

# Applied statistics in designing special organic mixtures

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**Abstract.** Samples of toilet soaps were produced by saponification of different mixture of palm oil (PO) and palm kernel oil (PKO). The produced soaps were analyzed for their total free matter (TFM), total free alkali (TFA), moisture content (MC), pH and chloride content ( $\text{Cl}^-$ ). The results of the analysis were compared with the British standard specification for toilet soap using t-test statistics and it was observed that the used of different blend of these locally produced oils can serve the industrial need of raw materials availability in the production of grade B toilet soap. Inter-correlation between the analyzed parameters were positive in all cases and a significant difference were observed when the produced soap were compare with the soap produced from 100% PKO and 100% PO respectively.

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**Key words:** : mean, standard deviation, correlation, variation.

## §1. Introduction

Most cleansing operations are done with soap and water. Consequently, soap can be considered as a chemical compound used in the cleansing of surfaces (Shaw, 1991). Woollatt (1985) stated that soap is a metallic salts of higher organic acids derived from oil or fat. Soaps are produced by the reacting suitable alkalis (such as sodium hydroxide or potassium hydroxide) with oil or fat in appropriate ratio (Better and Davidson, 1953). The hot and the cold processes are the two major industrial processes commonly used in the production of soap. Unlike the hot process, the cold process is the traditional method of producing soap and it leads to the production of low quality soap (Woollatt, 1985).

The most abundant oil-producing tree in Nigeria is oil palm tree, which is called, *Elaeis guineensis*. The tree is capable of producing two major types of oil namely, palm oil and palm kernel oil (Jacoby, 1964).. Palm oil is a reddish colour oil gotten from the freshly mesocarp of the palm fruit (Rukmini, 1994; Zeven, 1975). Palm oil (PO) and palm kernel oil (PKO) have closely similar chemical and physical properties however; PO can be differentiated from PKO by using chemical and physical

constants, which enables each of them to be characterized (Etuk, 2006).

Numerous researches have been carried out on the production of quality soap from plant oil such as coconut oil, groundnut oil, etc. but information on the methods of producing high quality soap from the local and the most abundant raw materials is scanty. Palm oil and palm kernel oil are widely distributed in Nigeria and many other developing nations of the world (Etuk, 2006) consequently utilization of the resources that can be gotten from these materials can encouraged global industrialization. The present study is aimed at finding industrial substitute for the production of toilet soap using local raw materials.

## §2. Materials and methods

20liters of palm oil and 20liters of palm kernel oil were purchased from Ikot Ekpene market (Akwa Ibom State, Nigeria). Various mixture consisting of PO and PKO in the ratio of 100:0, 4:1, 3:2, 1:1, 2:3, 1:4, and 0:100 were used to prepare five separate replicate samples of soaps according to the method described by Woollatt (1985). The produced soaps were analysed for total fatty matter (%TFM), total free alkali (%TFA), %Moisture content (MC), pH and Chloride ion concentration ( $\text{Cl}^-$ ).

The TFM was determined by the method reported by A.O.A.C.(1975). 10g of the soap sample were introduced into a separating funnel and the volume of the funnel's content was increased to 100ml by addition of some quantity of hot water. The extraction of the TFM was done by addition of diethyl ether and the weight of the TFM was determined after drying. The percentage TFM was calculated from the difference in weight before and after extraction.

The oven drying method was used in the determination of the moisture content of the soap. 10g of the soap was weighed into a dish and dry in an oven maintained at 100oC. When a constant weight was acquired, the difference in weight before and after drying was recorded as the moisture content of the soap.

The chloride content of the soap in mg/g was determined by dissolution of 10g of the soap sample in  $\text{Ca}(\text{NO}_3)_2$  followed by titration with  $\text{AgNO}_3$  using  $\text{K}_2\text{Cr}_2\text{O}_7$  as an indicator. The concentration of chloride ion the soap was calculated as mg/g of NaCl (Bassett et al., 1989).

In the determination of the pH of the produced soap, 10g of the soap was dissolved in 100ml of distilled water and the electrode of an Orion model-520 pH meter was immersed into the soap solution and the pH was read directly from the meter. Prior to the measurement, the pH meter was calibrated by using three standard buffers at pH of 1.65, 7.00 and 10.00 respectively.

## §3. Result and discussion

The results of the total free matter (TFM), total free alkali (TFA), moisture content (MC), pH and chloride content of the soap samples produced by using PO and

PKO in the ratio of 0, 0.25, 0.67, 1.0, 1.5 and 4.0 are shown in table 1. Fig. 1 to 5 show the various plots for the different analyzed parameters against the combining ratios of palm oil and palm kernel oil while table two shows the statistical t-test result when the produced soaps were compare with the soap produced from 100% PO.

