Institute, Bangalore	Dr. Brojeswari Das (Dr. Nivedita S)	3/3
4.	Central Silk Board, Bengaluru	Dr. P. Kumeresan	3/3
5.	Chamundi Textiles (Silk Mills) Limited, Bangalore	Shri Venu Gopal (Shri Shashi Shetty)	3/3
6.	Commissionerate of Handlooms & Textiles Amaravathi, Andhra Pradesh	Nomination Awaited	-
7.	Directorate of Handlooms & Textiles, Guwahati, Assam	Shri Ataur Rahman (Shri Naren Malakar)	1/3
8.	Directorate of Handicraft and Handloom, Kashmir, Jammu & Kashmir	Shri Imtiyaz Ahmad Dar (Shri Zahoor Ahmad Khan)	2/3
9.	Directorate of Handlooms & Textiles, Kanpur, Uttar Pradesh	Nomination Awaited	-
10.	Directorate of Textiles (Handlooms) Kolkata, West Bengal	Nomination Awaited	-
11.	Directorate of Handlooms and Textiles, Govt of Tamilnadu, Chennai	Shri Minnu Swamy	2/3
12.	Indian Silk Export Promotion Council, Mumbai	Shri Sanjeev Kumar Sharma	2/3
13.	Indian Institute of Chemical Technology, Hyderabad	Dr. Pradosh P. Chakrabarti	0/3

14.	Jaipuria Silk Mills, Bangalore	Shri Vikram Jaipuria	1/3
15.	Karnataka State Sericulture Development Institute, Bangalore	Shri A. Jambunath (Shri R. Rajanana)	2/3
16.	Khadi and Village Industries Commission, Mumbai	Shri D. Dhanpal (Shri J. K. Gupta)	1/3
17.	Lakshmi Weaving Factory, Bangalore	Shri Dinesh Pallem (Shri Ravindra Pallem)	1/3
18.	National Handloom Development Corp. Ltd., Lucknow	Shri Jitendra Tolambiya	1/3
19.	Office of the Development Commissioner for Handlooms, New Delhi	Principal, IIHT, Salem	2/3
20	Office of Director of Handlooms & Textiles, Govt. of Karnataka, Bangalore	Add Director (Textiles) (Dy Director (Ms Vrinda) Handlooms)	2/3
21.	Office of the Textile Commissioner, Mumbai	Shri Sourabh Kulkarni (Shri Pranav Parashar)	2/3
22.	Shri Ram Institute for Industrial Research, Delhi	Shri Vinay Samania (Shri Bhuvneshwar Rai)	2/3
23.	Silk Mark Organization of India, New Delhi/ Bangalore	Shri K. S. Gopal (Shri A. Subbaraj)	2/3
24	Textiles Committee, Mumbai	Shri Kartikay Dhanda (Dr. P Ravichandran)	3/3
25	The Bombay Textile Research Association, Mumbai	Ms Shital Palaskar (Shri Amol Thite)	2/3
26	The Tamilnadu Handloom Weavers' Coop Society Ltd., Chennai	Shri G Gunasekaran (Shri Alok Babelay)	1/3

ANNEX 2

(*Item* 3.1)

SUMMARY OF ACTIONS TAKEN ON THE MINUTES OF THE 8th MEETING OF TXD 38

Item No.	Decision	Action taken
2.1	Changes in scope and composition of TXD 28	The updated scope and composition are given in **Annex 1.**
4	**DRAFT STANDARDS FOR FINALIZATION**	
	Muga Raw Silk Grading and Test Methods.	Under publication
5	**RESEARCH AND DEVELOPMENT PROJECT**	
5.1	Computerized Zari Testing Protocol	Coming up for discussion under agenda **Item 4.1**
5.2 (a)	Spun Silk Grading — Method of testing for Commercial silk varieties	Coming up for discussion under agenda **Item 4.2 (a)**
5.2 (b)	Silk Fabrics from highly twisted yarns	Coming up for discussion under agenda **Item 4.2 (b)**
6	**IS 9586: 1980** Specification for silk-worm pupae oil	Archived

Annex 3

Development of Protocol for Computerized XRF-ED Zari Testing

INTRODUCTION

India produces 23K MT of mulberry silk, out of which 15K MT (2/3rd of the entire country production of mulberry silk) is used for the production of silk saree predominantly on handlooms. The prominent weaving clusters viz. Kanchipuram, Arni and Kumbakonam were once using pure gold-silver zari thread to weave the silk sarees on handlooms wherein a minimum of 240 g (1 Marc in local parlance) of zari was used along with 540 g of dyed silk to produce a silk saree of 6 meters length. During 2000, around 40,000 marcs, equivalent to 10,000 kg of zari thread was used per month for the production of pure silk sarees in Tamil Nādu as all the co-operative societies working under the fold of Tamil Nādu Handloom Department were using the pure zari to produce silk sarees. Even, the Khadi Village Industries Commission, Sarvodaya Sangha and Tamil Nādu Khadi Board were also using high-quality zari. The master weavers of Tamil Nādu were using the pure gold-silver zari. Karnataka Silk Industries Corporation has been using the pure zari thread for the production of crepe sarees since its inception. The zari thread consists of a Silk core, wrapped with flattened Silver-Copper alloy wire and electroplated with gold as shown in Figure 1. Thus, pure silk, gold, silver and copper are the constituents of the pure zari thread.

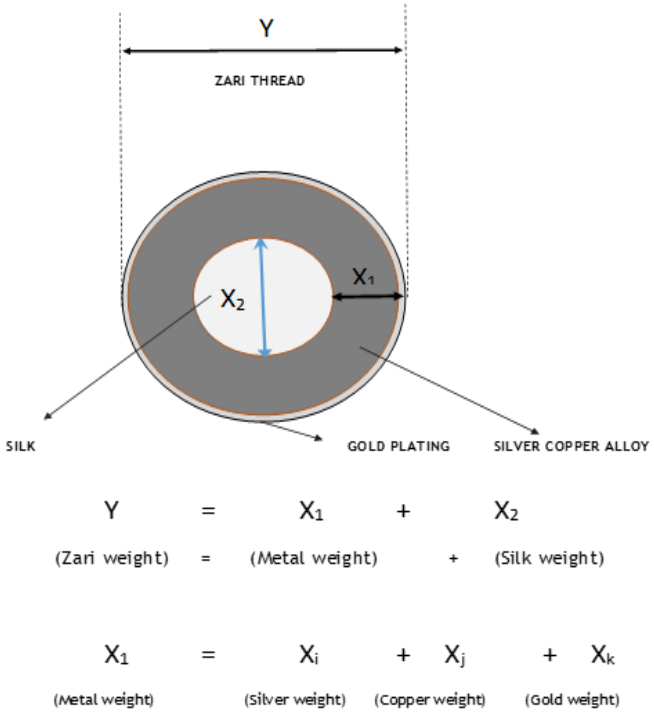


Figure-1. Schematic representation of Zari Thread

During 70^S, the cost of silver and silk were almost same and only few hundred marcs of zari was consumed in handloom. Thus, the quality of zari in terms of its constituent metals was consistent and the manufacturers, mostly from Surat, Gujarat were supplying to the master weavers and co-operative societies regularly based on mutual trust in the absence of established zari testing. The yardstick followed during those days was silver purity, Touch in local parlance that can only be cross checked by the gold-smith through his expertise/ dexterity and the procedure adopted by him was not known to validate for its correctness.

