

Evaluation of the Effect of Thickness on the Translucency of Super-high Translucent Zirconia & Zirconia Reinforced Lithium Disilicate

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Abstract

Background:

Esthetic restorations require materials with optimal translucency to achieve superior clinical outcomes. This study aimed to compare the translucency of super-high-translucent zirconia (Zolid Fx) and zirconia-reinforced lithium disilicate (LDS) at two thicknesses (0.9 mm and 1.3 mm).

Methods:

A total of 40 specimens (10 × 10 mm) were fabricated, including 20 Zolid Fx specimens [0.9 mm (ZrSH-1) and 1.3 mm (ZrSH-2)] and 20 LDS specimens [0.9 mm (LDS-1) and 1.3 mm (LDS-2)]. Translucency was evaluated using a spectrophotometer by calculating the translucency parameter (TP) from CIE L*, a*, and b* values. Statistical analysis was performed using one-way ANOVA with a significance level of $p < 0.05$.

Results:

A statistically significant difference in TP values was observed among all groups. Translucency decreased with increasing thickness for both materials. LDS demonstrated higher translucency than Zolid Fx at both thicknesses, although it showed a greater reduction in translucency with increased thickness.

Conclusions:

Within the limitations of this in vitro study, zirconia-reinforced lithium disilicate exhibited superior translucency compared to super-high-translucent zirconia, regardless of thickness. These findings suggest that LDS may be a preferable material when maximising esthetic translucency is a primary clinical consideration.

Introduction

In recent years, patients have increasingly demanded high-quality esthetic restorations. This increasing emphasis on esthetics has driven the evolution of all-ceramic restorative materials. (1) Ceramic crowns have gained wide acceptance due to their ability to mimic the natural appearance of teeth closely. (1) The introduction of yttria-stabilised tetragonal zirconia has further improved ceramic systems by enhancing wear resistance, chemical stability, and strength. (2) However, despite their high flexural strength, zirconia restorations often demonstrate inferior esthetic performance when compared with other all-ceramic materials such as lithium disilicate, which exhibit superior translucency. (3)

Glass ceramics were discovered by Stanley Donald Stookey in 1953, and in recent decades they have attracted considerable scientific interest. (3, 5) Although glass ceramics provide excellent esthetic outcomes, their limited strength restricts their use in stress-bearing regions. (6) To overcome this drawback, multiple strengthening strategies have been explored, including dispersion strengthening, with leucite being one of the earliest successful fillers. Currently, lithium disilicate is among the most widely used glass ceramics owing to its favourable combination of strength, toughness, and esthetics. This material contains approximately 70% interlocking rod-like lithium disilicate crystals, resulting in nearly twice the flexural strength and fracture toughness compared with leucite-based glass ceramics. (4, 5)

Translucency and colour are critical for reproducing the optical characteristics of natural teeth. (2, 7) Translucency refers to the property by which a major portion of transmitted light undergoes scattering, and it is a key determinant of the esthetic outcome of ceramic restorations. (8) Increased light transmission corresponds to greater translucency; however, translucency is inversely related to ceramic thickness. (9, 10) Although reducing ceramic thickness improves translucency, it may compromise strength. (1) Zirconia, however, maintains favourable mechanical properties even at minimal thicknesses of 0.9 mm. (10)

Recent advancements include high-translucent zirconia-reinforced lithium disilicate, containing approximately 10% zirconia dispersed within the glass phase, and super-high-translucent yttria-stabilised multilayered zirconia. Both materials claim to provide an optimal balance between esthetics and mechanical performance. (12, 14)

Despite available evidence on the influence of thickness and composition on translucency, direct comparisons between super-high translucent zirconia and zirconia-reinforced lithium disilicate at varying thicknesses remain limited. Therefore, this in-vitro experimental study aimed to evaluate the effect of thickness on the translucency of super-high translucent zirconia and zirconia-reinforced lithium disilicate.

METHODOLOGY

A total of 40 ceramic specimens were designed using CAD software (Ceramill® Mind, Amann Girrbach) and milled using a CAD/CAM milling unit (Ceramill® Motion 2, Amann Girrbach). Of these, 20 specimens were fabricated from super-high translucent zirconia (Zolid fx - Amann Girrbach) and 20 from zirconia-reinforced lithium disilicate (Vita suprinity- Amann Girrbach), all in A2 pre-shaded blocks. (Fig. 1)

Specimen Preparation

Super-high translucent zirconia blanks were mounted on the standard blank holder and milled to dimensions of 10 mm × 10 mm, followed by division into two groups based on thickness:

ZrSH-1: 0.9 mm and ZrSH-2: 1.3 mm. Dry milling was performed, followed by sintering in a Ceramill® Therm furnace and subsequent glazing.