The mean values of %TFM for the soaps produced from mixtures of PO and PKO in the ratios. 100:1, 2:4, 6:4, 1:1, 1:2, 1:4, and 1:100 were 68.18, 64.17, 63.15, 63.02, 77.68, and 76.89% respectively. The mean values of the %TFA for the soaps with ratios similar to those above were 0.034, 0.040, 0.034, 0.04, 0.058, 0.086, and 0.120 respectively. The mean values for the percentage moisture content (MC) of the soaps with similar corresponding ratios were 11.98, 11.98, 11.94, 15.00, 15.80, 18.00, and 19.61 respectively. However, the mean values for the pH of the corresponding soaps were 8.01, 8.01, 8.01, 8.01, 8.30, 8.42 and 8.66 respectively.

Comparison of the mean values of the %TFM of the soap produced from 100% PO with those produced from different combining ratios of PO and PKO shows a statistical significant difference ( $P < 0.05$ ). Similar statistical observations were seen for the %TFA except when the ratio, PO: PKO were 100:1, 4: 1 and 3:1. From fig. 1, it can be seen that the TFM of the soap remain almost constant as the ration increases but decreases sharply when the ratio is between 0.8 and 1.0 after which it remain almost constant. The TFM of soap is one of the parameter that can be used to assess the quality of any soap. The fact that the pH of the produced soap does not remain constant at the different ratio of PO and PKO suggest that mixing PO and PKO can affects the quality of the produced soap. For optimum quality, it is required that the TFM of the produced soap should not be above 76.50% implying that the best combining ratio of PO & PKO for quality soap production with respect to TFM should be less than 1. The value of 1 can therefore be regarded as the optimum value require for the production of quality soap. Correlation between TFM and TFA content of the soap was positive ( $r = 0.947$ ,  $P \leq 0.05$ ) indicating that the TFM content of the produced soap increases as the TFA of the oil sample increases. The regression equation relating TFA and TFM is  $TFA = 89.81TFM + 9.624$ . Similarly, correlation between TFM and MC ( $r = 0.8257$ ), pH( $r = 0.8906$ ) and  $Cl^-$  content ( $r = 0.955$ ) of the produced soap were also positive suggesting a proportional relationship between them. The regression equations relating them were  $TFM = 1.996MC + 39.56$ ,  $TFM = 24.60pH - 132.28$  and  $336.35Cl^- - 6.5$ .

The TFA of the sample strongly correlated with the pH ( $r = 0.9648$ ), MC ( $r = 0.947$ ) and with the chloride content ( $r = 0.6219$ ). This shows that as the combining ratio of PO and PKO, varies, the MC, pH, chloride content and TFA of the soaps tend to vary in the same direction implying that the combining ratios have an important influenced on the quality of the produced soap. The regression equation between TFA and MC, pH and chloride content of the soaps are,  $TFA = 0.009MC - 0.089$ ,  $TFA = 0.1159pH - 0.890$  and  $TFA = 0.952Cl^- - 0.153$  respectively. TFA is a quality index of soap that records the amount of alkali that has reacted with the oil during saponification process. This means that for a complete saponification, the amount of TFA will be as low as possible. The British standard for grade B soap and soap products requires the TFA content of grade B soap to be 0.2%. During the study,

the TFA content of the produced soaps ranges from 0.034 (100% PO) - 0.12 (0%PO). With the observed range, it can be stated that combination of PO and PKO for soap production may not adversely affects the TFA content of the soap.

The moisture content of the produced soaps decreases as the combining ratios of PO and PKO increases. This is shown in Fig. 2. There was a statistical differences between the moisture content and the pH of the soaps produced when the ratios of PO: PKO were 1:1, 2:3, 1:4, 100:1 and 2:3, 1:4, 100:1 respectively. Correlation between the moisture content of the soaps and the pH ( $r = 0.9284$ ) and chloride content ( $r = 0.6528$ ) were positive and the regression equation relating the pH, chloride content of the soaps to their moisture contents were  $\text{pH} = 0.0815\text{MC} + 6.900$  and  $\text{Cl}^- = 0.0045\text{MC} + 0.159$  respectively. The pH of a medium is a measure of negative logarithm of the concentration of hydrogen ion of that medium (Atkin, 1990) and water can ionize to produce hydroxyl ion and hydroxide ion hence it can influence pH of a medium. The observed moisture content of the produced soaps was lower than the value expected for grade B soap (Woolatt, 1985).

