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Physico-Chemical Parameterization of some Commercially Available Toilets and Laundry Soaps in Tansen, Palpa

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Abstract

Nepalese market has witnessed an impressive upsurge in the production and consumption of a variety of soaps in recent times since 2022 after covid pandemic. The physicochemical parameterization determines the quality, competency and cleaning properties of soap so that we urge sagacious use of these soaps to keep skin healthy. Due to scant knowledge about the quality of soaps, there is need to assess them. Ten parameters namely foam height, surface tension, p^H, moisture content, conductance, total fatty matter, total alkali, free caustic alkali and chloride content of commercially available toilet (Dettol, Lifebuoy, Liril, Lux, No.1, Haldi Kanti, Neem Kanti and Neem Chiuri) and laundry soap (Aaha, Darshan, Dhoni and Xpert) samples collected from local market of Tansen were determined using different standard documented method of analysis. The physicochemical parameters examined in collected different soap samples are found as; foam height (20-120) ml, surface tension (38.857-67.192) dynes/cm, p^H (6.67-10.54), moisture content (6.68-34.40) %, conductance (115-327) µs/cm, Total Fatty Matter or T.F.M. (42-85.10) %, total alkali (0.31-1.178) %, free caustic alkali (0.54-0.91) % and chloride content (0.1-0.69) %, indicating most of examined parameters for soap were in standard limit as quality criteria set by Bureau of Indian Standards, IS 286: 1978 except that of free caustic alkali content in laundry soaps. This study has recommended public to use toilet soap for bathing purpose as it removes dirt more and laundry soap are found to have good cleansing action for clothes.

Key Words: *Cleansing action, lubricating; quality criteria; competency; laundry.*

Introduction

Water soluble compounds of sodium or potassium salts of fatty acids containing more than eight carbon atoms produced by saponification reaction are called soaps (Vivian*et al.,* 2014). Man's day to day activities include luxurious baths to laundry where soap is an integral part. Although the preparation of soap is same worldwide, it is produced in different varieties for various purposes. Simply, soaps are made by saponification reaction by the hydrolysis of animal fat or vegetable oils and alkali but potassium alkali is used to make soft or liquid soaps (Arasaretnam & Venujah, 2019). Each and every costumer should be aware of its physical and chemical properties to minimize problems related to the skin or health (Girgis *et al.* 1998). Today after facing tons of problems related to skin cancer and other health problems, people can be found switching different soaps with the hope that next will be better according to fragrance and appearance of soaps but they don't know that the soap quality depends on its physical and chemical properties (Tarelia, 2004). Acid being fatty acid or triglyceride and base being sodium hydroxide and when these ingredients combine by the process of saponification, fatty acid separates from triglyceride and fuses with hydroxide ion forming the salt of fatty acid or soap (Mwanza & Zombe, 2020). Soap molecules are amphipathic that have a long hydrocarbon chain with a carboxylic acid group with ionic bonded sodium or potassium ion on one end. The hydrocarbon end is non polar or lipophilic which is highly soluble in non-polar substances and the ionic end is soluble in water or Hydrophilic. Thus, forming the micelle which helps in removing the germs and dirt of the clothes with ease (Habib *et al.* 2016).

Bathing soaps are the potassium salts containing long chain of carboxylic acids whereas laundry soaps are the chain of sodium salts of benzene sulphonic acid. Soaps are made by using chains of C_8-C_{22} fatty acids that contributes detergency properties but not less than chains of C_{10} for bath soaps as they may irritate the skin while chains of C_8-C_{22} fatty acids contributes lathering and washing properties of soap (Mahato, 2018). The physicochemical parameters of the soap include physical observable parameters (color, erosion from hand washing and consistency), foam height, surface tension, moisture content, pH, conductivity, total fatty matter, total alkali content, free caustic alkali and chloride content play key roles in determining the quality or efficiency of soap that are governed by alkali used, type of oils, completeness of saponification reaction etc. (Vivian *et al.*, 2014).

The objectives of this study are to access physicochemical parameters (physical observable properties, Foam Height, Surface tension, pH, moisture, conductance, T. F. M., Total alkali, Free Caustic Alkali and Chloride content) of easily accessible soaps in local market, to compare the physicochemical parameters with their standard values and to provide information about the soap quality and its hazardous effect.