Zirconia-reinforced lithium disilicate blocks were similarly milled to 10 mm × 10 mm dimensions and divided into two thickness-based groups:

LDS-1: 0.9 mm and LDS-2: 1.3 mm. Wet milling was carried out, followed by glazing in a ceramic furnace. (Fig. 2)

Translucency Measurement

All 40 specimens (10 per group) were evaluated for translucency using a spectrophotometer (Fig. 3). The translucency parameter (TP) was calculated as the colour difference (ΔE) between measurements obtained over white and black backgrounds, based on the CIE $L^*a^*b^*$ colour system.⁴⁻⁵ TP was calculated using the following formula:

$$TP=[(L_{W^*}-L_{B^*})^2+(a_{W^*}-a_{B^*})^2+(b_{W^*}-b_{B^*})^2]^{(1/2)}$$

Sampling and Sample Size

All specimens were fabricated in the CAD/CAM dental laboratory at Yenepoya Dental College, Mangalore, using non-randomised sampling. The total sample size was 40 specimens, divided into 4 groups of 10 specimens each. Sample size was determined using effect size, with 80% power, 10% level of significance, and an effect size of 0.8.

Statistical Analysis

Statistical analysis was performed using SPSS software. One-way ANOVA was used to compare mean TP values across groups based on material type and thickness. The Bonferroni post-hoc test was applied for multiple intergroup pairwise comparisons between ZrSH-1, ZrSH-2, LDS-1, and LDS-2.

Results

According to the spectrophotometric readings obtained, the TP values were calculated for each individual sample of the four study groups, ZrSH-1, ZrSH-2, LDS-1 and LDS-2. The highest and lowest TP values obtained for ZrSH-1 were 7.20 and 6.08 (average: 6.53), ZrSH-2 was 4.75 and 4.31 (average:4.60), LDS-1 was 12.32 and 9.46 (average:11.09) and for LDS-2 were 9.09 and 7.36 (average: 8.14), respectively.

Table 1(a): Overall Inter-group Comparison

	N	Mean	Standard Deviation	p-value
ZrSH-1	10	6.5240	0.3589	< 0.001 [*]
ZrSH-2	10	4.6020	0.1515	
LDS-1	10	11.0940	0.9753	
LDS-2	10	8.1400	0.6362	
p-value based on ANOVA (Analysis of Variance) Test				
[*] = Statistically Significant (p < 0.05)				

Table 1.a provides an overview of the inter-group comparison of the TP values for ZrSH-1, ZrSH-2, LDS-1, and LDS-2 using a one-way ANOVA test, and there was a statistically significant difference in the means and standard deviations calculated for each of the four groups.

Table 1(b): Individual Inter-group pair-wise comparison

		Mean Difference	p-value
ZrSH-1	ZrSH-2	1.9220	< 0.001*
	LDS-1	4.5700	< 0.001*
	LDS-2	1.6160	< 0.001*
ZrSH-2	LDS-1	6.4920	< 0.001*
	LDS-2	3.5380	< 0.001*
LDS-1	LDS-2	2.9540	< 0.001*
p-value based on Post-hoc analysis using Benferroni Test after adjusting for multiple comparisons			
* = Statistically Significant (p < 0.05)			

Table 1 b shows the individual inter-group pair-wise comparison of the TP values of ZrSH-1,ZrSH-2,LDS-1 and LDS-2 by means of Post-hoc analysis using the Benferroni test, and there was a statistically significant variation in the mean calculated for each of the four groups in comparison to each of the individual groups.

Table 1(c): Inter-group Comparison

	N	Mean	Standard Deviation	p-value
ZrSH-1	10	6.5240	0.3589	< 0.001*
LDS-1	10	11.0940	0.9753	
p-value based on Independent-t-Test				
* = Statistically Significant (p < 0.05)				

Table 1(d): Inter-group Comparison

	N	Mean	Standard Deviation	p-value
ZrSH-2	10	4.6020	0.1515	< 0.001 [*]
LDS-2	10	8.1400	0.6362	
p-value based on Independent-t-Test				
[*] = Statistically Significant (p < 0.05)				

Tables 1.c and 1.d show the individual inter-group pair-wise comparison of the TP values of ZrSH-1 and LDS-1, and ZrSH-2 and LDS-2 by means of a Paired t-test, and there was a statistically significant variation in the mean and standard deviation.