The pH of the produced soap was observed to decrease as the ratio of PO to PKO increases approaching a minimum value of 8.01 when the combining ratio was 1.00. After the ratio of 1.00, the pH remain constant implying that beyond PO: PKO ratio of 1.00, the pH of the produced soap is unaffected by mixing ratio. The observed constancy of pH value may be due to stabilization in the ionization potential or electrode potential of the mixture producing the soap. Moore (1990) has stated that the pH of a solution is related to the electrode potential of that system by  $E = -RT/F \times 2.303\text{pH}$ , where  $E$  is the electrode potential, which may vary for different concentration of chloride ion,  $R$  is the gas constant,  $T$  is the temperature and  $F$  is the faraday. From the equation, any factor that can affect the electrode potential of the system will certainly affects the pH of the same system. Therefore, the presence of chloride, and other ions in the caustic soda or the oil might have been responsible for the decrease in the pH of the soap below the combining ration of 1.00. Similarly, the constancy of pH implies that ionization might have reached it peak value (when the ratio was 1.00) such that further increase in combining ratio could not affect the pH of the system again.

The variation in concentration of chloride with the ratio of PO and PKO is shown in Fig. 5. From the graph, it can be seen that the chloride content of the produced soap decreases as the ratio increases and approaches it peak value at a ratio of 1.00. Beyond the ratio of 1.00, further increase in the combing ratio does not affect the chloride content of the soap. The constancy of chloride content of the produced soap implies that absorption of chloride by soap produced from different PO and PKO mixtures reaches its maximum value at the ratio of 1.0. Eddy and Ukpong (2006) have stated that the distribution of chloride between the soap and lye during saponification of caustic soda by PKO reaches its peak or optimum value when distribution coefficient is 1.5. Beyond 1.5, the absorption will either decreases or remain constant. The ratio of 1.00 corresponds to equal mixture of PKO and PO. The observed reduction after the ratio of 1.00 also indicates that there could be some changes in the thermodynamic properties of the PO and PKO when the two were mixed together. The changes in thermodynamic properties might have affected the absorption capacity of the caustic

soda- oil system for chloride salt and as the ratio gets above 1.00, the thermodynamic properties of the PO/PKO system remain constant hence the constancy of the absorption capacity of the system. The British standard specification for Grade B solid soap products, BS 1914:1984, requires that the chloride content of grade B soap should be less than 0.7mg/g. The produced soaps are therefore acceptable for used with respect to their chloride content. There was a positive correlation between the chloride content and the pH of the produced soaps ( $r = 0.7816$ ) and the regression equation was  $\text{pH} = 9.963\text{Cl}^- + 5.96$ . This confirms that the pH of the produced increases linearly as the chloride content increases.

Fig. 1: Relationship between TFM and the ratio, PO:PKO

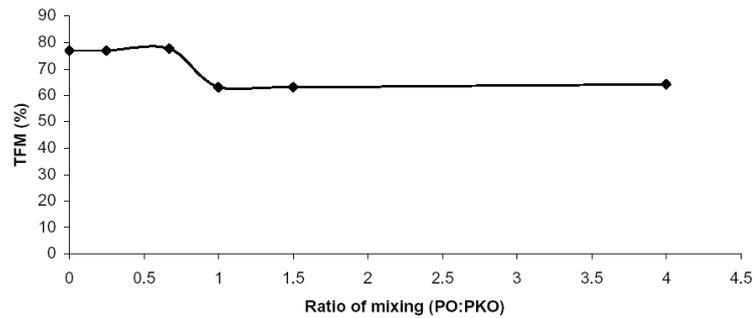


Fig. 2: Relationship between TFA(%) and mixing ratio of PO:PKO

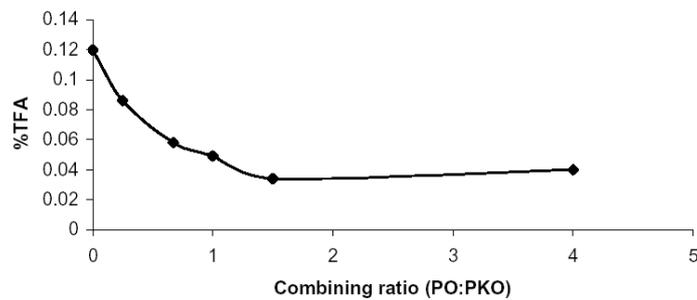


Fig. 3: Relationship between MC of the soap and combining ratio (PO:PKO)