Method and Materials

Collection of Sample

Easily available 12 bar soaps (Lux, Liril, Dettol, Aaha, Dhoni etc.) used for bathing or washing purposes in Tansen were purchased from the same soap keeping in mind these include most of commonly available soap samples. These were kept in an air tight container for quality assurance till reaching laboratory before onsite and in-laboratory analysis of physico-chemical parameters of soaps.

Determination of Physical Observable Parameters

Soap sample were analyzed with sensory method for the determination of color of soaps. Also, soaps were applied to hand to observe whether it fall off or not for the erosion from hand washing and consistency of soaps were determined based on the result of erosion from hand washing.

Determination of Foam Height

Foam Height was determined by observing foam obtained during dropping from certain height (Popescu *et al.,* 2011).2 gm of soap was first dissolved in 500 ml distilled water. 50 ml of prepared soap solution was taken in a measuring cylinder and then, 200 ml of the same soap solution was poured through funnel from certain fixed height. Increased in height is assumed to be foam height as;

Foam Height = Total reading volume - Volume of water (or 250 ml)

Determination of Surface Tension

Surface tension of soap was determined by the standard drop count method. 0.1 % soap or 0.1 g of soap in 100 ml distilled was pipetted up to the upper mark in Stalagmometer and the number of drops made by soap sample was counted carefully while falling freely. Once distilled water was also allowed to drop to find its surface tension. The surface tension was determined by the formula;

$$\frac{Y_x}{Y_w} = \frac{n_w}{n_x}\frac{d_x}{d_w}$$

where,

Y_x is surface tension of the sample,

Y_w is surface tension of water at 200c is $72.85\,\frac{\text{dynes}}{\text{cm}}$ n_w is number of drops made by water and nx is number of drops made by soap sample: Since, volume of soap and water is same so that, $\frac{d_x}{d_w} = \frac{M_x}{M_w}$.

Determination of P^H

A digital pH meter (HI-8314 membrane pH meter) was used to determine the p^H of the soap samples. For this pH meter was first dipped in distilled water and was left for 24 hours. Later on, it was calibrated using pH buffer solution of pH 4 and 7 respectively. The p^H of the 1 % soap solution or 1 gm soap in 100 mL water was thus determined by dipping the p^H meter in this emulsion after constant stirring.

Determination of Moisture content

Moisture content in each soap samples was estimated by Oven dry Method in accordance with IS 286:1978 standard (Wilhelm *et al.* 1993).1 g of each soap sample was taken in a pre-weighted porcelain basin and was dried in a hot air oven for about 2 hours at a temperature 105°C.Moisture content of the soap sample was calculated as;

$$\% \text{ Moisture Content} = \frac{C_s - C_h}{C_s - C_w} \times 100\%$$

where, C_s is weight of crucible and sample,

C_h is weight of crucible and smaple after heating and

C_w is weight of crucible.

Determination of Conductance

Conductivity of the soap samples was measured by using documented conductivity cell method (Schulz and Clausse, 2003). 0.1 % of soap solution (0.1 gm of soap in 100 ml of distilled water) is prepared and is left for one day for the complete dissolution of the soap. The conductivity of all soap sample samples was measured directly using conductivity meter (CM-611-E-M.S. Electronics) after calibrated using distill water to cell constant.

Determination of Total Fatty Matter

Total Fatty Matter in soap was determined by the procedure given by Mak-Mensah (2011) and Onyekwere (1996). 5 g of each sample with 100 ml of water was heated and 20 ml of 15 % H_2SO_4 solution or 75 ml of sulphuric acid in 500 mL distilled water was added to make emulsion having pH less than 1. The resulting emulsion is solidified with 35 g of candle wax to form the soap cake. Then, these cakes were blotted and its moisture was removed. TFM of the soap was calculated using the formula as;

$$\text{T.F.M. } \% = \frac{A - X}{W} \; 100\%$$

where, A is weight of wax and oil or fatty matter,

W is weight of soap after drying and X is weight of candle wax.