Figure 4 shows the mean values of the translucency parameter for each group, ZrSH-1, LDS-1, ZrSH-2, and LDS-2, as a bar graph. The bar graph shows that the TP value is the highest for LDS -1 and the lowest for ZrSH-2. The bar graph also depicts that ZrSH-1 shows better translucency than ZrSH-2, but slightly less when compared to LDS-2. LDS-2, despite being the same thickness as ZrSH-2, shows higher TP values than ZrSH-2.

Figure 5 shows that when ZrSH-1 is compared with LDS-1, the translucency parameter values are higher in the LDS-1 group. The mean values of 6.5240 and 11.0940 for the groups Zrsh-1 and LDS-1, respectively, are depicted in this graph.

Also, figure 6 shows that when ZrSH-2 is compared with LDS-2, the translucency parameter values are higher in the LDS-2 group. The graph depicts the mean value of 6.5240 and 11.0940 in the groups Zrsh-1 and LDS-1, respectively.

Figure 7 depicts the mean values and the highest and lowest limits of the translucency parameter values obtained from spectrophotometer readings. The graph shows the high mean TP value for the group LDS-1 and the least mean TP values for the group LDS-2. The graph also shows that the range of variability in the TP values is greater in the LDS-1 and LDS-2 groups than in the ZrSH-1 and ZrSH-2 groups.

Discussion

The increasing demand for highly esthetic tooth-colored restorations poses a continuous challenge in achieving an optimal balance between optical properties and mechanical strength. Lithium disilicate ceramics are known for their superior esthetics due to higher translucency; however, their limited strength restricts their use in stress-bearing areas. (9) To address this limitation, newer materials such as zirconia-reinforced lithium disilicate and super-high translucent zirconia have been introduced, claiming improved esthetic and physical properties.

The present study evaluated the translucency of super-high translucent zirconia (ZrSH) and zirconia-reinforced lithium disilicate (LDS) at two clinically relevant thicknesses (0.9 mm and 1.3 mm). The results demonstrated that LDS exhibited significantly higher translucency parameter (TP) values than ZrSH at both thicknesses. This difference may be attributed to the inherent material composition and microstructure. LDS is primarily a glass ceramic reinforced with approximately 10% zirconia, whereas ZrSH is predominantly zirconium dioxide stabilized with yttria. The higher zirconia content in ZrSH is associated with increased light scattering at polycrystalline interfaces due to refractive index mismatches, thereby reducing translucency. (13, 14, 15, 16, 17)

An inverse relationship between translucency and thickness was observed for both materials, with thinner specimens demonstrating higher TP values. This finding corroborates reports that increasing ceramic thickness lengthens the optical path of transmitted light, thereby increasing scattering and reducing translucency.(2, 9, 10, 11, 12) The statistically significant differences between thickness groups within each material confirm that thickness remains a key determinant of the optical outcome.

Intergroup comparisons further indicated that LDS at 1.3 mm exhibited higher translucency than ZrSH at 0.9 mm, suggesting that material composition may influence translucency more than thickness alone. These findings are consistent with those of Fu Wang et al., who reported that translucency increases with decreasing thickness and that the magnitude of the change is material-dependent.² Reports by Baldissara et al. and other investigators similarly support the concept that increased zirconia content contributes to greater opacity, even with minimal compositional variations.(10,18,19,20,21)

Within the limitations of this in vitro study, zirconia-reinforced lithium disilicate demonstrated superior translucency compared with super-high-translucent zirconia at both tested thicknesses, suggesting its potential advantage in highly esthetic clinical situations. The null hypothesis was rejected, as changes in thickness significantly influenced translucency in both ceramic materials.

