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Tailoring Structural and Optical Properties of Cu Doped Chemically Deposited ZnSe Nanostructured Thin Films

ECS Transactions, 107 (1) 6691-6702 (2022)
10.1149/10701.6691ecst ©The Electrochemical Society

Tailoring Structural and Optical properties of Cu Doped Chemically Deposited ZnSe Nanostructured Thin Films

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Chemical bath deposition has been used for depositing undoped and copper doped ZnSe thin films at 343 K temperature. Growth of the thin film requires zinc sulphate cation and sodium selenosulphate anion. The preparative parameters are optimized with an aim to obtain high quality thin films. Three different concentrations of Cu source are used. XRD pattern indicates the incorporation of copper in to polycrystalline cubic ZnSe in doped thin films and is confirmed by EDAX spectrum. SEM micrographs indicate that ZnSe dispersion in the films is homogeneous. UV–visible transmission spectra of the thin films have put into evidence that the dispersion of ZnSe nanocrystals in the thin film is improved their optical transmission. Room temperature PL spectra have shown that the addition of Cu into ZnSe enhanced the emission with additional green peak other than blue band edge emission. Electrical conductivity also modified on addition of Copper.

Introduction

The binary chalcogenide II-VI group semiconducting thin films are potential candidates in short wavelength optoelectronic devices like photovoltaic cells, lasers and light emitting diodes due to their novel physical properties (1-3). Metal selenides find various applications in light emitting devices, photovoltaic cells, optical sensors and optical recording materials (4-7). Zinc selenide has benign optical and luminescent properties with attractive characteristics which makes it promising candidate for optoelectronic applications (3, 8). It is an n-type wide band gap semiconducting material having direct band gap energy 2.7eV with unique physical properties such as high refractive index, low optical absorption and dispersion and high transmission in the visible and infra-red spectral region (9-10). ZnSe films find several applications in optoelectronic devices (11-12), optical coatings, thin film transistors, window material in hetero junction solar cells (13, 14) and photo electrochemical applications (15). Polycrystalline ZnSe thin films have been reported suitable device applications in optoelectronics like non-toxic buffer layer for Cu (In,Ga) Se_2 based photovoltaic cell, LED, blue green laser diodes (4-5, 16).

A vast variety of techniques are available for deposition of polycrystalline ZnSe thin films like Chemical Bath Deposition (CBD) (15-19), electrodeposition (20),

Solvothermal (21), hydrothermal (22), Successive Ionic Layer Adsorption and Reaction (SILAR) (12, 23-24) and Photo assisted Chemical Deposition (PCD) (25-27). In this work we report the investigation of effect of Cu doping on structural, morphological, optical and electrical properties of nano structured ZnSe thin films synthesized through typical chemical bath deposition (CBD).

Experimental Details

The chemicals used were $ZnSO_4$, Na_2SO_3, selenium powder, Triethanol ammine (TEA), trisodium citrate (TSC) and NaOH. For the preparation of aqueous chemical bath 20 ml 0.25 M Zinc sulphate solution was taken. Under constant stirring, 30 drops TEA was added in to it. The resultant solution becomes milky turbid indicating the formation of $Zn(OH)_2$. Addition of sufficient amount of 4M NaOH dissolved the turbidity and the solution became transparent. Then 5 ml 0.1M TSC was added to the bath, followed by 20 ml 0.25 M freshly prepared anionic source sodium selenosulphate (Na_2SeSO_3) solution. The Na_2SeSO_3 solution was prepared by refluxing 2gm Selenium powder and 6gm Sodium sulphite (anhydrous) in 40 ml water at 343 K for 5 hours under constant stirring.

Sodium seleno sulphate releases Se^{2-} ions through hydrolysis in aqueous alkaline medium (28-29). Microscopic glass substrates of dimensions 75x25x2 mm^3 were placed vertically in the chemical bath at 343 K for 1.5 hours. The properties of substrate affect the quality of thin films and hence substrates were well cleaned and ultrasonicated in distilled water prior to the deposition process. The final pH of the solution was maintained at 12.25. The deposition is based on slow release of Zn^{2+} and Se^{2-} ions in the solution which condense on the substrate surface. ZnSe deposition occurs when the ionic product of Zn^{2+} and Se^{2-} exceeds the solubility product of ZnSe (14).

After the deposition, the samples were thoroughly washed in distilled water, dried in air and annealed at 373 K for 30 minutes. This work describes the synthesis and characterizations of copper doped ZnSe thin films with three different weight percentages of dopant such as 2%, 4% and 6%. The source of dopant, Copper sulphate solution was added into the zinc sulphate solution. The undoped sample was named as ZS and the doped samples with increase in copper concentration were named ZCU1, ZCU2 and ZCU3 respectively.

Results and Discussion

The undoped and doped films appear well adherent, uniform and pale yellow in colour. The thickness of the samples having mass ‘m’ is estimated using the equation

$$t = \frac{m}{\rho A} \qquad [1]$$

where ‘ρ’ represents the bulk density of ZnSe 5.27x10^3 Kg/m^3 and ‘A’ represent the deposited area of the film. It is seen from Table I. that the thickness decreases with increase in copper concentration.

Structural Properties

The structural properties of the thin films are studied from the X-ray diffraction patterns in the range 20^0 to 80^0 and shown in Figure 1.

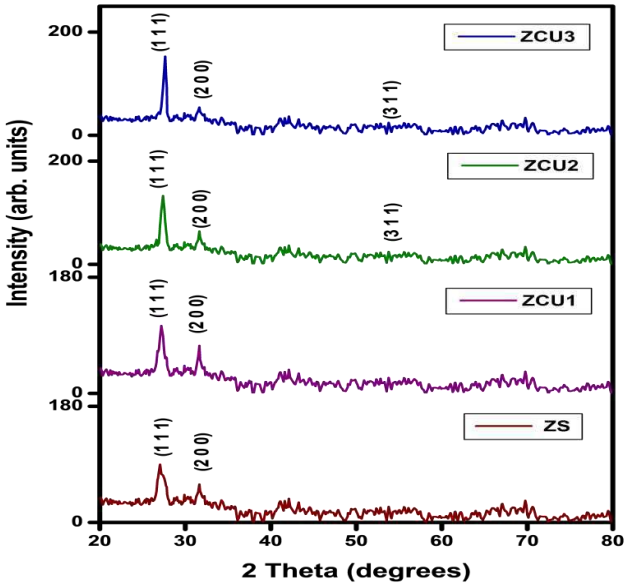


Figure 1. XRD spectra of undoped and Cu doped ZnSe thin films

The diffraction spectra of all the samples display the polycrystalline cubic zinc blende phase of ZnSe with lattice constant 5.618 A^0 (JCPDS card No: 80-0021) (30). Two diffraction peaks are observed along directions (111) and (200) for all samples. Some samples possess orientations along (311) direction also. The intensity of the peak (111) increases with increase in doping concentration which indicates the preferred direction of orientation.

TABLE I. Structural Properties of ZnSe thin films prepared via CBD.