Determination of Total Alkali Content

The Total alkali content is determined by titrimetric analysis by titrating excess acid present in emulsion with standard NaOH solution (Mak-Mensah, 2011). Titration mixture was prepared by heating 10 g of soap with 100 ml of ethanol for dissolving, followed with the addition of 5 ml of conc. 0.5 N H_2SO_4 or 3.47 mL sulphuric acid in 250 mL distilled water. This titration mixture was titrated against 1N NaOH (2.5 gm NaOH in 250 ml distilled water) using phenolphthalein indicator until the pink color appears. Total alkali content was calculated as,

$$\% \text{ Total alkali} = \frac{V_A - V_B}{W} \times 3.1$$

where, V_A is the volume of acid

V_B is the volume of base and

W is the weight of soap sample

Determination of Free Caustic Alkali

Free Caustic Alkali content (as NaOH) in soap is determined by titration method (Vivian *et al.* 2014). The titration mixture was prepared by heating 1 g of soap sample with 5 ml of 20 % aqueous Barium chloride solution in water bath until it was completely dissolved. The titration mixture was titrated against 0.05 M H_2SO_4solution using Phenolphthalein till the disappearance of pink color. Free Caustic Alkali was calculated as: -

$$\text{Free caustic alkali (as NaOH)} = \frac{0.31 \times V_A}{w}$$

where, V_A is volume of acid consumed and W is weight of soap sample.

Determination of Chloride Content

Argentometric titration method was used to determine chloride content (Vivian *et al.* 2014). 1 g of finished soap in 100 ml of distilled water was heated to dissolve sample and 20 ml of 20 % aqueous calcium nitrate solution was added with shaking and further, distilled water was added to make 250 mL solution. The filtrate obtained from mixture was titrated against 0.1 N silver nitrate using 20 % potassiumchromate solution as indicator till a brick-red color was obtained. The chloride content was calculated as;

$$\text{Cl \%} = \frac{\text{Volume of } AgNO_3 \text{ Consumed}}{\text{Wt of Soap Sample}} \times 0.585$$

Resulsts and Discussion

Analysis of Physical Parameters

The physical parameters such as color, erosion from hand washing, consistency, foam height and surface tension of the twelve different soap samples were tabulated in Table 1.

Table 1:*Physical Parameterization of some toilet and laundry soaps collected in Tansen.*

Sample Symbol	Color	Erosion from Hand washing	Consistency	Foam Height (ml); $\bar{X} \pm$ SD (n=4)	Surface-Tension (dynes/cm); $\bar{X} \pm$SD (n=4)
T1	Orange	None	Firm	120±1.2	46.09±2.3
T2	Red	None	Firm	105±0.6	38.857±1.7
T3	Light Green	Fairly low	Firm	85±1.3	60.644±2.4
T4	Pink	Fairly low	Firm	120±0.4	57.443±3.1
T5	Light Orange	None	Firm	115±0.3	47.358±1.2
T6	Orange	Medium	Firm	115±0.5	52.428±1.7
T7	Green	Medium	Firm	110±0.7	63.305±2.1
T8	Dark cream	Fairly low	Soft	110±1.1	50.742±4.1
L9	Dark Brown	Medium	Firm	85±0.7	50.825±3.7
L10	Light Green	None	Too much firm	75±1.1	53.776±4.8
L11	Yellow	Fairly High	Too much firm	80±0.4	46.967±2.3
L12	White	Fairly High	Firm	105±1.2	62.288±5.4

Collected toilet soaps had most variation in colors may be due to attract customers with commercial interest whereas, laundry soap has almost uniform color though all soaps are commercial soaps. Consistency and erosion from hand washing are inter-related or the soap that do not erode would lead to high lifetime than the soap that erode when washing. Result showed that toilet soap samples are subjected to medium erosion from hand washing while laundry soap samples have comparatively high erosion rate and toilet soaps have longer life than that of laundry soaps.

Foam Height formed by the collected Twelve different soap samples were shown in Table 1. Foaming capacity of soaps were different due to foaming agent and difference in soap making process but the soap with high foaming capacity could be considered as good quality soap (Mahato, 2018). Figure 1 showed that Toilet soaps had highest tendency to form foam about (85 -120) ml than laundry soap or (75-105) ml. Soaps with lower surface tension can be considered as the efficient cleansing agent (Mak-Mensah & Firempong, 2011). Also, laundry soaps have lower surface tension in the range of (46.967-62.288) dynes/cm but toilet soaps have surface tension values is in the range of (38.857-63.305) dynes/cm. It had been concluded that laundry soaps are good for washing clothes to remove dirt because of their lower surface tension and toilet soap are good to remove dirt from body though some toilet soaps because soap T7 (~63%) was found to have highest value followed by soap T3 (~60%) and soap T4 (~57%) but soap T6 (~52%), soap T8 (~50%), soap T5 (~47%), soap T1 (~46%) and soap T1 (~38%) were found to have lower surface tension.