Clinical Implications

From a clinical perspective, zirconia-reinforced lithium disilicate may be preferred over super-high translucent zirconia in cases requiring maximum translucency, particularly for anterior restorations where blending with natural enamel is critical. (9) Since translucency decreased with increasing thickness in both materials, clinicians should consider that incremental increases in ceramic thickness may compromise esthetic outcomes, especially when masking is not required. (2, 9, 10, 11, 12) However,

material selection must be guided by functional demands, as zirconia-based ceramics may still be indicated in situations requiring enhanced mechanical strength or when minimal thickness restorations are planned. (13, 14) Therefore, appropriate case selection and thickness planning remain essential to achieve a predictable balance between esthetics and durability. (2, 9, 10, 11, 12)

CONCLUSION

According to the findings of the present study, Vita-suprinity, which is lithium disilicate reinforced with zirconia, is a more translucent ceramic material than Zolid fx, which is super-high translucent zirconia that has a higher amount of yttria in it than conventional zirconia. Although the constituents of the material cause differences in translucency, the thickness of the material also plays a key role in producing an exponential difference in translucency. In this study, increased thickness 1.3mm has shown decrease in the translucency of both the materials, but more so in Vita-suprinity. Hence, a tooth preparation of 0.9mm would achieve good esthetics with Vita Suprinity compared to Zolid FX.

Declarations

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****Author Contributions Statement****R.S. and F.T. conceived and designed the study, conducted the research, collected the data, and contributed to data interpretation. S.K. contributed to manuscript writing, editing, and correspondence related to the submission and publication process. S.K.S. critically reviewed the manuscript and provided intellectual input to improve its scientific content. M.Z. was responsible for specimen preparation and laboratory procedures. All authors reviewed, revised, and approved the final manuscript.

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Figures



Figure 1

Computer-assisted milling of ZrSH samples.

ZrSH

LDS

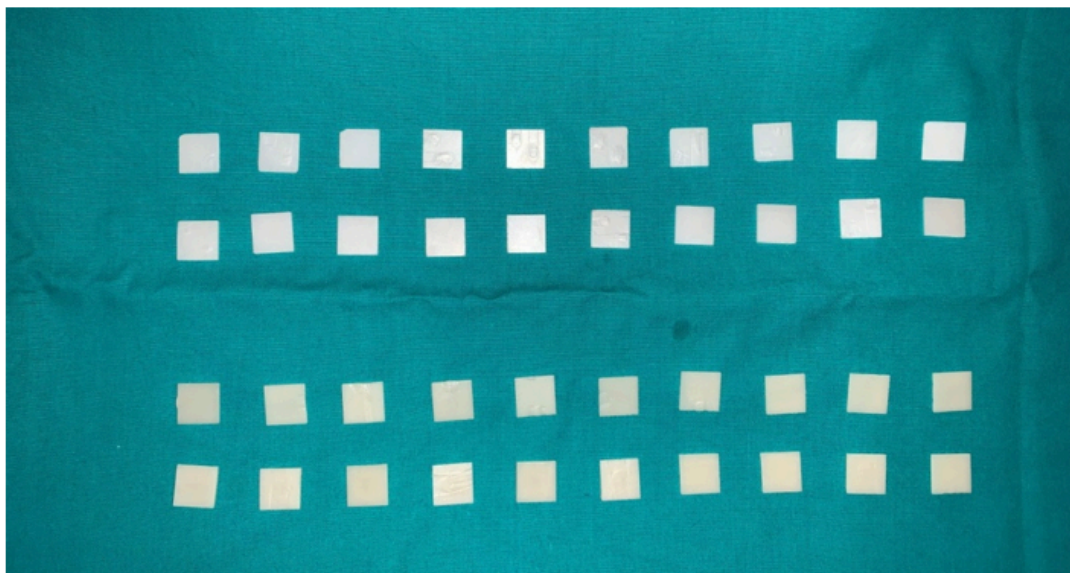


Figure 2

milled samples of ZrSH and LDS after glazing



Figure 3

Reflectance spectrophotometer. (I1 Pro[®] X-Rite)