Sample	Thickness (nm)	Grain size (nm) from		Micro strain ($x10^{-3}$)	Dislocation density ($x10^{15}$ lines/m)
		W-H plot	FWHM		
ZS	505	26.3	28.4	5.4	1.1
ZCU1	483	26.9	29.3	4.3	1.07
ZCU2	459	28.8	30.1	4.27	1.01
ZCU3	411	31.5	32.5	3.8	0.95

The peaks become sharper with increase in copper concentration represents enhancement of clusters and hence better crystallinity in doped films. The peaks are gradually shifted to higher θ values with increase in impurity concentration designating adhesion of Cu in to the ZnSe lattice. As a result the lattice is under compressive strain. The grain size D can be evaluated using Debye-Scherrer Equation (31-32)

$$D = \frac{k\lambda}{\beta cos\theta} \quad [2]$$

where 'k' is the shape factor (k=0.94) λ the wavelength of X-ray used for diffraction, 'β' the FWHM of the XRD signal with peak position 'θ'. The average grain size is found to increase with increase in copper concentration. The grain size is also evaluated from the reciprocal of y-intercept of the W-H plot. The plot is shown in Figure 2. The values obtained from the two methods are comparable. The negative slope of W-H plots confirms the compressive nature of residual strain in the doped and undoped thin film lattice.

According to Williamson and Hall the FWHM (β) of the XRD peaks can be expressed as a linear combination of micro strain (ε) and particle size (D) given by (33)

$$\frac{\beta cos\theta}{\lambda} = \frac{1}{D} + \frac{\varepsilon\, sin\theta}{\lambda} \quad [3]$$

The slope of the plot of (β cosθ)/λ versus (sinθ)/λ gives the residual strain and the reciprocal of Y-intercept gives the average grain size of the sample. The micro strain can be determined using the tangent formula (34)

$$\varepsilon = \frac{\beta}{4\, tan\theta} \quad [4]$$

Dislocation density is a function of grain size and is given by the equation (35-36)

$$\delta = \frac{1}{D^2} \quad [5]$$

The micro strain and dislocation density values are found to decrease with the doping concentration. This represents the improvement in crystallinity in doped films. The estimated values are tabulated in Table I.

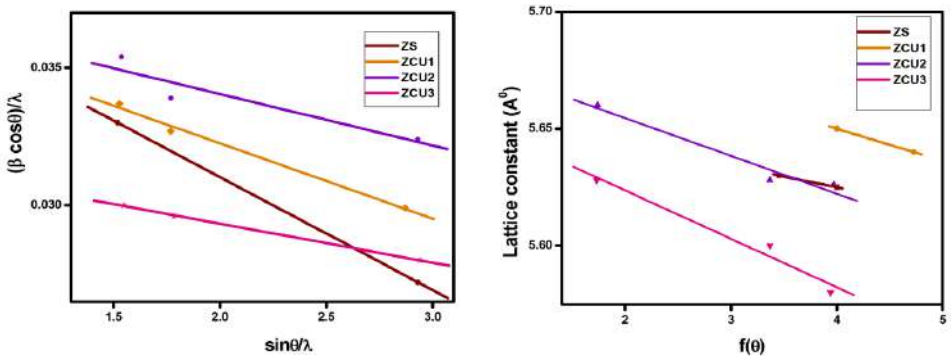


Figure 2. W-H plot and Figure 3. Nelson-Riley plot of Cu doped ZnSe thin films

The lattice parameter 'a' can be calculated for cubic crystal from the interplanar spacing 'd_{hkl}' corresponding to the Miller indices h, k and l value obtained from XRD spectra using the relation (31)

$$d_{hkl}{}^2 = \frac{a^2}{[h^2+K^2+l^2]} \quad [6]$$

The corrected values of lattice parameter are estimated from the Nelson-Riley plot between calculated lattice parameters for different planes and the error function (37)

$$f(\theta) = \left(\frac{\cos^2\theta}{sin\theta}\right) + \left(\frac{\cos^2\theta}{\theta}\right) \quad [7]$$

'a' can be determined by extrapolating the plot to $\theta=90^0$ or $f(\theta)$ to zero. The N-R plot is shown in Figure 3. and the obtained values are tabulated in Table II. The lattice parameters are found to approach the ideal value with rise in copper concentration and show slight variation in doped thin films. The deviations in lattice parameter cause stress and strain in the lattice.

TABLE II. Lattice parameters of undoped and Cu doped ZnSe thin films

Sample		Ideal	ZS	ZCU1	ZCU2	ZCU3
Lattice constant (A^0) form	d-value	5.618	5.63	5.653	5.64	5.613
	W-H plot		5.652	5.678	5.673	5.653

Morphological and compositional properties

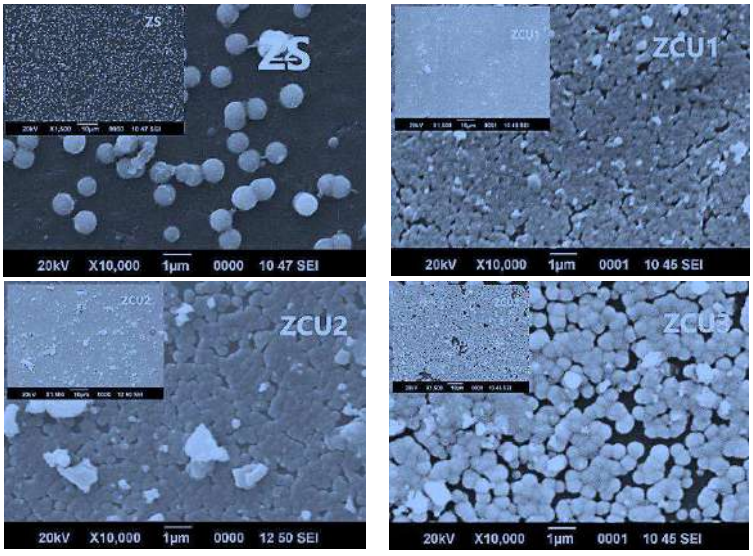


Figure 4. SEM micrographs of undoped and Cu doped ZnSe thin films (inset x1500)

The morphological aspects of the thin films are studied from the SEM micrographs. Figure 4 shows the obtained SEM images of the samples with two different magnifications. The film grows in two dimensions resulting in homogeneous deposition over the substrate surface. Uniform round shaped agglomerations without cracks are distributed on smooth background. The introduction of copper in to the ZnSe lattice considerably increased the density. The smooth background may possess amorphous phase of ZnSe film (38). Doping caused the fusion of spherical aggregates with increased density of agglomerations on the film surface, which may be a reason for variations in optical and transport properties of doped films.

The elemental composition of copper doped Zinc selenide thin films are studied from the EDAX spectra. A representative EDAX spectrum of 4% Cu doped ZCU1 is shown in Figure 5. The spectrum contains peaks corresponding to Zn, Se and Cu. The additional peaks like O, Si, C, Na and Ca are associated with the composition of the soda lime glass substrate (39-40). The inset shows the pie diagram showing the contributions of Zn, Se and Cu. The obtained atomic percentages of Cu in various doped samples are depicted in Table III. The observed doping concentrations are in agreement with the expected values.