The zari is traded/ sold by weight, Marc which is equivalent to 242 g that contains 60 g of silk. When there is no much cost difference between silk and silver, the trading of zari was carried out based on silver purity which describes the percentage of silver in silver-copper alloy wire that did not make much difference. During 2000, when the precious metal cost scaled up many fold, the trading of zari thread in terms of metal purity alone couldn't be practiced and the master weavers as well as other Govt. agencies realized the importance of understanding the zari content value in terms of weight per marc in percentage and resorted to chemical zari testing (Gravimetric) in which 6 g of zari thread is tested based on BIS method 9925:1981 as shown in Figure 2 and the results in terms of constituent % are given for silk, gold, silver and copper.

The manufacturers at Surat take care of the silver-copper alloy constituents by meticulously planning the process involved in melting the silver and copper metal in furnace besides the gold plating techniques but seldom have any details about the quantity of silk used for the production of zari. Even, they don't cross check the denier of the silk thread, very fine raw silk, plied, twisted, degummed and dyed, used for the production of zari thread. The process of winding the zari thread on the bobbin is controlled by the weight of zari thread but not by its length. More clearly, the bobbin can hold 60 g of zari thread that may have 4600 ~ 5000 meter of zari thread. In general, the length of zari thread should be 4800 meter as per the calculation, thus, the manufacturer will be incurring losses if he supplies 5000 m length of zari thread per bobbin and will be making profit if he supplies 4800 m of zari thread per bobbin for a given silver-copper alloy.

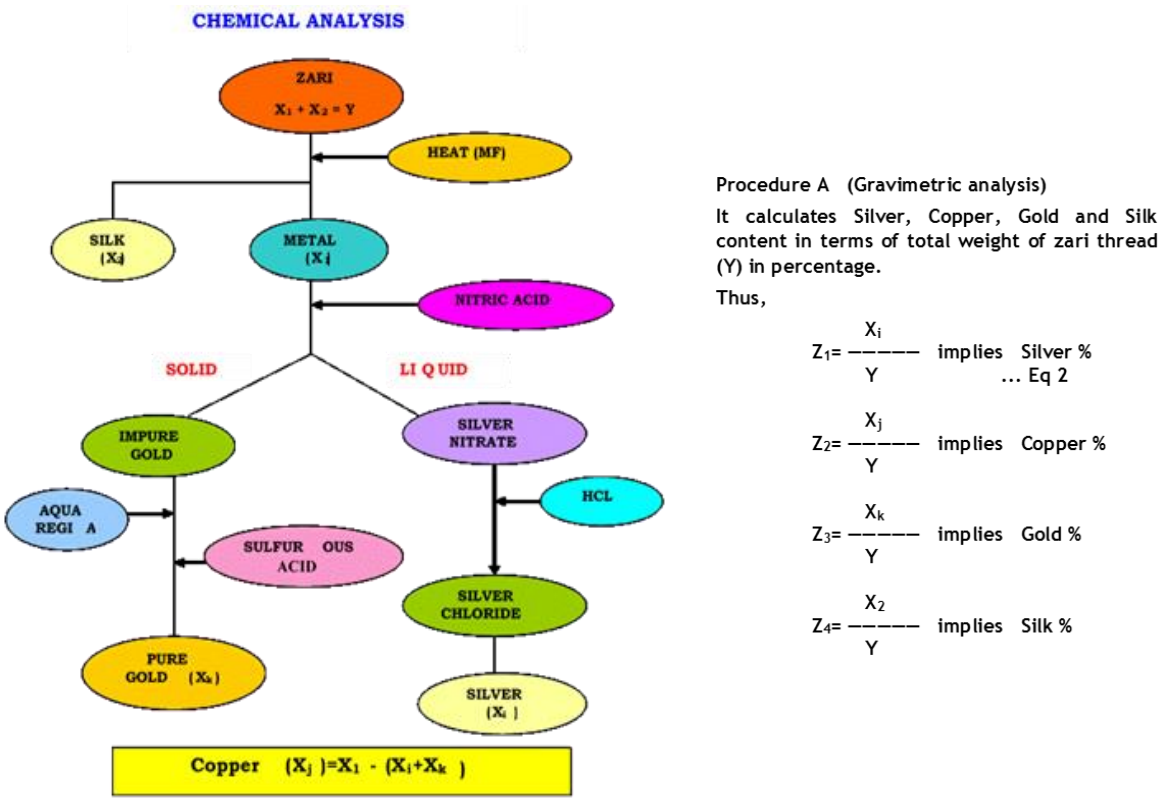


Figure-2. Gravimetric Analysis of Zari thread

The following zari test results obtained through chemical analysis as shown in Table 1 indicate that sample A is having higher silver content and deserves better price when compared to sample B and C. But the zari suppliers/ manufacturers insist that all the zari samples have same silver purity, Touch in local parlance and want the same price for all the zari samples.

Table 1.Zari Content and Silver purity value of zari thread

Sample	Silk	Metal	Gold	Silver	Copper	Silver Purity
	(X_2)	**(X_1)**	**(X_k)**	**(X_i)**	**(X_j)**	**(X_i/ X_1)**
A	20	80	0.5	50	29.5	62.5
B	24	76	0.5	47.5	28	62.5
C	28	72	0.5	45	26.5	62.5

Moreover, the above samples as per the calculation would have the alloy content and silk content in grams as well as zari thread length per bobbin as mentioned in Table 2. It is evident that the sample A has higher length of zari thread in a bobbin due to finer silk used in zari manufacturing.

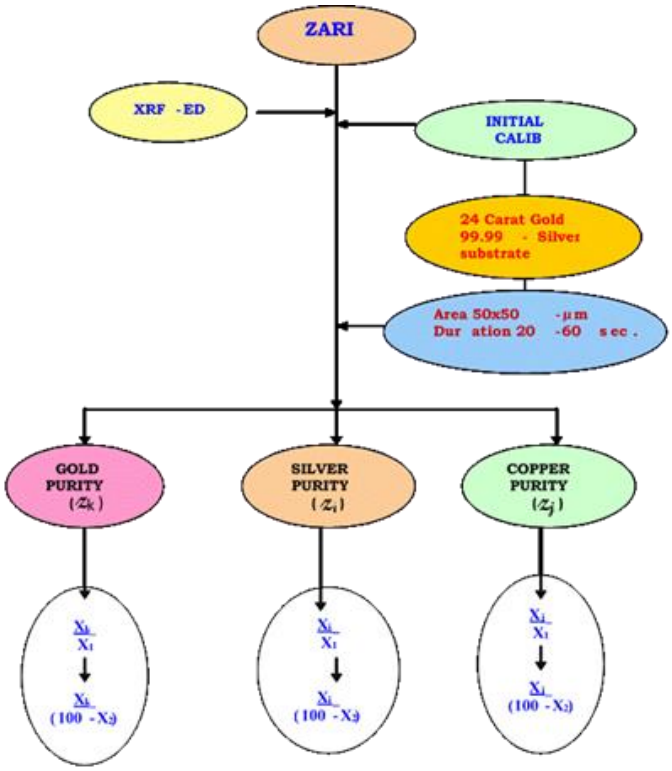
Table 2. Content, Linear density and length of zari thread

Sample	Silk Content %	Silk Linear Density		Silk Weight/ Bobbin (g)	Alloy Weight/ Bobbin (g)	Length / Bobbin (g)
	(X_2)	**(d)**	**(d)**			
A	20	13/15	22	12.1	48.4	5000
B	24	16/18	27	14.5	46	4800
C	28	20/22	33	16.94	43.56	4600

Thus, if the targeted zari quality is B and if the manufacturer endups with quality A, he will be incurring losses but the master weaver would be gaining. If the zari manufacturer produces quality C in place B, then he would be making profit and the master weaver would be making losses. Thus, efforts were made to educate the zari manufacturers to have stringent process and quality control measures in place and the master weavers were asked to purchase the zari thread based on zari content values instead of silver metal purity value (Touch). Now, it is reality in the silk industry that the zari is transacted on its content value instead of silver purity value. Even the Government of Tamil Nādumade it mandatory to transact the zari thread only on content basis.