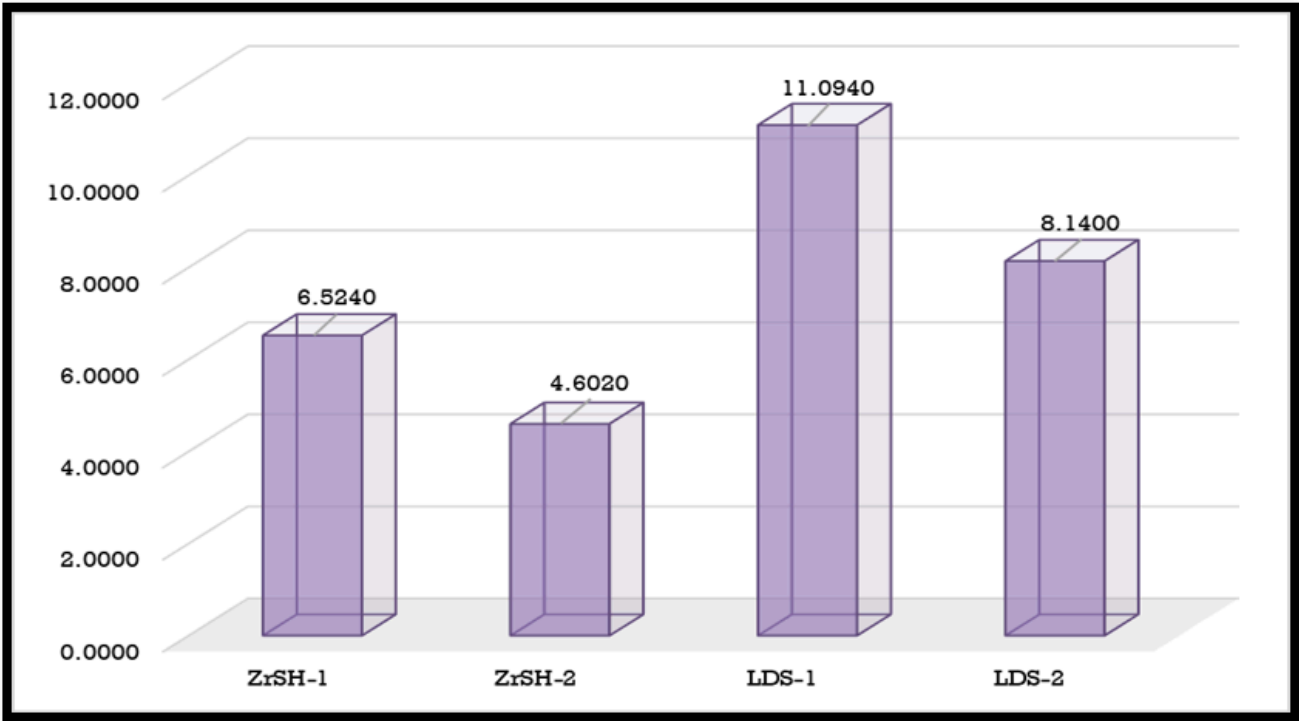


Figure 4

Mean TP values of ZrSH and LDS at different thicknesses of 0.9mm and 1.3mm

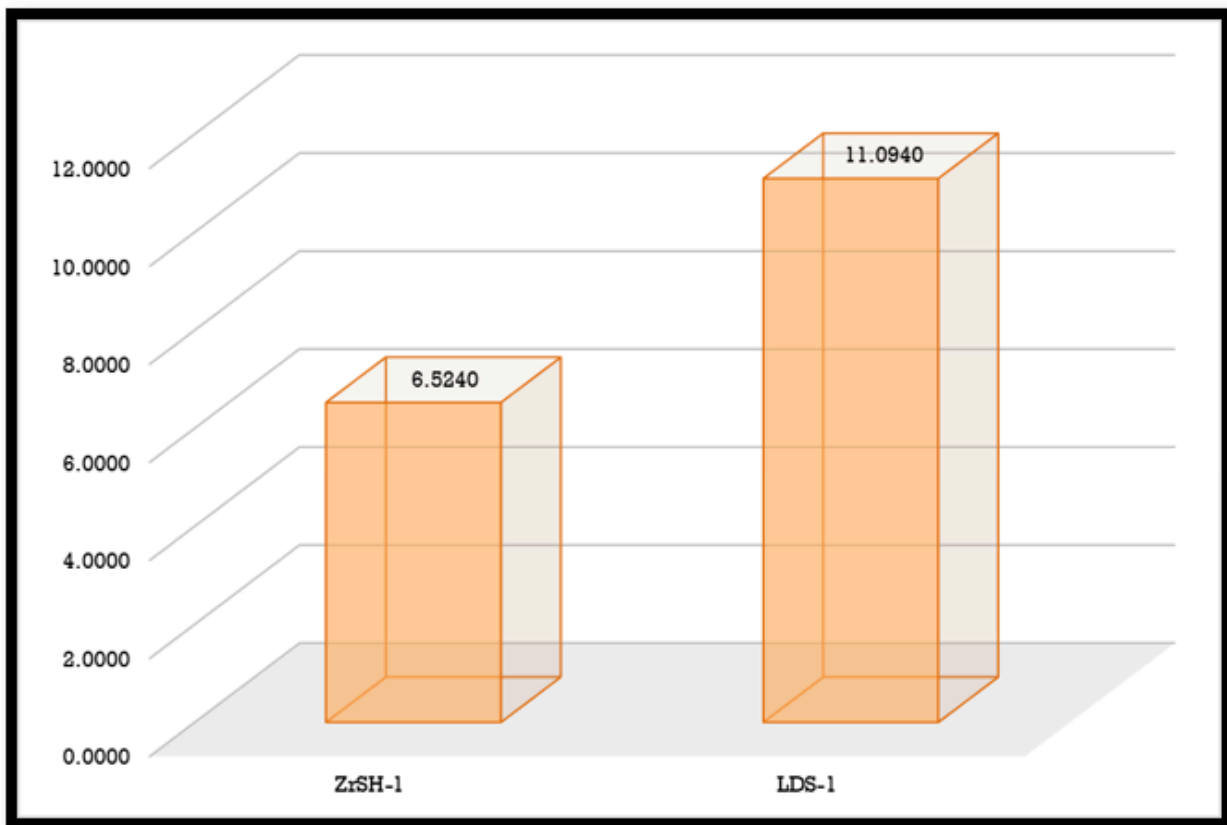