TABL E III. Weight percentage of copper in ZnSe thin films

Sample	ZS	ZCU1	ZCU2	ZCU3
Weight % of Cu	0	1.91	3.75	5.6

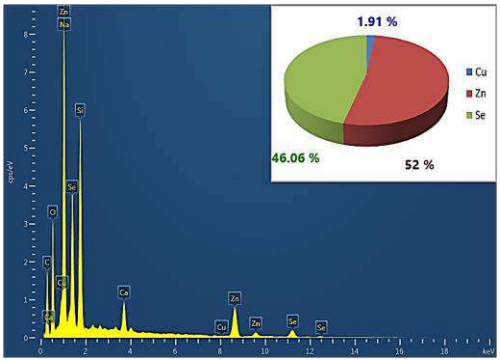


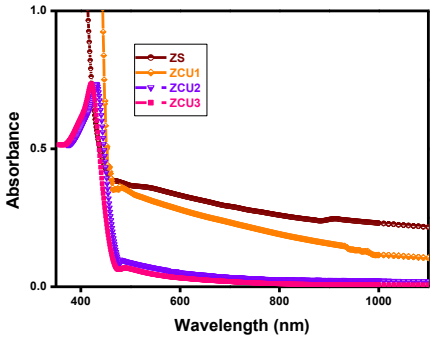
Figure 5. Representative EDAX spectrum of ZCU1

Optical Properties

The UV-visible absorption and transmission spectra of the undoped and copper doped ZnSe thin film samples are shown in Figure 6 and Figure 7 respectively. Absorption of the samples are very low towards the visible and IR region. The samples possess sharp absorption edges indicating direct transition taking place within the sample. The doped samples possess very low absorbance which is further reduced with increase in copper concentration.

All samples possess uniform optical transmission values and are found to increase with increase in dopant concentration. The thin films doped with 4% and 6% copper have a uniform transmission greater than 90%. This implies that a minimum amount of copper

doping is required to enhance the transmission. The uniform transmission may be due to the increased crystallinity and uniformity on doping. Optical transmissions at 600 nm are depicted in Table IV.



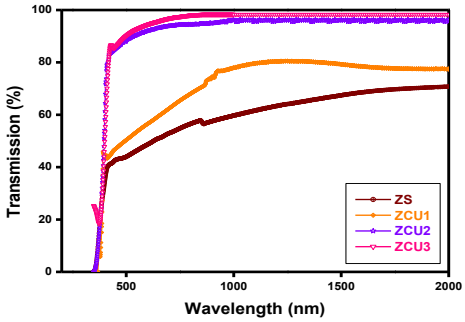


Figure 6. Absorption spectra Figure 7. Transmission spectra of Cu doped ZnSe thin films

The optical band gap values of the thin film samples are related to the optical absorbance values through the Tauc relation given by the relation (41)

$$\alpha = \frac{A(h\nu - Eg)^n}{h\nu} \quad [8]$$

$$\alpha = \frac{2.303Abs}{t} \quad [9]$$

where hυ is the photon energy E_g is the band gap energy, A and n are constants. A depend on transition probability, temperature phonon energies. For allowed direct transition n=1/2. The Tauc plot is depicted in Figure 8.

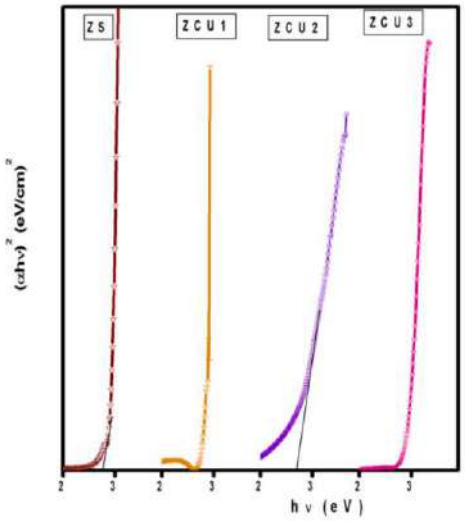


Figure 8. Tauc plot of undoped and Cu doped ZnSe thin films

It can be seen that the plot varies linearly above the band gap value. The band gap energies are evaluated from plot by extrapolating the linear portion of the graph towards the X–axis. The linear nature of plot confirms the direct transition from valence band to conduction band in the thin film. The optical band gap value is found to decrease on the introduction of Cu in to the ZnSe thin films. Further increase in copper concentration enhances the optical band gap energy. The decrease in band gap on the introduction of copper may be attributed to increased lattice scattering due to defects and sudden increase may be caused by the improved crystallinity. The obtained band gap energies are depicted in Table IV.

Table IV. Optical characteristics of Cu: ZnSe thin films

Sample	Band gap (eV)	Transmission at 600 nm (%)	PL peaks (nm)
ZS	2.78	51.4	458
ZCU1	2.69	59.6	437,524
ZCU2	2.72	93.4	456,515
ZCU3	2.77	95.9	433, 528

Photoluminescent Properties

The room temperature PL spectra of copper doped zinc selenide samples excited with electromagnetic radiation of wavelength 350 nm are shown in Figure 9.

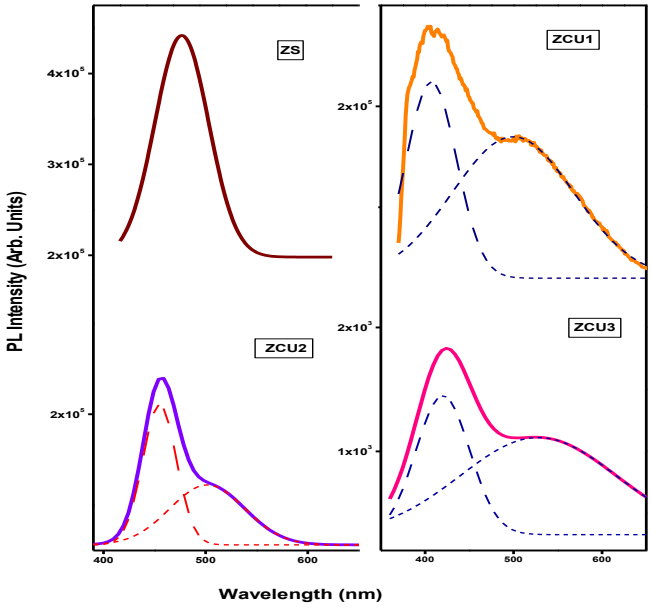


Figure 9. PL spectra of undoped and Cu doped ZnSe thin films

The PL spectra of all samples indicate emission peak near 450 nm resulting in the band to band transition of ZnSe (42). In the Cu doped samples, an additional peak related to Cu impurity near 520 nm in green region is also present. It is reported that the peak around 520 nm is attributed to trap states (43-45). For Cu: ZnSe, two copper acceptor centres have reported, one at 0.4 eV above VB (530 nm) and other 0.7 eV above VB (620nm) involved in red emission (46-47). The observed green emission may be resulted from transition of electrons from CB or surface states to the $^2T_2$ acceptor level of Cu^{2+}, which is a deep level transition (48). For deep transition states, emission indicates a small

shift as the transition is from deep levels. This may be the reason for slight shift in wavelength of peak for various samples. The observed peak and EDAX spectra confirm the doping of copper impurity in the ZnSe crystal.