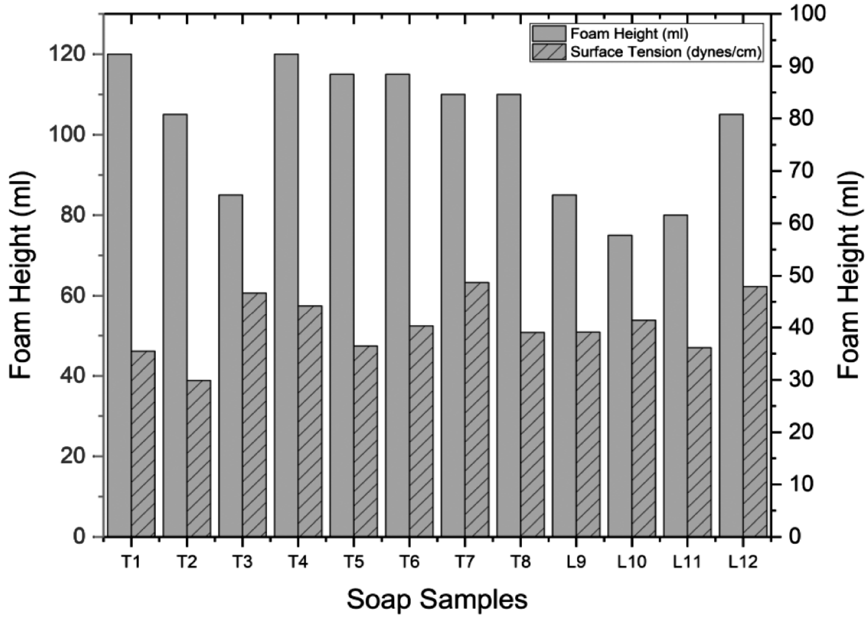

Figure 2:*Foam Height and surface tension of Different Soap Samples*

Figure 2 shows the dependency of foam height on the surface tension of different soap samples in Tansen. It evinced that there was a negative correlation between these variables (r^2= 0.00181 and r = -0.04256), that is, the dependency of surface tension on foam height for different soap samples was very low or poor. The results attributed that soap with low surface tension may enhanced the greater foam height or better cleansing soap in most cases.

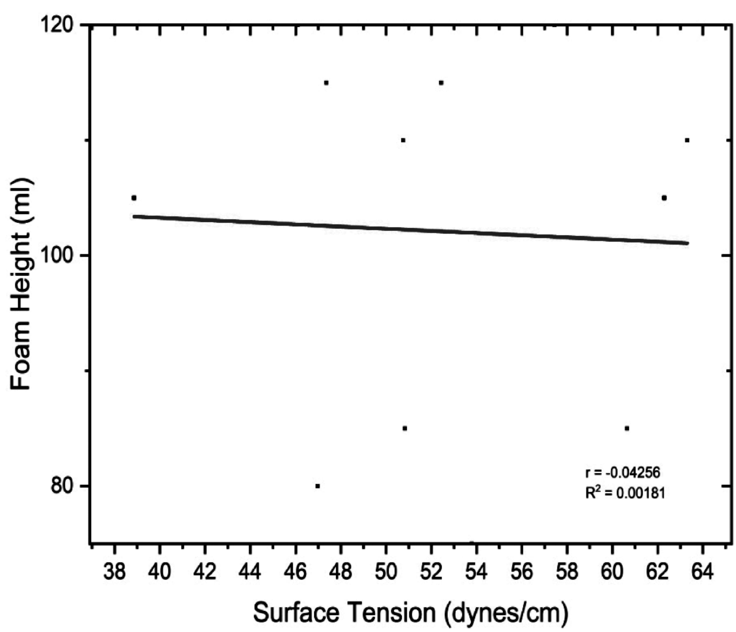

Figure 2:*Relation Between Surface Tension and Foaming Capacity*

Analysis of Chemical Parameters

The onsite analysis (% moisture, pH and conductance) and in-laboratory analysis (% TFM, % Total alkali, Caustic alkali and % Chloride content) for chemical parameters of all collected soap samples are done.