Figure 5

Depicts the difference in the TP values of ZrSH-1 and LDS-1

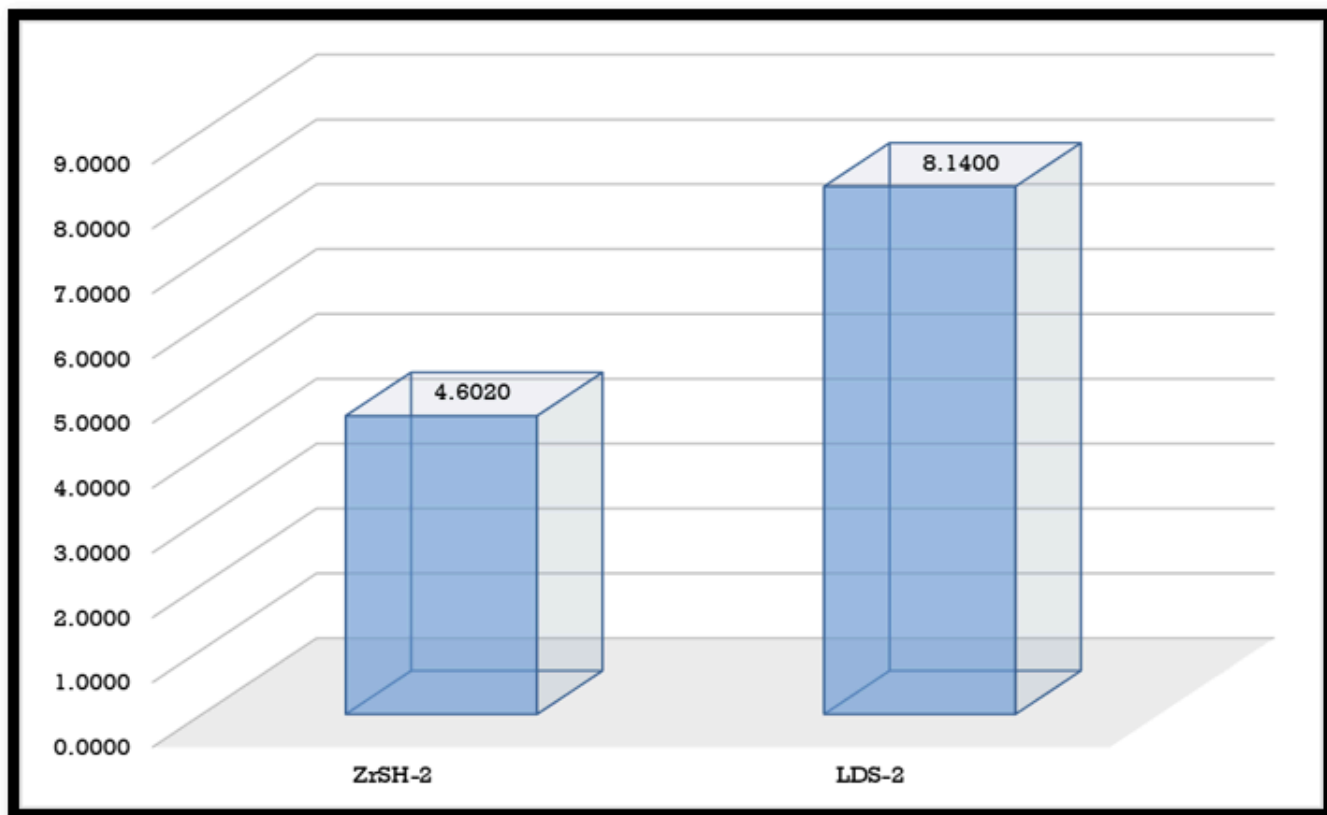


Figure 6

Depicts the TP values ZrSH -2 and LDS-2.