Electrical properties

Electrical conductivity of the films is enhanced for the doped films. The room temperature electrical properties of the thin film samples are analysed by the Keithly two probe set up. According to Ohm's law, electrical resistance is proportional to sample's length 'L', and resistivity 'ρ' and inversely proportional to sample's cross sectional area 'A' given by product of the film thickness and the width of the film. The equation for resistivity is given by

$$\rho = \frac{RA}{L} \qquad [10]$$

The estimated values are depicted in Table V. The resistivity increases on the introduction of copper initially. The increased concentrations of copper impurity further reduced the resistivity considerably. The resistivities of all samples are of the order of 10^4 Ω-cm. The increased resistivity on doping may be due to the lattice scattering occurred on the introduction of Cu impurity. The further decrease may be attributed to the improvement in crystallinity, which reduced the grain boundaries.

Table V. Electrical properties of Cu: ZnSe thin films

Sample	ZS	ZCU1	ZCU2	ZCU3
Resistivity (x10^4 Ω cm)	2.86	7.25	3.62	1.94

Conclusion

Nano structured polycrystalline Cu: ZnSe thin films prepared through CBD technique. The effects of addition of copper impurity into crystal lattice on various physical properties of the ZnSe thin films were analysed. The undoped and doped samples crystallized in to cubic zinc blende crystal structure. Doping slightly enhanced the crystallinity. The thickness and crystal imperfections like micro strain were found to decrease on doping and grain size increased. The lattice parameters of the unit cell were estimated and found to approach the bulk ZnSe lattice parameters on increased concentration of copper.

The morphology shows that doped films are more densely packed than undoped films. The elemental composition one of the doped samples was confirmed by EDAX spectra. The doped samples with 4 and 6 weight percentages showed very high transmission above 90%. These properties make the samples a potential candidate for window and buffer layer applications in photovoltaics.

The optical band gap energies were first found to decrease on doping which further increased with copper concentration. These properties make the samples a potential

candidate for window and buffer layer applications in photovoltaics. The PL spectra of the doped sample showed an additional peak corresponding to impurity level of copper in addition to the band to band transition. The PL emission intensity can be tuned by controlling the amount of copper in the reaction bath. This may be the reason for slight shift in wavelength of peak for various samples. The electrical conductivity of the samples found to decrease on introduction of dopant which further increased with copper concentration. The tunable band gap, increased electrical conductivity and induced green emission on copper doping and enables ZnSe thin films to find application in optoelectronic devices.

Acknowledgments

The authors express sincere gratitude to SAIF-STIC, CUSAT, U C College, Aluva for offering technical support and one of the authors (T L Remadevi) acknowledges KCSTE for giving financial support.

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Original Research Article

Customer perception-cum-preferences in jewellery purchases from goldsmiths versus retail shops in Kerala

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ARTICLE INFO

Article history:
Received 18-06-2021
Accepted 28-06-2021
Available online 17-06-2021

Keywords:
Customer perception
Preference
Jewellery shops
Consumer behaviour
factor analysis
Kerala

ABSTRACT

Customer perception and preferences are determined by a host of factors and the importance among them is economic and psychological. Considering gold as an investment-cum-custom-oriented commodity the demand ramifications are vivid. The present system of retailing in gold jewellery business in Kerala has almost eclipsed the importance of traditional goldsmiths in ornament making and sale. The study based on primary data and empirically substantiated with factor analysis shows that selection of design is a major reason for preference in jewellery purchase from shops. Advertisements and promotional activities do influence the purchase decision from the retail jewellery shops.

1. Introduction

Customer perception is a vital determinant in the buying behaviour of any product. The perception in a way is explained by a hierarchy of preferences and in this sense, it is mere a psychological introspection in the buying behaviour. This is more so for an investment-cum-custom-oriented commodity like gold and hence have wide implications and therefore difficult to disentangle perception-cum-preferences. In order to make this to satiate and translate into demand retailer act to attract the customers and, in this respect, they have hegemony over the traditional goldsmiths.

The demand for gems and jewellery in the global field is growing at an exponential growth, the industry per sehas and Research and Development wing for adopting and use of innovative technologies for maintaining quality and consumer confidence and preference with hundred percent precision. Today's consumer is more quality conscious and he is looking for fineness than its price as every consumer in the global market is willing to pay a premium price provided the product is superior in quality. This is the reason for the jewellery designers to go for new technology in designing to make the designs exquisite. Hence, every process in the jewellery making starting from mine to market is envisioned with modern technology. Each stage of manufacturing likes refining, moulding and polishing is used with machine tools with experts in the process. All these not only help in saving time and cost, but it also helps in increasing product quality and consumer acceptance. Along with these, in the various production stages of the use of technology, it is also used in packing for consumer attraction. One such technology that has gained popularity in the jewellery manufacturing is the use of "light weight technology" as it helps to reduce the cost of the product and because of this many budget consumers have been attracted in the jewellery sector.[1]

Gold presently is considered as one of the major safe assets globally owing to its liquidity, particularly in crisis situations. This yellow metal has been the major measuring scale for the currencies of the leading economies across the globe, popularly known as 'Gold Standards', where

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https://doi.org/10.18231/j.jmra.2021.013

currencies have easily been changed to gold. Historically, gold has always maintained its purchasing power and during the German inflation of 1918-24 the value of most of the assets like bonds and stocks came down but gold showed its strength (Kenoyer J. M, 1991).[2] The consumer demand for gold has shown a tremendous increase, though with occasional oscillations. But the global gold production has shown a marginal increase from 2430 MT in 2004 to 3110 MT in 2017, i.e. CAGR of 1.78 percent but remained steady during the period. The major gold consumer demand is from India and China, which are considered to be the two main consumers of gold (GFMS Gold Survey, 2018).[3]

Gold, gold-jewellery and gems are part of Indian culture and tradition. The affinity for gold ornaments of the Indian women is world-famous and hence gold jewellery becomes an integral part of the Indian marriages. Ornament and Jewelleries are mythologically connected and hence have been part of the history of India and the Indian culture itself is moulded with ornament and jewellery and it is well documented in the Indus-Valley civilization (Kenoyer J. M, 1991). Gold ornaments are also part of the Indian deity-worship and because of its importance both men and women wore gold ornaments in the ancient period. This shows that gold ornaments are not mere concept of wealth but even part of the belief system and in fact, the culture of the Indian to wear ornaments. It has also become an inseparable component in the social status of the society and the very psyche of the Indian (Indian Jewellery Review, 2013).

Gems and Jewellery is important in India in many ways. The most important are the foreign exchange earnings through the export of gems and jewellery, and employment to many, both directly and indirectly. Tremendous transformations have happened in this industry as Computer Aided Design (CAD) software is used almost every part of the industry today to design gems and jewellery (Ghag D. S and Dange J. J, 2013).[4] This has helped the customers to visualise easily the design of the jewellery with the help of computers before they make any purchase. India leads among world countries in jewellery consumption. It consumes high at an average of 600 tonnes per year for the last 10 years. Only in the year 2009 and 2016, it goes below 500 tonnes and it may be due to particular economic situations like global financial crisis, GST, demonetisation etc. But it regained its consumption level in 2017 and is expected to continue at a higher rate in the coming years. The severe problem that India is facing is the ever-widening gap between the gold production and consumption.