The chemical zari testing requires 2 days' time to complete the gravimetric analysis of the zari sample and thus could test 600 samples per annum that compelled Central Silk Board (CSB) is a Statutory body established in 1948 by an Act of Parliament working under the administrative

control of Ministry of Textiles, Government of India to introduce computerized zari testing at Kanchipuram during 2007 which works on XRF-ED principle as depicted in Figure 3 that confirms to DIN 50987 and ISO 3497 standards. The computerized zari testing machine is supplied with in-built software that estimates the Gold, Silver and Copper content of the zari after initial calibration of the machine with 24 Carat Gold and 99.99% pure Silver standards supplied along with the instrument and the copper is estimated by default. The in-built software supplied can be programmed for various substrates say zari in Bobbin, zari in Saree etc. with different modules available as Applications in which the calibration has to be carried out by feeding the chemical analysis data of known zari thread by covering the entire range of zari thread being manufactured and supplied. Earlier, 70% silver (92% Touch) to 40% silver (52% Touch) zari threads were available in the market with 0.4 to 0.65% gold content. Thus, the zari testing method was calibrated with 50 nos. chemical test results and whenever different quality of the zari sample was traced in chemical testing / encountered in the market, immediately, the chemical test results were fed to the computerized zari testing machine as purity value by scanning the new sample.



Procedure B (XRF- ED)

It calculates Silver, Copper and Gold content in terms of total weight of metal (X_1) in percentage. (Touch in local parlance)

Thus,

$$Z_1 = \frac{X_i}{X_1} \text{ implies Silver \%} \quad \text{... Eq3}$$

$$Z_2 = \frac{X_j}{X_1} \text{ implies Copper \%}$$

$$Z_3 = \frac{X_k}{X_1} \text{ implies Gold \%}$$

Figure 3. Computerized XRF-ED testing

Thus, the chemical analysis data available in the form of zari content values has to be converted into Metal purity value. These metal purity values are to be fed to the zari equipment during

calibration while scanning the known sample to create the data base. The system estimates the metal purity value of the known sample based on the Silver-Copper alloy as well as gold foil library created by the manufacturersand ask the operator during calibration to feed the metal purity value based on the chemical analysis. The system software creates a regression equation based on the metal purity values of computerized zari testing and chemical testing methods and finally arrives at the probable metal purity values of the zari thread viz. Silver, Copper and Gold purity.

If the zari weight is Y g that contains X_1 g of Metal and X_2 g of Silk, then X_1 g of metal contains X_i g of Silver, X_j g of Copper and X_k g Gold. Thus, $X_1 = X_i + X_j + X_k$. The purity of the metals has to be calculated using the formulae $z_1 = [X_i / X_1]$, $z_2 = [X_j / X_1]$, $z_3 = [X_k / X_1]$ and the content value of the constituents has to be calculated using the formula $Z_1 = [X_i / Y]$, $Z_2 = [X_j / Y]$, $Z_3 = [X_k / Y]$. Thus, by combing the above formulae, we can rewrite $Z_1 = z_1 [1-(X_2/Y)]$, $Z_2 = z_2 [1-(X_2/Y)]$, $Z_3 = z_3 [1-(X_2/Y)]$ as explained in Figure 4. Thus, by using the aforesaid formulae the chemical test results, Zari content values are converted to Metal purity value and are fed to the computerized zari testing machine during the calibration while developing the application for a particular substrate module viz. Bobbin and Saree. In the same way, the metal purity values estimated by the computerized zari testing machine are converted back by assuming the X_2 value which is nothing but the silk content.

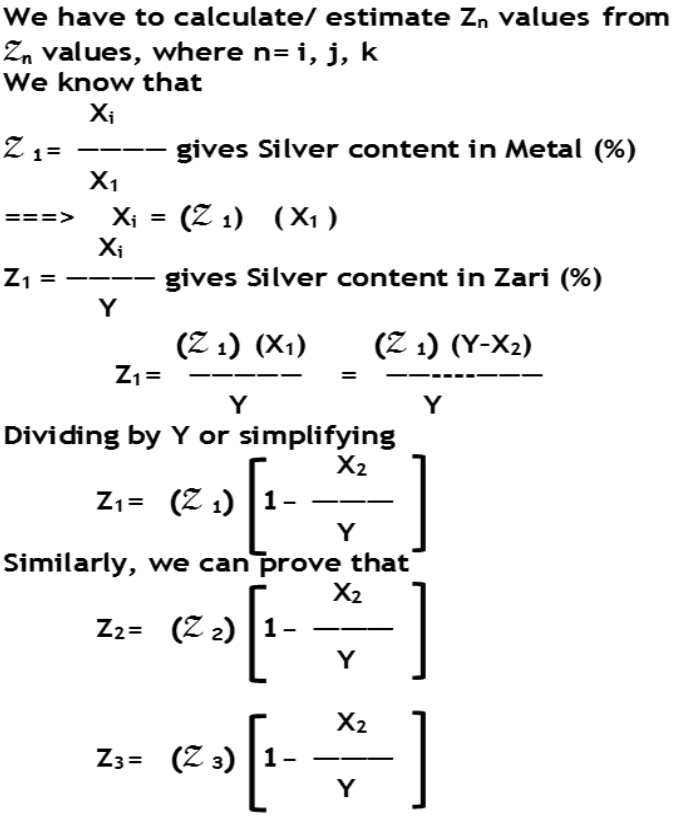


Figure 4. Conversion of computerized zari testing metal purity values to Zari content value

As discussed earlier by referring Table 1 and 2, if you assume X_2= 24%, then the Sample A may not fetch the price commensurate with the quality and the sample C may fetch better price. Thus, efforts are required to be made in assuming the X_2 value while converting the Metal purity values as Zari content values as the complete industry has started the zari trade practices using zari content values. Efforts should be made to educate the zari manufacturer in using the consistent quality zari so as to get the Chemical testing results and computerized zari test results more are less same with the required length of zari per bobbin that weighs around 60.5 g.

Nowadays, the zari manufacturers have resorted to use metal alloy with 25% to 85% silver purity besides using 0.1~ 0.2% gold. Thus, the complete data base of the chemical testing (Gravimetric method) has to be created for the wide range of zari available in the market, calibrate the computerized zari testing equipment with the chemical analysis data, fine tuning the regression analysis to get the best fit, reproduce the Chemical analysis results from the computerized zari testing analysis test results which is the metal purity value to the zari content value by assuming the silk %. Thus, it was envisaged to initiate a research project to develop the protocol for computerized zari testing and validate the same in consultation with the industry partners, besides

grading of zari based on its content values into different grades. The main objective of this research project is to 1)Study the characteristics of commercial zari threads in terms of content and purity, 2) Calibrate the computerized zari testing machine with Data of Gravimetric analysis, 3) Develop the protocol using Artificial Intelligence (AI) tool to determine the zari content values and its validation and 4) Recommend the zari testing / grading standards to the appropriate authority for further popularization.