The pH value of soap is related to the hydrogen ion, $[H^+]$ in soap water emulsion and it may be alkaline due to alkali added during saponification process which may undergoes incomplete hydrolysis. It is known that one's healthy skin has a pH of 5.4-5.9, while the body's internal environment maintains a pH of 7-9 and with the increase in pH causes an increase in dehydrative effect and irritability to the skin.However, it can also find that high P^H value makes soap basic and will lather easily (Habib *et al.,* 2016, Gfatter et al., 1997). Figure 3 showed that eight toilet soaps under study had their P^H in the range of (9.26-9.86) and laundry soaps have p^H in the range of (9.88-10.54). This indicates that the analyzed laundry soaps are corrosive to the skin except soap L10 (~9.88). Also, moisture content or existence of water is another important parameter that is used in assessing the self-life of a soap product. High moisture content would lead to reaction of excess water with unsaponified fat to give free fatty acid and glycerol in the process called hydrolysis of soap on storage (Samuelsson *et al.*, 2006).It is found that laundry soap or L9, L11 and L12 except L10 had higher moisture content (> 20%) but all toilet soap had lower moisture content in the range of (6.68-18.57) % as shown in Figure 3. This may be because laundry soap does not have moisture seal packaging like toilet soap.

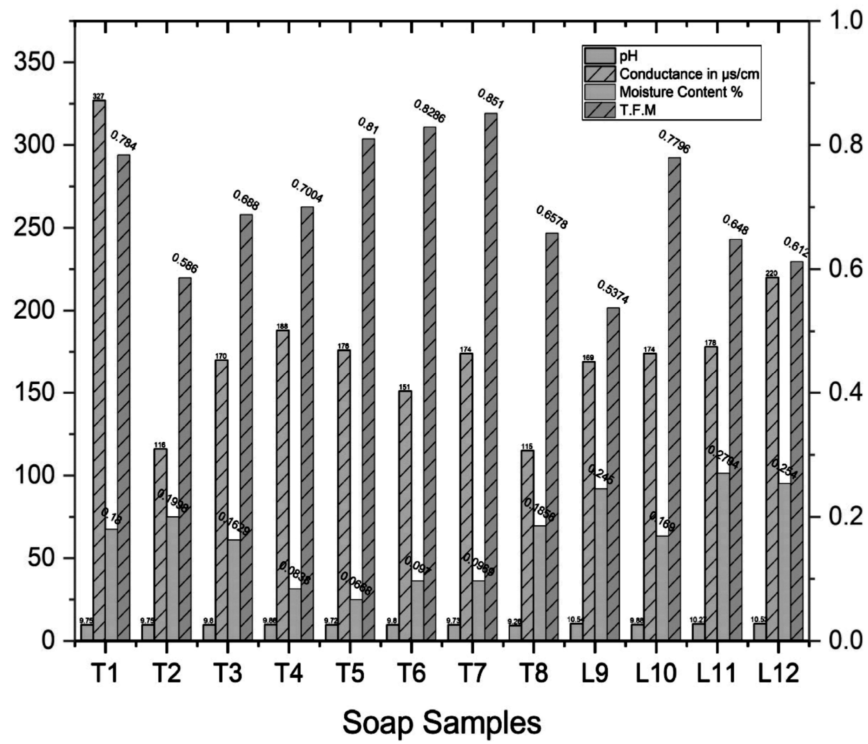

Figure 3: *pH, Conductance, Moisture content and T.F.M content of different soap samples*

Conductivity is one of the next parameters of soap quality related to the concentration of ions present in soap because of the ion that are present in the alkalis that are added during the saponification process (Schulz and Clausse, 2003). The Conductivity of collected different toilet and laundry soap samples were in the range of (115-327) µs/cm as shown in Figure 3. The result obtained that, toilet soap T1 (327 µs/cm) was found to have highest conductivity followed by laundry soap L12 (220 µs/cm). Bureau of Indian Standard categorized toilet soap according to its T.F.M. content into three grades: TFM of soaps with more than 76 % are grade I, those with more than 70 % are grade II and those with 60 % or more are grade III soaps and laundry soaps should have minimum of 45 % of T.F.M (Toilet soap, IS 2888: 2004). Higher TFM value ensures that soaps are least harmful to the skin and do not cause dryness. Also, soap having high TFM values are good quality soap that form more lather, lasts longer and more efficient cleansing action (Popescu *et al.*, 2011). Results revealed that soap T1, soap T5, soap T6 and soap T7 were grade-I soaps, only soap T4 was grade II soap and soap T3 and soap T8 are grade III soaps but only soap T2 was not in the range as laid by BIS though company claims that it has min 60% TFM value but was observed as 58.60 %. Also, Figure 3 showed that laundry soap L10 had the highest amount of TFM value which is 77.96 % but all TFM values of laundry soaps were under BIS standard.