Since 1991, Kerala followed the policy of liberalisation in all her production sectors. She is famous for traditional industries namely; coir, handloom and handicrafts. Although there exists good scope to capitalize the synergies and potentialities, factors like price oscillation, poor modernization efforts, lack of product diversification, quality improvement process, designs, over-dependence on traders etc. have adversely affected the growth and development of this sector. Innovations and new designs, setting up of Quality Testing Centres, creating awareness about the developments taking place elsewhere are to be taken seriously to protect the interests of the industry in domestic and global markets. In this respect the study focussed customer's preferences and perceptions towards machine made branded ornaments and the factors leading to their domination.

2. Materials and Methods

The consumption behaviour of gems and gold India has identified that the demand peaks in festival season and hence the seasonality aspects and its variations are important Rian Raghavjee (2005).[5] Jokinen H (2011)[6] mentioned on consumer behaviour, shows that gems and jewellery is connected with many socio-psychological indicators. Dinesh Kumar (2002)[7] well portrayed the brand preference of jewellery of women in India. Tirupathi Rajan S (2014)[8] links the important factors in jewellery consumption, like personality, tradition, beliefs, culture and rituals.

The study used primary data collected from the consumers of Kasaragod and Trissur district in Kerala. These districts are identified on the basis of the number of traditional goldsmith community who are still doing the jewellery work. Unlike in other districts of Kerala, the traditional goldsmiths are either involved in manufacturing and servicing of gold ornaments at household level workshops or in hired small shops in rural and urban areas. 300 customers (150 customers each from these two districts) are randomly selected to evaluate customers' perception towards jewellery and their preferences. For data analysis Likert Scale and Factor Analysis were used.

3. Results, Analysis and Discussion

3.1. Profile of customers

The customer's profile is an important determinant of the demand for gems and jewellery, which in turn is determined by demographic, education and occupation. These are bound to have significant impacts in the purchase decision and preferences of the customers. Unlike other assets, where the male participation in purchase decision is generally low, gold or jewellery purchase is determined more by the female members of the households. Jewellery is often an item of investment or saving and consumption, is female-centric as it is mostly used for their purposes. Data show that 66.7 percent in the group are females and majority of the customers belong to middle age. Majority of the customers are well educated with a qualification of graduation and above (57.3 percent). In terms of occupational profile, most of them works in the private sector (43 percent) and 38.3 percent are government sector employees, 18.7

percent belong to other category like housewife, and labourers(Figure 1).

3.2. Customer perception

Customer perception evaluation would help to identify the customer's preferences and purchase patterns. This also sheds light the reasons for the lack of livelihood for the traditional workers.

3.2.1. Preferred purchase mode

During the pre-liberalisation era, the customers had limited modes to procure gold jewellery. The major sources included goldsmiths and person to person. Also, in most of the cases, the customer had to give an order for a particular ornament and will wait until it is manufactured by the goldsmith. In some cases, they used to give their old ornament to the goldsmith and convert it into new design or the design they prefer to. In such cases also the customers had to wait till the goldsmith makes a new ornament for them. The customers rarely had an option to choose from an existing design.

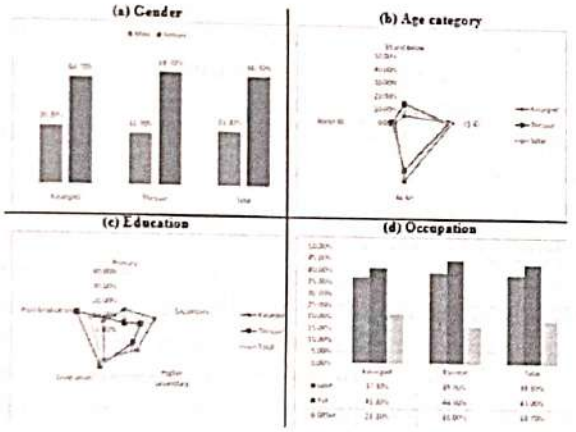


Fig. 1: Profile of customers Source: Survey data

Now the sources are manifold. The private jewellers have a range of designs from which the customers can choose. New designs together with hallmarking, ready availability, easy exchanges etc. would mean that the present customers are keener to visit private jewellers (be it small or large) rather than visiting a goldsmith and giving him the work. This is confirmed with the customer survey results(Figure 2), where they were asked to rank their preference of purchase (i.e. whether from goldsmith, small local jewellery in their region or big jewellery brand showrooms). The traditional goldsmiths are only their last resort in terms of jewellery purchase as none of them have given this source as first rank. The customers, irrespective of region, were unanimous in selecting traditional goldsmiths as the 3^{rd} option while they intended to purchase jewellery. In this, 86 percent of respondents gave second preference to the local jewellers and 1^{st} preference was given to the branded jewellery by 86 percent of the respondents. Region-wise, the proportions of the customers preferring local jewellers are more in Kasaragod, whereas the customers giving preference to the branded jewellery are more in Thrissur. The results show that those who prefer to purchase fresh jewellery from the traditional goldsmiths are very rare as all of them surveyed have indicated goldsmith's as the third preference.

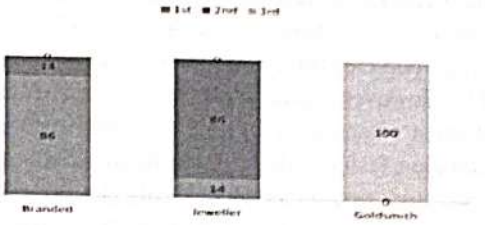


Fig. 2: Customer preference while purchasing jewellery Source: Survey data

3.2.2. Purchase objective

The purchase objective varies from customer to customer. However, the results show that the perception on purchase objective of the customers have a particular pattern. The intention of purchase is both in the form of consumption or purchase of a new design as well as investment or savings in the form of gold. Wearing gold ornaments are always considered as a sign of prosperity and social status. Gold has always been considered as an asset which can be utilised for emergency needs by pledging or selling the same. The field inference showed that rather than for one purpose, the customers consider their ornaments purchase with many purposes and also as an investment. However, they feel that gold once purchased is only to be sold in cases of emergency. For change in design, the customers generally exchange their old ornaments. For financial requirements, the customers mainly pledge the ornaments with banks and other NBFCs. Even though, the jewellery shops in the state are mostly crowded, the importance of purchase of gold varies. They purchase gold for wearing or as gift on special occasions like weddings, childbirth etc. Among this, on an average, gold purchase for wedding is the highest. Another such occasion is during the festive season. The jewellery shops have a record sale during the festive occasions like "Akshayatritiya" and festivals like Onam, Ramzan, Christmas, etc. During these seasons, the jewellers (especially the large ones) try to lure the customers with advertisements, discounts and exchange offers. Changing fashions are also a reason to purchase gold especially as the majority of the customers are women. Some exchange old-fashioned or damaged ornaments with the new designs and have cited this as one of the major reasons for jewellery purchase.