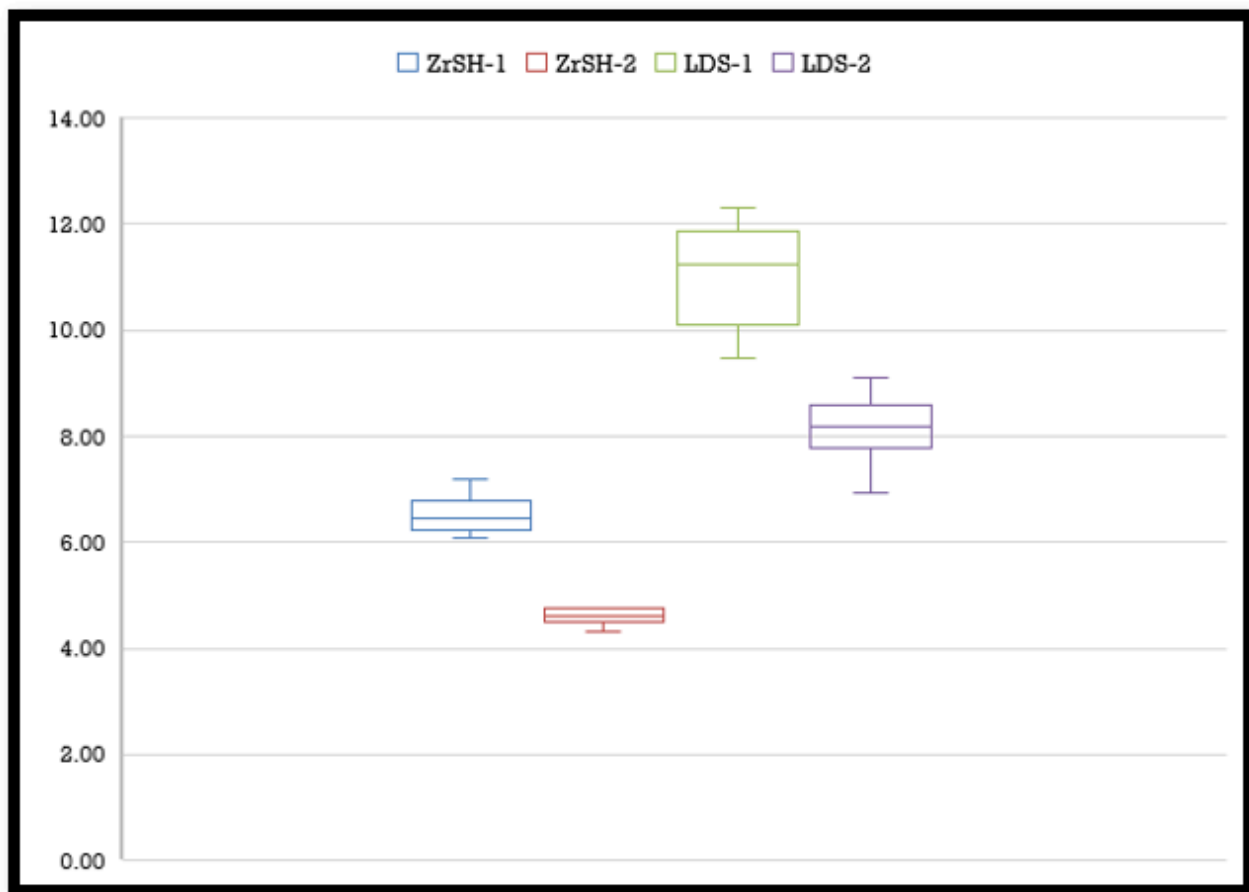


Figure 7

Depicts the upper and lower limits of the TP values of each group along with the mean values.