EXPERIMENTAL

Materials and Methods

Sixty-eight pure zari thread samples each weighing 15 g were sourced randomly from the Master Weavers, Traders and Manufacturers at free of cost. Each sample was divided into three parts weighing 5 g each. The first part was subjected to gravimetric analysis as per BIS standard test method, the second part to computerized zari testing analysis as per DIN standard test method (M/s. Helmut Fischer GMBH, Germany. X-ray tube; Max Anode Current: 1mA, Voltage: 50KV, Wattage: 50Watts, Current Settings: 0 to 1000 µA; Measurement Condition: Air) and the third part to volumetric analysis as per BIS standard test method. The test results were compared after converting to the metal purity values as per the procedure discussed earlier and statistical analysis carried out with Minitab18 software.

In order to ascertain the randomness of the sample drawn, the Chi-square goodness of fit for all the four parameters viz. Silk, Gold, Silver and Other metal content was carried out. To improve the data information apropos the normality (Goodness of fit), the following analysis were carried out

1. Outlier Test using Minitab 18 statistical analysis tool –Grubbs Test.
2. Data transformation using Box-cox method
3. Central Limit theorem using Python programming

To improve the consistency and repeatability in testing, the two types of computerized zari testing equipment were calibrated with Gravimetric data and the results after the calibration was statistically analyzed.

Also, to convert the metal purity values found through computerized zari testing technique to the zari content values of the metal, the silk content (X2) has to be estimated. Since, the silk content

values is continuous, it is considered as the regression model and K-Nearest Neighbour (KNN) algorithm was used to estimate the silk content value.

The data generated was utilized to arrive at different grades for Gold and Silver content in zari as percentage and different categories for silk content in zari as percentage using the empirical formula of the normal distribution curve based on the probability distribution. The said grading and categorization were discussed with the master weavers through interaction programs organized during March 22 and April 22 and the feedback from the stake holders were obtained through online Google forms. The grading methodology was modified, based on the feedback, and incorporated in the proposed testing and grading method for the computerized zari testing.

RESULTS AND DISCUSSION

Characteristics of commercial zari threads

The descriptive statistics of all the four parameters/constituents of pure zari samples tested as per the gravimetric analysis are given in Table 3. It is evident that the silk content in zari varies from 17 – 25%. Thus, it can be inferred that the zari samples having less silk content shall have more metal (silver-copper alloy) content for a given unit weight of zari thread that should fetch better price when compared to the zari thread sample having more silk content.

Table 3. Descriptive statistics of the Zari samples

N = 68	Silk	Gold	Silver	Others
Minimum	16.96	0.04	12.80	4.34
Maximum	25.18	0.58	70.07	67.35
Mean	20.38	0.22	26.37	53.04
SD	1.78	0.12	9.39	10.32

Normality

The Chi-square goodness of fit test was carried for all the four constituents of the pure zari thread samples that were tested as per the gravimetric analysis.

Silk Content

The chi-square value and the probability distribution curve on the expected and observed frequency are given in Figure 5. It is evident from the chi-square value that the Silk content of the

zari thread samples tested is not significant as the calculated p value is 0.666 that is more than 0.01(significant at 99%) and the observed frequency forms the normal distribution curve.

SAMPLE SIZE =	68					
MINIMM =	16.96					
MAXIMUM =	25.18					
RANGE	8.22					
CELL LENGTH	1.16		RANGE/(1+3.322*LOG N)			
NUMBER OF CELL	7.09	7	RANGE/CELL LENGTH			
COORECTED CELL LENGTH	1.17					
MEAN =	20.38					
STANDARD DEVIATION=	1.78					
						CHI SQUARE
CELL NUMBER	CELL START	CELL END	PROBABILITY	EXP [E]	OBS [O]	(E-O)^2/E
1st CELL	16.96	18.13	0.0762	5	7	0.638
2nd CELL	18.13	19.31	0.1704	12	12	0.015
3rd CELL	19.31	20.48	0.2500	17	22	1.471
4th CELL	20.48	21.66	0.2407	16	12	1.164
5th CELL	21.66	22.83	0.1520	10	9	0.173
6th CELL	22.83	24.01	0.0630	4	4	0.019
7th CELL	24.01	25.18	0.0171	1	2	0.601
			0.9694	65.9159	68.0000	4.0809
					DF (#CELL-1)	6
					P VALUE =	0.666

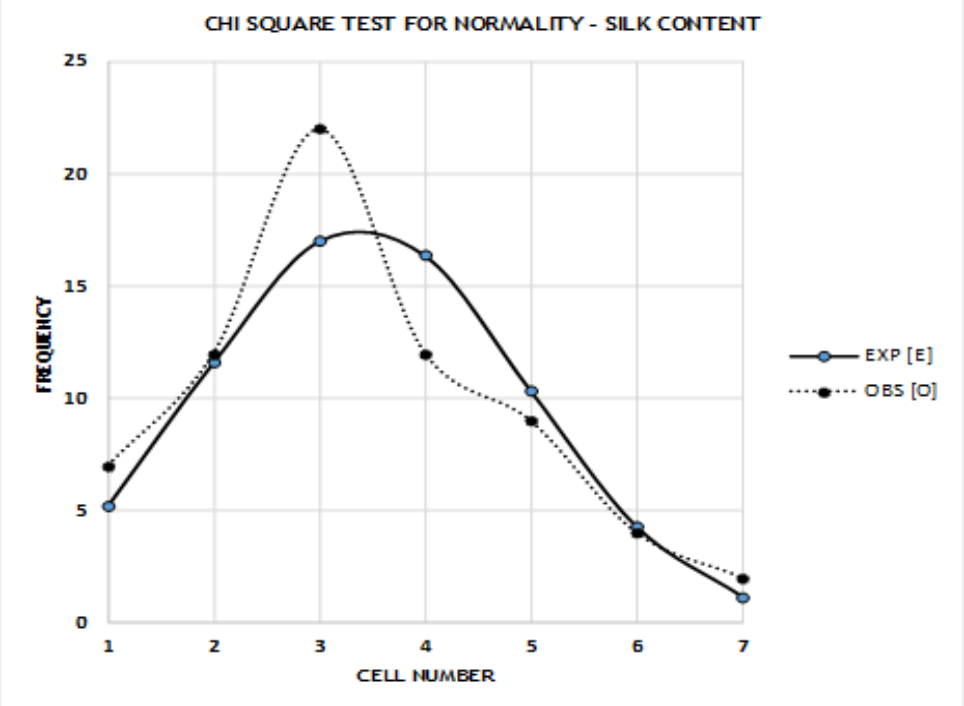


Figure 5. Chi-Square Normality Test of Silk content in Zari thread

Gold Content

The chi-square value and the probability distribution curve on the expected and observed frequency are given in Figure 6. It is evident from the Chi-square value that the Gold content of the zari thread samples tested is not significant as the calculated p value is 0.015 that is more than 0.01 and the observed frequency forms the normal distribution curve.