The customers were asked to record their perception on each occasion they purchase gold in terms of frequency (Figure 3). About 81.3 percent of the customers always purchase jewellery during special occasions like wedding and 18.7 percent most often purchase. While festivals are not an occasion for some of the customers to purchase jewellery (19.3 percent rarely and 32.7 percent never purchase gold during festivals), 24.3 percent most often and 19 percent often make a jewellery purchase during festivals. Purchase of jewellery based on change in fashion is not so common. Most of them rarely (24 percent) or never (32.7 percent) purchase jewellery based on changing fashions. However, some 'most often' or 'often' (14.3 percent most often and 19.7 percent often) purchase gold with changing fashion. Apart from luxury consumer good, gold and gold ornaments are highly liquid assets with higher security during crisis with a high probability of increase in price covering more than the inflation rate, majority of the customers also purchase gold as a saving or investment tool (43.7 percent most often and 37.7 percent often purchase gold as an investment tool). Compared to buying land or other related property, the fact that gold can be purchased in small denominations, hence makes it an attractive investment tool for many customers. Also, some of the jewellers have introduced jewellery purchase scheme where customers can purchase small denomination of gold from the jewellers which will be entered into the customer's pass book. Customer can further redeem this into ornaments as and when required.

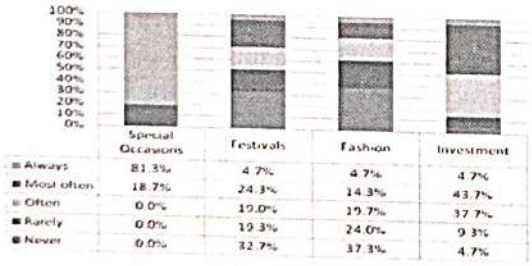


Fig. 3: Frequency of purchase during occasions Source: Survey data

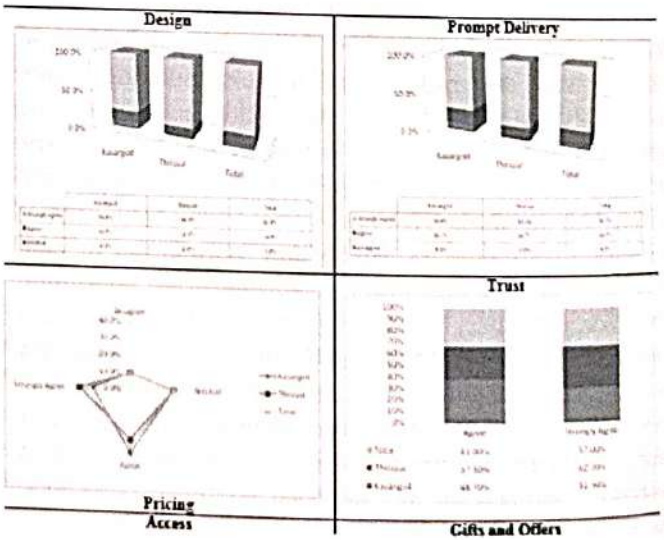
3.2.3. *Reasons determining purchase decision:*

(1)Preference for Traditional Goldsmiths

The main preference for gold purchase is wedding and for this they purchase good quantity of jewellery and the dependence on traditional goldsmiths has come down. In fact, some even do not remember the last instance when they visited traditional goldsmiths for giving a fresh order. Only 4.7 percent have visited the local goldsmith to give a fresh purchase order. Most of the customers have visited goldsmiths for small repairs, polishing, etc. of the existing jewellery. They feel that it is better to go to a local goldsmith nearby for such small things rather than visiting a jewellery shop. About 13 percent of the customers visited the goldsmiths for sale of their old jewellery during financial need as they felt that it is more convenient for them to visit the goldsmith than going to the jewellery. However, the customers as per the field inference have opined that they always approached the jewellery (be it local shop or big jewellers) when they intended to exchange their old ornament. Lack of accessibility has been identified as a major factor rose by the customers with regard to the jewellery shops.

Fig. 4: Reason for preferring traditional goldsmiths Source: Survey data

The results show that one of the reasons why they prefer local goldsmiths over the jewellery shops in terms of small repairs or cleaning of jewellery is the fact that the goldsmith or goldsmith household is available in every locality and therefore easily accessible to the customers. It is due to this fact that most of the customers favour goldsmiths for small repair works; about 95.3 percent have cited this as a reason. Only 4.7 percent perceived that they can trust local goldsmiths in terms of purity (Figure 4). Another factor which has come up during the field inference is the niche design (temple ornaments, other religious symbols, etc) for which the customers usually prefer to traditional goldsmiths. However, such works are a rarity and only a very few of the customers approach goldsmiths with such a work. The perception appraisal with regard to the traditional goldsmiths seems to be difficult as majority do not visit the goldsmith any more for purchase and exchange of ornaments.



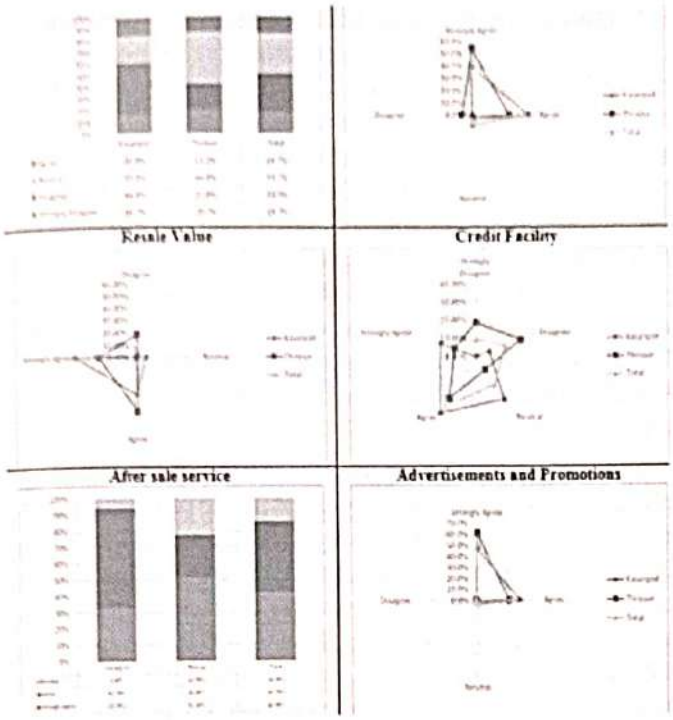


Fig. 5: Reasonsfor opting jewellery shops reasonsfor opting jewellery shops

(2). Reason for opting Jewellery Shops

It was identified that majority have given the third or least preference to the traditional goldsmiths while purchasing jewellery. The first and second priority was given to the branded jeweller or local jewellery shops by the majority of customers. The customers were asked the reasons why they opted for jewellery shops (both small and large shops) while purchasing gold ornaments. The perception on the ten positive attributes was recorded in a five-point scale viz. strongly agree, agree, undecided, disagree and strongly disagree. The district wise comparison of reasons for opting jewellery shops by the customers is given in(Figure 5)