Figure 4 shows the correlation of moisture content on the TFM values of different soap samples under study. The correlation coefficient (r^2= 0.5810 and r = -0.7622) revealed the negative impact of TFM values on the moisture content for different soap samples was very low or poor. The results attributed that laundry soap had lower TFM but higher amount of moisture content whereas Toilet soap had higher TFM but lower moisture content.

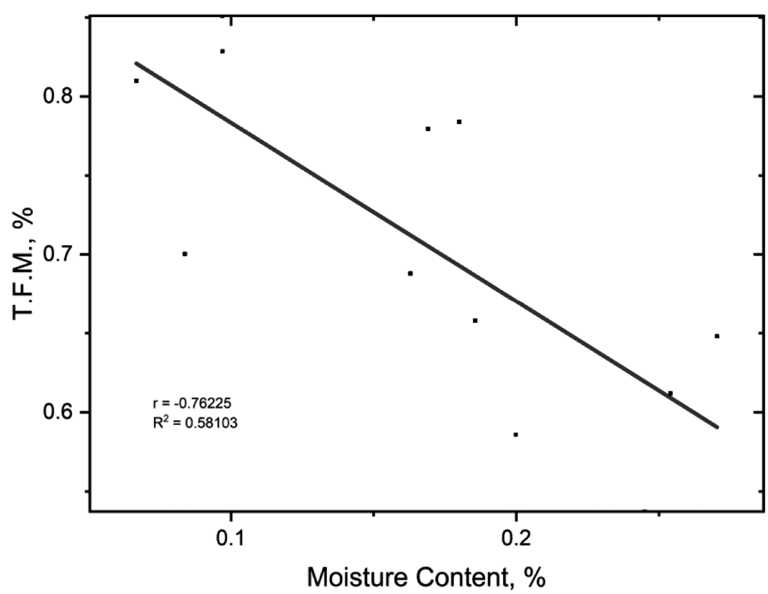

Figure 4:*Correlation between Moisture Content and T.F.M*

Total Alkali content of soap indicates the presence of total alkaline components and its high value favors detergency (Besty et al., 2013). Figure 5 showed that laundry soap samples contained high amount of total alkali in the range of (1.037-1.178) % whereas toilet soap samples contained less than 1 % total alkali except soap T1 and soap T2. The lowest amount of Total alkali in soap T8 because it is herbal soap and uses natural oils for the saponification instead of chlor-Alkali. All soaps examined were standard according to International Standard Organization since, soap must contain less than 2 % of total alkali to be good quality soap according to ISO.