SAMPLE SIZE =	68					
MINIMM =	0.04					
MAXIMUM =	0.58					
RANGE	0.54					
CELL LENGTH	0.08		RANGE/(1+3.322*LOG N)			
NUMBER OF CELL	7.09	7	RANGE/CELL LENGTH			
COORECTED CELL LENGTH	0.08					
MEAN =	0.22					
STANDARD DEVIATION=	0.11					
						CHI SQUARE
CELL NUMBER	CELL START	CELL END	PROBABILITY	EXP [E]	OBS [O]	(E-O)^2/E
1st CELL	0.04	0.12	0.1231	8	11	0.826
2nd CELL	0.12	0.19	0.2304	16	16	0.007
3rd CELL	0.19	0.27	0.2707	18	23	1.145
4th CELL	0.27	0.35	0.1997	14	12	0.184
5th CELL	0.35	0.43	0.0925	6	1	4.450
6th CELL	0.43	0.50	0.0269	2	3	0.752
7th CELL	0.50	0.58	0.0049	0	2	8.352
			0.9482	64.4792	68.0000	15.7166
					DF (#CELL-1)	6
					P VALUE =	0.015

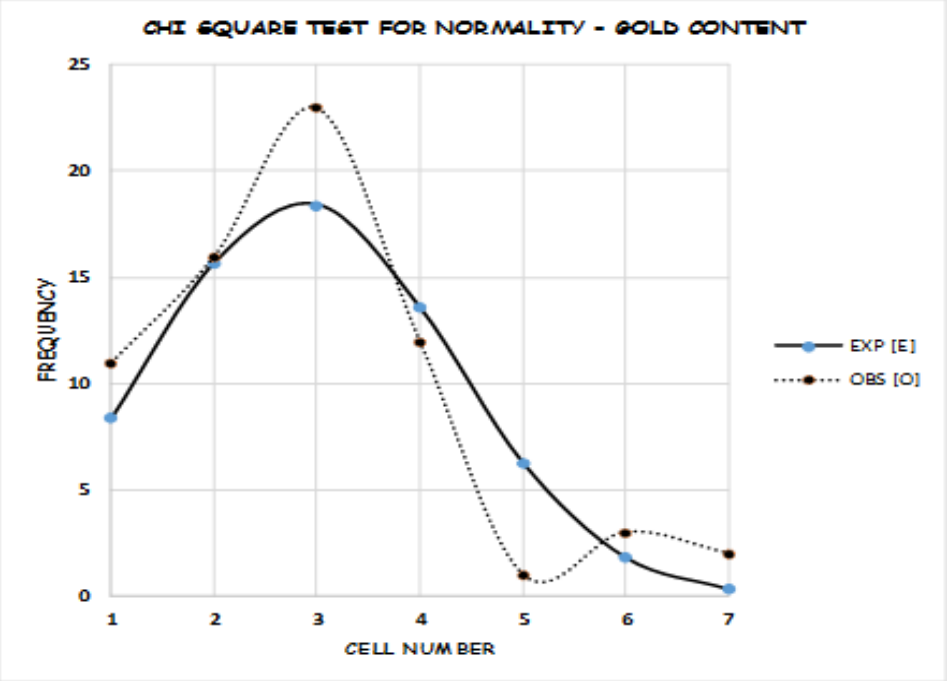


Figure 6 Chi-Square Normality Test of Gold content in Zari thread

Silver Content

The chi-square value and the probability distribution curve on the expected and observed frequency are given in Figure 7. It is evident from the chi-square value that the Silver content of the zari thread sample tested is significant as the calculated p value is less than 0.05 and the observed frequency doesn't form the normal distribution curve.

SAMPLE SIZE =	68					
MINIMIM =	12.80					
MAXIMUM =	70.07					
RANGE	57.27					
CELL LENGTH	8.08		RANGE/(1+3.322* LOG N)			
NUMBER OF CELL	7.09	7	RANGE/CELL LENGTH			
COORECTED CELL LENGTH	8.18					
MEAN =	26.37					
STANDARD DEVIATION=	9.39					
						CHI SQUARE
CELL NUMBER	CELL START	CELL END	PROBABILITY	EXP [E]	OBS [O]	(E-O)^2/E
1st CELL	12.80	20.98	0.2089	14	9	1.906
2nd CELL	20.98	29.16	0.3338	23	47	26.012
3rd CELL	29.16	37.34	0.2617	18	4	10.697
4th CELL	37.34	45.53	0.1006	7	6	0.103
5th CELL	45.53	53.71	0.0189	1	0	1.284
6th CELL	53.71	61.89	0.0017	0	0	0.117
7th CELL	61.89	70.07	0.0001	0	2	767.845
			0.9257	62.9476	68.0000	807.9646
					DF (#CELL-1)	6
					P VALUE =	0.000

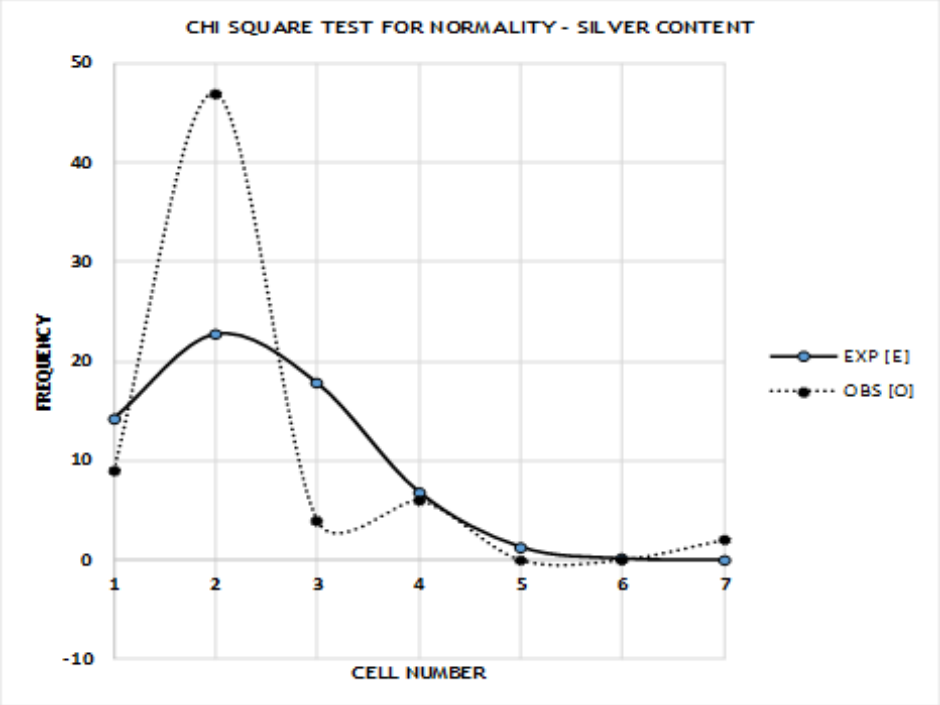


Figure 7 Chi-Square Normality Test of Silver content in Zari thread

Thus, it can be inferred that only Silk and Gold content in zari thread form the normal distribution curve whereas Silver in zari thread didn't form the normal distribution curve and hence require more samples. The Silver and copper are interrelated as the outer sheath of the zari is silver copper alloy.

Outlier Test

The outlier test (Grubbs test) in respect of the Gold and Silver content was carried out and found that the silver content showed that there are two sample values that are outlier as shown in Figure 8, but in real sense the production of that particular Silver content quality zari thread is being manufactured and is being used by the reputed master weavers and hence the outlier values are not due to sampling error.