One of the main motives of visiting jewellery shops in relation to the local goldsmith is the availability of many designs, in both the traditional and modern. This is an important factor especially considering that majority of the customers surveyed were females. As 81 percent strongly feel or strongly agree to the fact that their preference of the jewellery shop is mainly due to the availability of designs with the shop compared to their local goldsmith with whom they do not have limited selection. Region-wise, both the districts have more than 75 percent of responses in the strongly agree category (76 percent for Kasaragod and 86 percent for Thrissur). In fact, none of the surveyed customer has disagreement regarding the statement that designs are available in plenty with the shops. In situations where the preferred design is not available with the jeweller or where the customer requires specific custom-made designs, the jewellery accepts the order by taking an advance payment from the customer with a promise of delivering the product on a specific date. Majority feel that the delivery is prompt by the jeweller in such cases as 76.6 percent strongly agree to the statement. However, region-wise promptness in delivery is more with the jewellers in Thrissur district (83.3 percent strongly agree) than in Kasaragod (70 percent strongly agree); whereas, 4.7 percent disagree the promptness in delivery and all those who perceived less promptness is more in Kasaragod district. In terms of prompt fulfilment of orders, though difference is less, the jewellers in Thrissur district outperform the Kasaragod district as per the perception of customers. Here, it is pertinent to mention that Thrissur has a much more developed retail jewellery sector and hence these shops are more professional in fulfilling the order of the customers than the jewelleries in Kasaragod.

Price-wise, the customers feel that it is on the higher side compared to what they used to get from the traditional goldsmiths. About 62.3 percent agree or strongly agree to the fact that the jewellery shops are on the higher side in terms of pricing. Whereas, 28.3 percent are neutral in their opinion and 9.3 percent disagree. The district-wise difference in this respect is unavailable. Irrespective of the region the customers feel that the price the jewellers charge is slightly higher, apart from the rate of gold, the shops also charge making and other costs from the customers during the purchase of jewellery. Also, during buyback, the jeweller deducts the making charge. Even for gold coins the jewellers put an additional making charge.

Customer preference for jewellery shops though the price is high, is its consideration of purity. The customers also feel that the jewellery shops are more trustworthy. Hallmarking is an important factor in determining purity and customers consider jewellery with 916 purity. This priority is well marketed by the jewellery shops. Generally, it is a fact that gold ornaments with 916 hallmarking get the highest resale value deducting only making charges. The customers either strongly agree or agree to the fact that they trust the jewellery shops (57 percent strongly agree and 43 percent agree). The trust factor is more seen among the customers in Thrissur as 62.7 percent strongly agree to this than the customers with 51.3 percent in Kasaragod.

Accessibility-wise, it seems that the perception that the jewellery shops are inaccessible to the majority as most of the shops is situated in the market places or in town area. In this case, 51.7 percent disagree or strongly disagree to the statement regarding the accessibility of the jewellery shops. Whereas, 33.7 percent are neutral and only 14.7 percent are agreeing to this. It also shows that 60.7 percent in Kasaragod do not feel that the jewellery shops are accessible compared to 42.7 percent in Thrissur.

In comparison to the traditional goldsmiths, the local jewellers offer discounts and other sales-promotion items

like free gift, waiver of part of making cost, exchange guarantee or exchange offers etc. to attract customers. Festive offers are also part of their marketing strategy. Most of the customers show interest in these offers and hence decide to visit the jewellery shops as 46.7 percent strongly agree and 43.7 percent agree that the jewelleries provide gifts and other promotional offers. Those who are neutral in their opinion are only 5 percent and customers disagree are only 4.7 percent. District-wise evaluation also shows that those who strongly agree are more in Thrissur (54 percent) than in Kasaragod (39.9 percent). This would imply that the customers in Thrissur get more promotional offers from the jewellery shops than Kasaragod. This may be because of the higher competition between the shops.

It seems that resale value is an important factor in determining the customer preference towards the jewellery shops as 48 percent strongly agree and 38 percent agree to the fact that the gold ornaments purchased from the jewellery shops have good resale value. In the case of districts, those who strongly agree are more in Kasaragod than in Thrissur. Data show that 18.7 percent in Thrissur disagree that the gold brought from the jewellers has good resale value, while none in Kasaragod has this opinion. The results show the difference in perception of customers in terms of resale or exchange value they receive when they sell or exchange their ornaments. However, this has to be connected with the making charges incurred which differ based on design.

Purchase of jewellery with diamond and other stones incur additional cost of stones as well as higher making charges, but during exchange or sale the weight of stones and making charge is also deducted. Hence, those who purchase designer jewellery will get lower price compared to those purchasing normal ornaments without stones and intricate designs. The field inferences show that majority of the customers in Thrissur prefer to new designs and patterns with diamond and other stones. Some in the district also prefer to exchange their ornaments frequently, which usually is a costly affair.

In the case of advance booking of the jewellery by paying a nominal amount, and paying the remaining amount in instalments (this works like Systematic Investment Plans of Mutual Funds), where the market fluctuations, especially the ups in gold price is negated. This helps the customers in price protection and is more beneficial to the customers who find difficulty in paying the money in one time. In this category 52.4 percent have expressed their agreement with the statement (18.7 percent strongly agree and 33.7 percent agree). However, higher preference is shown by the customers in Kasaragod district compared to Thrissur as 18.7 percent strongly disagree and 29.3 percent disagree to this. Those who strongly agree and agree are 14 and 28.7 percentages in Thrissur compared to 23.3 and 38.7 percentages in Kasaragod respectively.

Another major provision quite often given to customers is credit facility for facilitating customer preference when it comes to the jewellery shops. The jewellers are extending credit scheme to the customers where they can repay in monthly instalments. Some schemes are even claiming to charge zero percent interest from the customers. There is also an informal setup which is more seen for wedding or other occasions where some jewellery shops give ornaments by paying a token amount for a few days and after that they need to return to the jeweller after the function or occasion. The token amount given is the profit or revenue of the shop owner. Such an informal practice is beneficial on either party.

Another facility for getting the customers attracted is service facility by the jewellery shops. None of the customer disagrees to the fact that the jewellery shops provide better service to the customers. Majority agree (43.7 percent) and strongly agree (42 percent) regarding the service quality of the jewellery shops. However, there is difference in terms of district as 61.3 percent in Kasaragod agree with regard to the service quality, whereas the corresponding percentage in Thrissur is 26 percent. Those who strongly agree with regard to the service quality of jewellery shops are more in Thrissur (51.3 percent) compared to Kasaragod (32.7 percent). This would imply that, based on customer perception that the jewellery shops in Thrissur provide better service to the customers than in Kasaragod.

It is a fact that advertisements and promotions in the print and visual media work as major factors for attracting the jewellery shops by the customers. The brand and name of the jewellers, the customers wish to make a purchase from, is well elicited through the promotions carried out by the jewellers. As 54 percent strongly agree and 40.7 percent agree that the advertisements are an important factor in determining the customer preference. However, a district-wise comparison shows that the influence of advertisements is slightly less in Kasaragod (61.3 percent strongly agree in Thrissur compared to 46.7 percent in Kasaragod). However, difference based on district is very less.