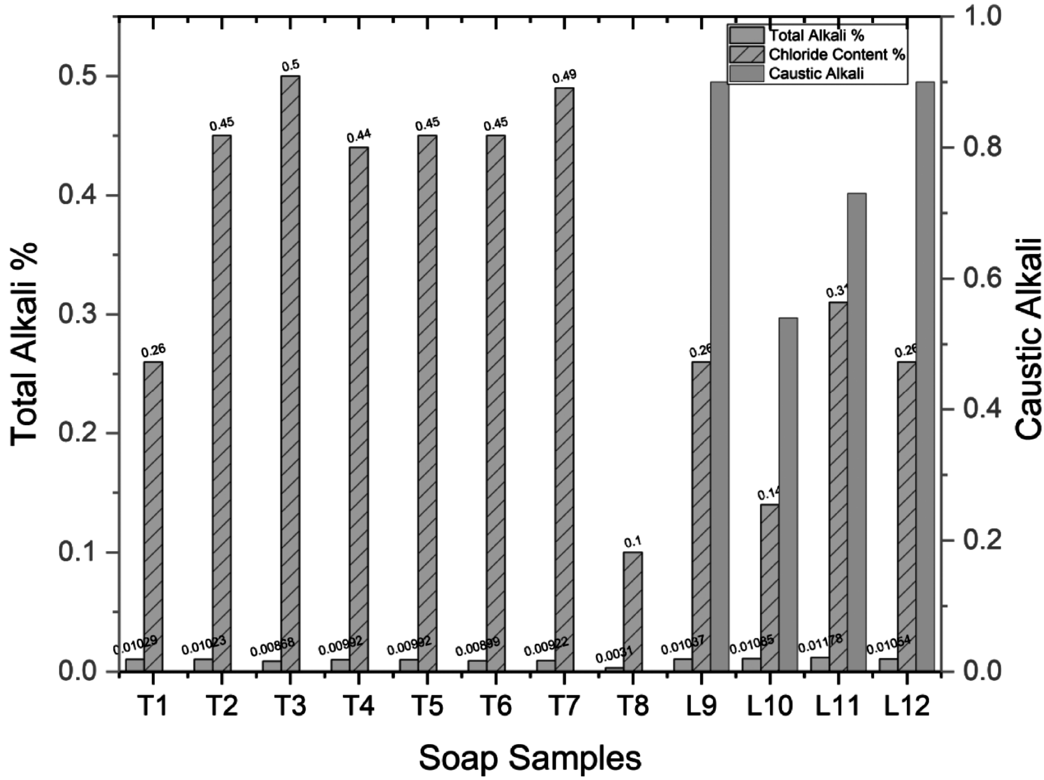

Figure 5: *Total alkali content, Chloride content and Caustic alkali of different soap samples*

The amount of alkali that is free to counter and avert the soap from becoming oily refers to Free Caustic Alkali of the soap. Its content should be lesser than 0.2 % for the laundry soap while 0.05 % for other body soaps (Vivian *et al*., 2014). Figure 5 showed that all toilet soaps had almost 0.00 % free caustic alkali that indicates they were standard whereas, all laundry soaps had more Free caustic alkali than it should be according to the standard as given by BIS which is 0.50 %.It was revealed that laundry soaps investigated were corrosive in nature and it should not be used for the bathing purpose, while toilet are better for bathing purpose and lower level of caustic alkali can reduce harshness on skin and cloth. Also, Chloride content of collected twelve different commercial soap samples is in the range of (0.10-0.49) % as shown in Figure 5. The lowest amount of chloride is reported in soap T8 (0.10 %) which might have used any other natural ingredients for the precipitation instead of synthetic chloride. None of the investigated soap was found to have excess chloride content than mentioned by BIS which is < 1.50 % for toilet soaps and < 2.00 % for laundry soaps.

Conclusion

The physicochemical parameters of eight toilet soaps (Dettol, Lifebuoy, Liril, Lux, No.1, Haldi Kanti, Neem Kanti and Neem Chiuri) and four laundry soaps (Aaha, Darshan, Dhoni and Xpert) available in Tansen were successfully investigated to know the present situation of soap quality. As expected, all measured parameters such as physical observable parameters, foam height, surface tension, pH, moisture content, conductance, TFM, total alkali, free caustic alkali and chloride content were well under international standard (BIS) except TFM of lifebuoy soap is not in the standard range though company claimed it as grade III toilet soaps. Similarly, free caustic alkali of all laundry soaps was excess than recommended by international standard and therefore these analyzed soaps should not be good for hand and body washing. Moisture content, pH and total alkali were contained in higher amount in laundry soaps than in toilet soaps and hence, laundry soap favor detergency. The minimum amount of moisture in toilet soaps indicates hardness of toilet soaps or laundry soaps are soft with good self-life. The pH of investigated soaps was greater than 9 indicating good lathering tendency. TFM and conductance of toilet soaps were found as higher than that of laundry soaps. The high amount of TFM in toilet soaps helps for lubricating skin during washing hands or body. On average, most soaps investigated herein were of fairly acceptable and were fit for use.

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Author Contribution

Experiments; sample collection, data analysis etc. are designed by PA and MG. PA performed experiments to get results according to documented methods. The first draft of the manuscript was written by MG, and both authors read and approved the final manuscript.

Disclosure Statement

Conflict of Interest: The authors declare that there are no conflicts of interest. Compliance with Ethical Standards: The article does not contain any studies involving human or animal subjects.

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