Figure 8. Chi-Square Normality Test of Silver content in Zari thread

Data transformation

The lambda (λ) value assumed for the data transformation as per Box-Cox method are given in Table 4. The p value of chi-square test in respect of Gold content improves considerably as high as 0.89 when λ = 0.5 as shown Figure 9. In the same way, the p value of chi-square test for Silver content didn't improve when λ =-1.0 as shown in Figure 10 but the bell shape curve in normality in goodness of fit is almost equivalent to normal distribution curve.

Table 4 – Data transformation; Box-cox method

Lambda λ	Standard transformation
- 3	Inverse cube
- 2	Inverse square
- 1	Inverse
- 0.5	Inverse square root
0	Logarithmic
0.5	Square root
1	No transformation
2	Square
3	Cube

SAMPLE SIZE =	68					
MINIMIM =	0.20					
MAXIMUM =	0.76					
RANGE	0.56					
CELL LENGTH	0.08		RANGE/(1+3.322* LOG N)			
NUMBER OF CELL	7.09	7	RANGE/CELL LENGTH			
COORECTED CELL LENGTH	0.08					
MEAN =	0.46					
STANDARD DEVIATION=	0.12					
						CHI SQUARE
CELL NUMBER	CELL START	CELL END	PROBABILITY	EXP [E]	OBS [O]	(E-O)^2/E
1st CELL	0.20	0.28	0.0525	4	3	0.092
2nd CELL	0.28	0.36	0.1411	10	9	0.037
3rd CELL	0.36	0.44	0.2412	16	15	0.120
4th CELL	0.44	0.52	0.2623	18	23	1.494
5th CELL	0.52	0.60	0.1815	12	12	0.010
6th CELL	0.60	0.68	0.0799	5	4	0.379
7th CELL	0.68	0.76	0.0224	2	2	0.151
			0.9811	66.712	68.000	2.2821
					DF (#CELL-1)	6
					P VALUE =	0.892

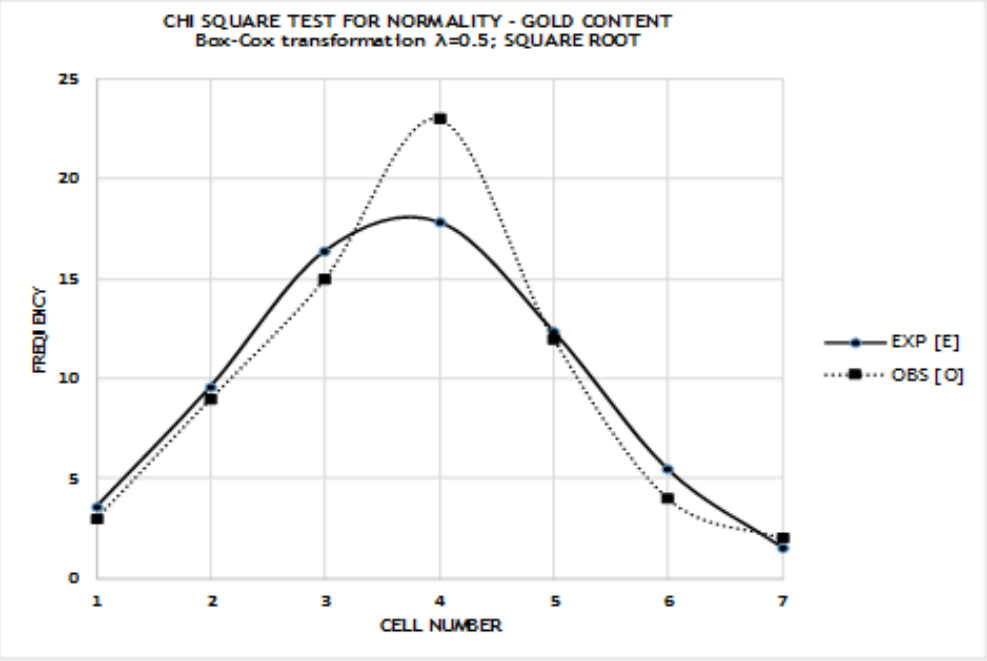


Figure 9. Chi-Square Normality Test of Gold content in Zari thread; Box-Cox data transformation with $\lambda = 0.5$ (Square root)

SAMPLE SIZE =	68					
MINIMM =	0.0143					
MAXIMUM =	0.0781					
RANGE	0.0639					
CELL LENGTH	0.0090		RANGE/(1+3.322* LOG N)			
NUMBER OF CELL	7.0876	7	RANGE/CELL LENGTH			
COORECTED CELL LENGTH	0.0091					
MEAN =	0.0412					
STANDARD DEVIATION=	0.0109					
						CHI SQUARE
CELL NUMBER	CELL START	CELL END	PROBABILITY	EXP [E]	OBS [O]	(E-O)^2/E
1st CELL	0.0143	0.0234	0.0449	3	2	0.361
2nd CELL	0.0234	0.0325	0.1623	11	9	0.377
3rd CELL	0.0325	0.0416	0.3033	21	32	6.271
4th CELL	0.0416	0.0508	0.2931	20	16	0.775
5th CELL	0.0508	0.0599	0.1464	10	5	2.468
6th CELL	0.0599	0.0690	0.0378	3	1	0.957
7th CELL	0.0690	0.0781	0.0050	0	3	20.769
			0.9928	67.510	68.000	31.9776
					DF (#CELL-1)	6
					P VALUE =	0.000

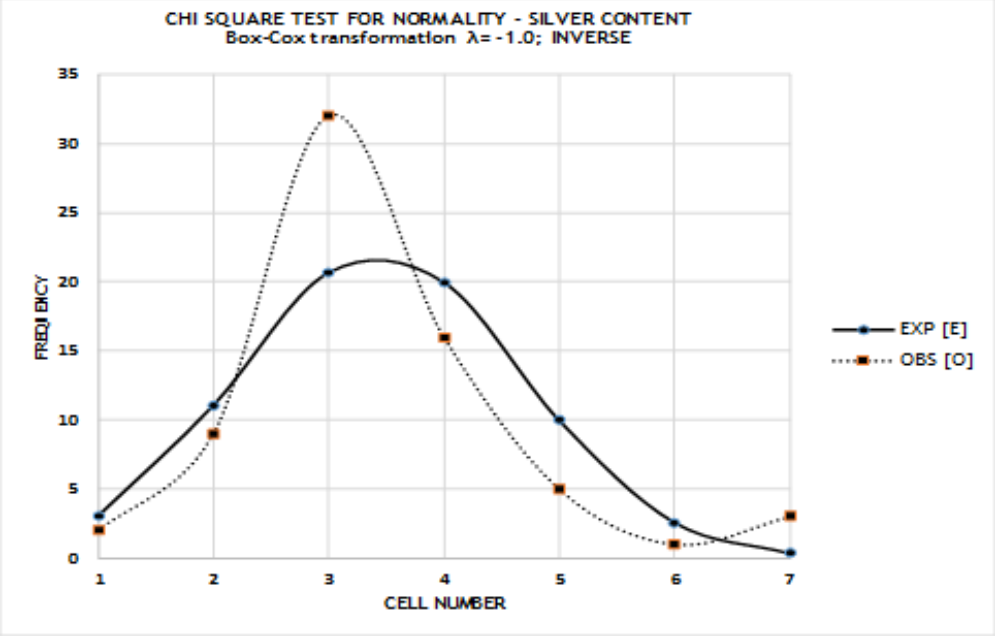


Figure 10 Chi-Square Normality Test of Silver content in Zari thread; Box-Cox data transformation with λ = -1.0 (Inverse)

Central Limit Theorem

The Silver content data with and without outlier values were analyzed based on Central Limit Theorem using the Python software and the results are given in Figure 11. It is evident that the Silver content values in the range 42 ~ 64% in the case of with outlier values and Silver content values in the range 27.5 ~ 31% in the case of without outlier values are missing and the said range

samples needs to be collected and tested so as to get the insignificant p value of chi-square test in the goodness of fit.