3.2.4. *Customer preference Index*

Customer preference index based on the preference scores of the customers have been developed by recoding the values into low, medium-low, medium, medium-high and high preferences so as to evaluate the preference level of customers towards the jewellery shops (Figure 6). It is seen that in terms of customer satisfaction and preference, the jewellery shops have been rated impressive and none of the customer have perceived that their preference in terms of quality of services is below average or below medium level.

Majority (62.3 percent) of the customers have a medium-high preference for the jewellery shops, 19 percent have high preference level and 18.7 percent have moderate preference. An inter-district evaluation shows that Thrissur

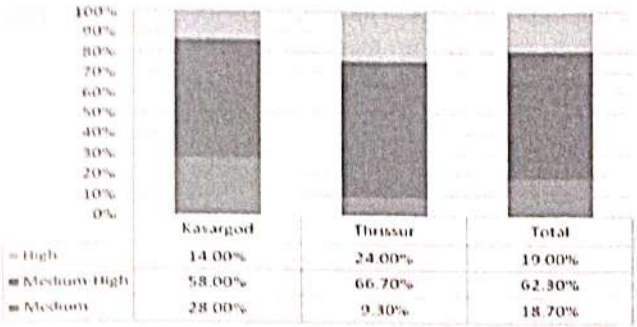


Fig. 6: Customer preference index source: survey data

has higher percentage of responses in the medium-high and high preference level than in Kasaragod (Figure 6). Hence, the preference level with regard to the jeweller's changes for the customers based on district. Similarly, a low preference by the customers would have meant that they prefer the goldsmiths to jewellers. Again, though such a situation was identified for some attributes like accessibility, the score for the traditional goldsmiths was 95 percent, the jewellery shops seems to outperform the goldsmiths in terms of customer choice and preference in most of the important indicators. A better customer preference for the jewellers would imply a lack of choice for the customers to choose the traditional goldsmiths.

Table 1: KMO and bartlett's test: Customer preference

Kaiser-meyer- olkin measure of sampling adequacy.		.724
Bartlett's test of sphericity	Approx. Chi-square	1084.398
	Df	45
	Sig.	.000

Table 2: Total variance explained: Customer preference

Component	Initial eigenvalues			Extraction sums of squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.317	33.167	33.167	3.317	33.167	33.167
2	1.733	17.331	50.497	1.733	17.331	50.497
3	1.426	14.261	64.758	1.426	14.261	64.758
4	.827	8.270	73.028			
5	.745	7.447	80.475			
6	.714	7.135	87.611			
7	.446	4.462	92.073			
8	.378	3.783	95.856			
9	.244	2.442	98.298			
10	.170	1.702	100.000			

Extraction method: Principal component analysis

3.2.5. *Determinants of customer preference for jewellery shops*

Here, the customer preference attributes are identified from the 10 preference indicators with the aid of factor analysis. Kaiser-Meyer-Olkin test is used to measure the sample adequacy. The value of 0.724 (Table 1) is well above the accepted minimum value. Similarly, Bartlett's Test of Sphericity has also attained significant value. In the Total Variance Explained (Table 2), is clear that three factors with an eigen value of more than 1 are extracted. The first, second and third factors explain 33.167 percent, 17.331 percent and 14.261 percent of the total variance.

The results of the component matrix (Table 3) shows that the first factor explains five, the second three and the third two with attributes. Design, delivery, trust, service and resale are explained by the first factor. The customers perceive that the selection of design is a major reason for opting purchase from jewellery shops followed by promptness in delivery and the trust they have with the jewellers with respect to quality. Service is also good as they treat the customers well. Even though the making charges are deducted, the customers are confident that the product will fetch a decent resale value for gold compared to what they used to get from goldsmiths. The first factor explains the features which the customers consider as a quality of the jeweller. It can be termed as statements relating to the product. The second factor shows statements relating to price and promotional activities by the jeweller. While advertisements and gifts are two of the promotional activities which attract the customers to the jeweller compared to the traditional goldsmith, they find the pricing also good. The third factor shows credit and access.

Table 3: Component matrix: Customer preference

	Component		
	1	2	3
Credit	-.016	-.132	.828
Price	-.038	.704	.135
Advertisements	-.037	.839	-.279
Gift	-.005	.711	.340
Access	-.084	-.026	-.713
Service	.792	.057	-.114
Delivery	.897	.044	-.017
Resale	.569	-.064	.074
Design	.911	-.005	.017
Trust	.849	.015	-.002

Extraction method: Principal component analysis. a. 3 components extracted.

The result retreats that the product attributes are the prime reasons for choosing private jewellers, the pricing point (which may be high but compared to the goldsmiths is more transparent) along with the promotional activities work as reasons for the customer preference towards the

jeweller. Credit or other financial incentives are seemed to be important as the third factor. The last statement in the third factor is relating to the place attribute, i.e., access which has generated a negative sign. This would imply that apart from the access factor, which they consider only during minor repairs, the preference of customers towards the jewellery shops is high. They no longer approach the traditional goldsmiths for giving new order.

4. Conclusion

The customer's perception seems to be a clear exposition of the changes that has happened in the jewellery sector of Kerala as more and more customers prefer retail jewellery shops to the traditional goldsmiths-based jewelleries. It is happening with annulment of the livelihood of the poor traditional goldsmiths by giving place to the retailers and retail-chains for monopolising the sector. This has not happened all on a sudden, but it is the result of several changes like innovations in design, sales promotions to lure the customers and quality assurance through hallmarking. The customers, irrespective of region, were unanimous in selecting traditional goldsmiths as the second option when they intended to purchase jewellery. Data inference implies that 86 percent of respondents gave second preference to the local jewellers and first preference to the branded jewellery. Region-wise picture explains that the proportions of the customers preferring local jewellers are more in Kasaragod compared to Thrissur. Most of the customer's purchases are based on wedding related special occasions, whereas to others purchase decision is also based on change in fashion. However, majority of the customers purchased gold as a saving or investment tool.

With regard to the customer preference, based on customer preference index, shows that majority of customers have a medium-high preference for the jewellery shops. Inter-district evaluation in this respect shows that Thrissur has higher percentage of responses in the medium-high and high preference levels than in Kasaragod. The customers perceived that the selection of design was a major reason for opting purchase from jewellery shops followed by promptness in delivery and the trust they have with the jewellers with respect to quality. They also have high regard for service and also their attitude towards the customers well. Even though the making charges are deducted, the customers are confident that the product fetches a decent resale value compared to what they used to get from the goldsmith's gold. The statistical inference obtained from the Factor Analysis highlights that the first factor as quality of the jeweller. It could be termed as statements relating to the product. The second factor shows statements relating to price and promotional activities by the jeweller. While advertisements and gifts are two of the promotional activities which attracted the customers to the jeweller compared to the traditional goldsmith, they find the pricing also to be good. The third factor illumines credit and access. Customer preference explains that the product attributes are the prime reasons for choosing private jewellers, the pricing point along with the promotional activities work as reasons for the customer preference towards the jeweller. Credit or other financial incentives are seemed to be important. All these show that the perception of the customers towards the jewellery shops is positive and quite high.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Cite this article: Pradeep KV, Karunakaran N. Customer perception-cum-preferences in jewellery purchases from goldsmiths versus retail shops in Kerala. *J Manag Res Anal* 2021;8(2):53-60.