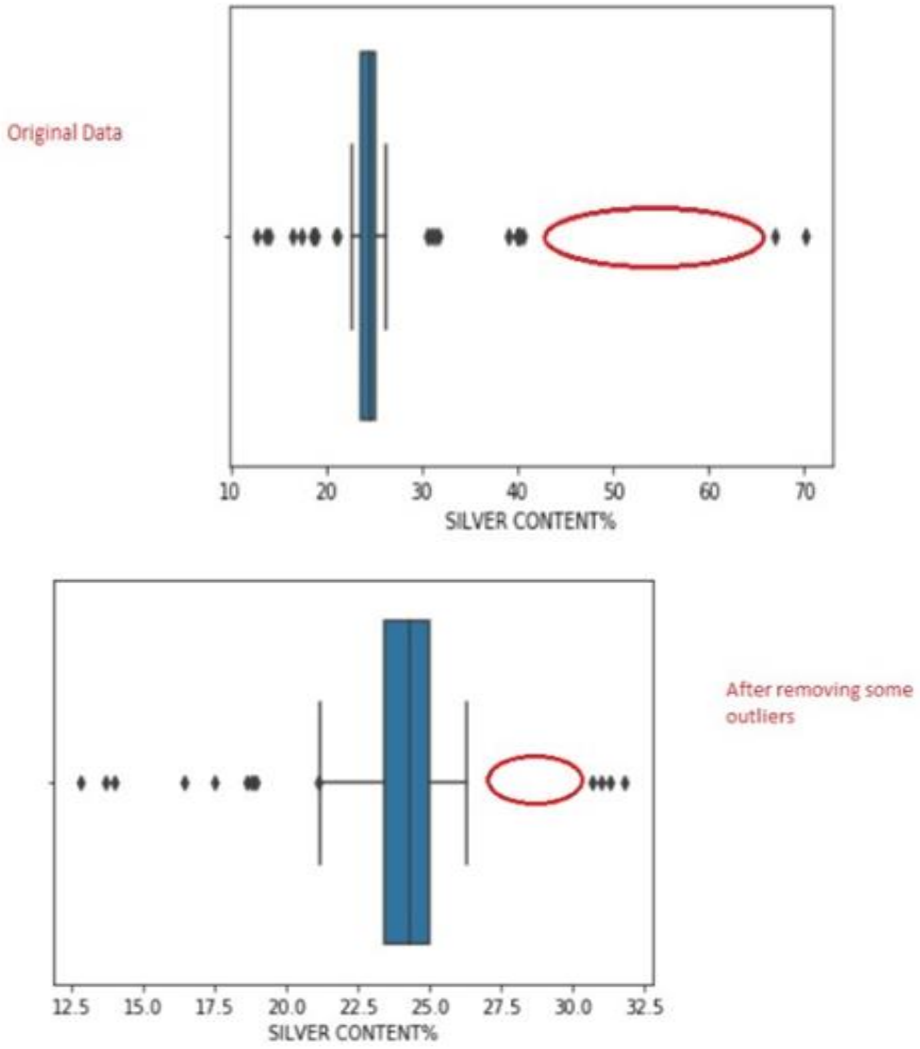


Figure 11 Chi-Square Normality Test of Silver content in Zari thread; Central Limit Theorem with and without outliers

Based on the findings of the Central Limit Theorem that states that the distribution of a sample variable approximates a normal distribution (i.e., a “bell curve”) as the sample size becomes larger, assuming that all samples are identical in size, and regardless of the population's actual distribution shape. Thus, it is decided to source fifteen more samples from the manufacturers to make the Silver content to represent the population that follows the normal distribution. Since the algorithm used

in Artificial Intelligence doesn't require the data to form a particular distribution, it is decided to explore other objectives of the research study.

Calibration of computerized zari testing **equipment**

The gravimetric data available in respect of 68 samples was utilized to calibrate the computerized zari testing machine. The statistical analysis of metal purity values before and after the calibration in respect of two types of equipment that are considered under this research project are given in Table 5. It is evident that the results after calibration have improved significantly as it is almost equal to the gravimetric analysisas the p value of paired t-test is not significant that denotes the results obtained in computerized zari testing analysis are at par with the gravimetric analysis. The correlation coefficient is also very significant for all the three parameters. Also, the collimator size in respect of a particular type of computerized zari testing equipment has influenced the test parameter which are shown in table. Thus, both the computerized zari testing machines are now able to test the zari samples for its metal purity values with higher precision that are comparable with gravimetric analysis converted metal purity values.

Table 5. Statistical analysis before and after calibration

XRF-ED Instrument	Kanchipuram			Bangalore		
Parameter	Gold	Silver	Copper	Gold	Silver	Copper
A. Before calibration						
Correlation; r-value	0.13	0.79	0.84	0.18	0.69	0.74
Paired t-test; p- value	0.00	0.00	0.00	0.00	0.00	0.00
B. After calibration						
I. 0.3 mm Collimator						
Correlation; r-value	0.84	0.99	0.99	0.80	0.97	0.97
Paired t-test;p- value	0.08	0.07	0.07	0.08	0.06	0.06
II. 0.1 mm Collimator						
Correlation; r-value	0.74	0.98	0.98			
Paired t-test; p- value	0.12	0.10	0.10			

Note: 1. In Correlation, if r value >0.75 is acceptable and >0.9 is desirable

2. In paired t- test, if p value >0.01 is acceptable and >0.05 is desirable

Estimation of Silk content

The gravimetric data of 68 samples on the zari content values viz. Z_1, Z_2, Z_3 were converted to metal purity values viz. Z_1, Z_2, Z_3. Then, all the 68 samples were tested for metal purity values in computerized zari testing equipment. The gravimetric metal purity converted dataZ_1, Z_2, Z_3 and Silk content Z_4 along with the metal purity values measured using the computerized zari testing equipment were analyzed based on KNN algorithm using the python programming and the Silk content value was calculated for all the samples. The actual and estimated values of all the samples are given in Table 6 along with the p value of the paired t test as well as correlation coefficient r value.

Table 6. Statistical analysis Predicted by KNN algorithm Vs Actual gravimetric value

Parameter	Silk %	Gold %	Silver %	Copper %
Correlation; r- value	0.46	0.80	0.99	0.99
Paired t-test; p- value	0.07	0.07	0.34	0.23

Note: 1. In Correlation, if r value >0.75 is acceptable and >0.9 is desirable

2. In paired t- test, if p value >0.01 is acceptable and >0.05 is desirable

It is evident that the correlation co-efficient for all the four parameters, Actual Vs Estimated, are significant and the p-value of the paired t test is more than 0.05that is highly desirable. Thus, it can be inferred that the KNN algorithm estimate the Silk content of the zari thread that is almost equal to the gravimetric value. Hence, it is concluded that based on computerized zari testing values, KNN algorithm can estimate the Silk content very precisely that is very much essential to estimate the other metal content of zari thread for fair trade practice.

Grading of Zari thread

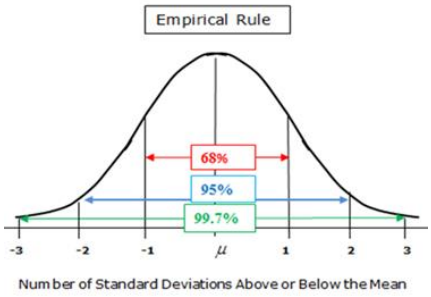
Initial Grading

The important three constituents of the zari thread viz. Gold, Silver and Silk content are only considered for zari thread grading as per the empirical formula of the normal distribution as shown in Figure 12. Thus, the mean and standard deviation of the said three parameters were used to arrive at grades for Gold and Silver and category for Silk content. The Gold and Silver content data of the zari thread generated in gravimetric analysis have been segregated into five grades, A to E and Silk content data have been divided into five categories I to V as shown in figure.

Figure 12 Initial Grading of Zari thread based on Gold, Silver and Silk content in %

	#	SILK	GOLD	SILVER	OTHERS
N = 68	Max	25.18	0.58	70.07	67.35
	Min	16.96	0.04	12.80	4.34
	Ave	20.38	0.22	26.37	53.04
	SD	1.78	0.11	9.39	10.32
68%	1	22.15	0.33	35.76	63.35
	-1	18.60	0.11	16.98	42.72
95%	1.96	23.86	0.44	44.78	73.26
	-1.96	16.89	0.00	7.96	32.81
99%	2.58	24.96	0.507	50.60	79.66
	-2.58	15.79	-0.06	2.13	26.41

Grade/ Category	Gold %	Silver %	Silk %
A / I	> 0.45	> 46	< 17
B / II	> 0.33 up to 0.45	> 36 up to 46	> 17 up to 19
C / III	> 0.11 up to 0.33	> 18 up to 36	> 19 up to 22
D / IV	> 0.015 up to 0.11	> 8 up to 18	> 22 up to 24
E / V	< = 0.015	< = 8	> = 24



Validation Program

The computerized zari testing protocol along with the grading techniques were discussed with the stakeholders by conducting the validation programs at two major silk handloom weaving clusters viz. Kanchipuram and Arni in which more than 80 master weavers and other officials per cluster attended the validation program and gave their feedback through online Google sheet. The extract of the feedback are as follows.

a) All opined that the Computerized zari testing method has to be popularized by installing the equipment in major silk weaving cluster and silk markets in the southern part of India so as to protect the consumer as well as to get reasonable remunerative price for the quality of zari used in the silk saree.

b) Most of them suggested for five grades for Gold and Silver content and three categories for Silk content.
c) All of them suggested that the zari having less than 20% Silver content and 0.2% Gold content should be graded as lowest grade of E.
d) It was opined that Alphanumeric grade should be given to the overall grade of the zari thread for its quality and that needs to be popularized through advertisement.

Final Grading

The grading methods have been changed based on the feedback received from the stakeholder in the validation program. The revised grade details are mentioned in Table 7 for all the three important constituents of the zari thread along with the percentage of population it would represent. The overall grade of the zari would be the alphanumeric value with three digits, the first two Alphabetic digits would represent Gold and Silver grade respectively and the third numeric digit would represent Silk category. Thus, the grade for the samples A, B and C would be of the grade "BBII", "BBIII" and "BCIII".

Table 7. Final Grading of Zari thread based on Gold, Silver and Silk content

A. Gold %		
Range	Grade	Population %
Above 0.55%	A	0.12
Above 0.44% and up to 0.55%	B	2.15
Above 0.33% and up to 0.44%	C	13.59
0.20% and up to 0.33%	D	41.35
Below 0.20 %	E	42.79
B. Silver		
Above 50%	A	0.50
Above 45% and up to 50%	B	2.00
Above 35% and up to 45%	C	13.36
20% and up to 35%	D	59.26
Below 20%	E	24.88
C. Silk		
Below 20%	I	41.55
20% and up to 22.15%	II5	42.45

Above 22.15%	III	16.00

Conclusion

The fine zari samples collected from the industry and analyzed using the gravimetric analysis can be used as standards to calibrate the Computerized zari testing machine so as to get the accurate metal content value. Moreover, the silk content of the fine zari value can be estimated through algorithm using the python programming. Thus, the computerized zari testing protocol developed under this project shall pave way to test the zari thread either in Bobbin or Saree form, which is a non-destructive analysis, so as to get the content value of the constituent of fine zari thread, used in the production of high value brocade silk saree, at par with the gravimetric analysis within 2-3 mins in the computerized zari testing instrument with the help of KNN algorithm using the Artificial Intelligence technique.

The research project findings in unequivocal terms recommend the popularization of the Computerized zari testing and grading so as to protect the interest of the manufacturers who uses the genuine high quality fine zari thread to weave the silk saree that should fetch reasonable remunerative price.

PROPERTIES AND PERFORMANCE OF CHIFFON FABRIC

SI No.	Characteristics	Min Value	Max Value	Modal Value
1	End Per Inch	127	160	145.3
2	Picks Per Inch	92	119	103
3	Warp Crimp (%)	0.50	24.33	4.00
4	Weft Crimp (%)	2.67	41.33	15.56
5	Weight Per Sq. Mt. (G)	19.20	30.75	24.97
6	Air Permeability	0.53	0.95	0.80
7	Area Shrinkage (%)	12.97	64.52	54.94
8	Drape Co-Eff (%)	16.21	52.39	28.17
9	Degumming Loss (%)	15.67	226.90	48.76
10	Warp Break	1.00	17.50	6.33
11	Weft Break	2.00	11.00	8.01
12	Wvg. Efficiency (%)	32.80	71.58	60.62

- In the Sl. No. 9, the values of the degumming loss are very high, which might be because of typographical error.

Requirements of Chiffon Fabrics

Sl. No.	Combination	Epi	Ppi	Warp crimp %	Weft crimp %	Air permeability	Area shrinkage %	Drape co—eff %	Degum-ming	Weight per sq. mt. (g)	Warp wvg. breaks	Weft wvg. breaks	Wvg. efficiency
1	2600 4S4Z * 3200 S	145	111	18.73	28.43	0.74	48.34	23.85	26.59	26.77	5.50	8.50	58.16
2	2600 4S4Z * 3600 S	144	104	14.67	29.20	0.75	50.26	29.40	26.09	27.91	3.50	6.50	62.63
3	2600 4S4Z * 4400 S	134	105	13.13	35.47	0.72	54.00	24.75	26.38	28.22	4.00	7.00	67.11
4	3000 4S4Z * 3200 S	149	113	15.93	13.27	0.74	54.18	27.26	27.38	28.94	3.50	7.00	70.09
5	3000 4S4Z * 3600 S	144	196	20.07	30.00	0.73	55.50	25.13	26.53	30.75	6.50	7.50	62.63
6	3000 4S4Z * 4000 Z	144	106	20.40	18.90	0.68	50.74	24.12	26.95	28.10	9.00	7.00	59.65
7	3000 4S4Z * 4400S	142	108	22.40	29.30	0.74	58.40	24.87	27.69	25.77	6.00	9.00	68.60
8	3000 2S2Z * 3200 S	136	110	20.20	24.53	0.77	54.99	28.39	26.52	28.52	5.00	8.00	68.60
9	3000 2S2Z * 4400 Z	136	101	14.10	19.73	0.80	53.34	22.34	25.42	28.03	3.50	9.00	71.58