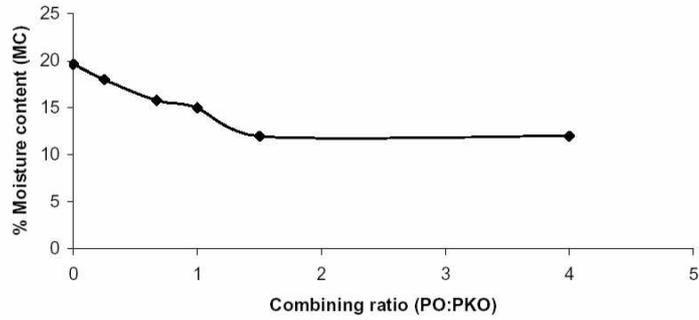


Fig. 4: Relationship between pH of the soap and the combining ratio of PO & PKO

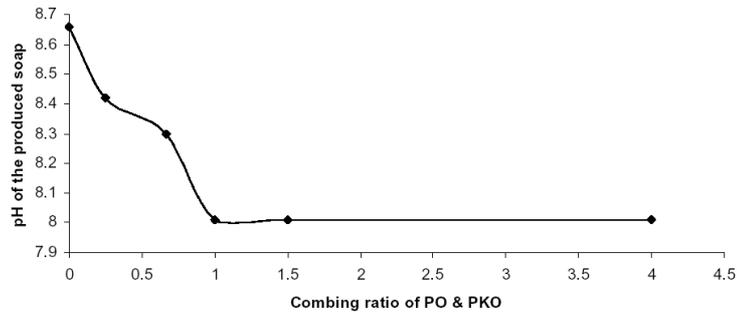


Fig. 5: Relationship between chloride content of the soap and the combining ratio of PO & PKO

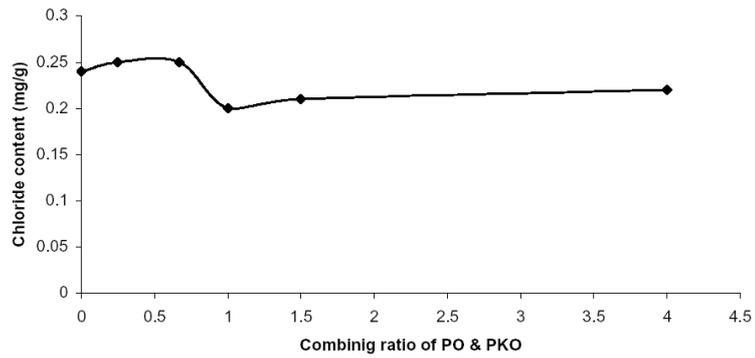


Table 1: Analytical properties of soaps produced from PO & PKO

**combined at different ratio**

<i>PO : PKO</i>	<i>TFM(%)</i>	<i>TFA(%)</i>	<i>MC(%)</i>	<i>pH</i>	<i>Cl<sup>-</sup>(mg/g)</i>
100 : 0	68.18 ± 0.66	0.034 ± 0.006	11.98 ± 0.049	8.01 ± 0.14	0.20 ± 0.01
80 : 20	64.17 ± 1.76	0.040 ± 0.007	11.98 ± 0.67	8.01 ± 0.01	0.22 ± 0.02
60 : 40	63.15 ± 0.64	0.034 ± 0.006	11.99 ± 0.057	8.01 ± 0.09	0.21 ± 0.02
50 : 50	63.02 ± 0.12	0.049 ± 0.003	15.0 ± 0.141	8.01 ± 0.02	0.20 ± 0.03
40 : 60	77.68 ± 0.43	0.058 ± 0.003	15.80 ± 0.534	8.30 ± 0.22	0.25 ± 0.02
20 : 80	76.89 ± 0.52	0.086 ± 0.005	18.00 ± 0.65	8.42 ± 0.34	0.25 ± 0.03
0 : 100	79.87 ± 0.25	0.120 ± 0.011	19.61 ± 1.05	0.25 ± 0.03	0.24 ± 0.04

\* Mean of 5±Standard deviation

#### §4. Conclusion

Palm oil tree is a very common tree in most part of the world and the major raw materials from this economic tree are palm oil and palm kernel oil. The study on the possibility of producing good quality toilet soaps from mixture of different mixture of PO and PKO significantly provide the bases for the utilization of our local raw materials for the production of grade B soap. This fact is worth considering in the attainment of indigenous goal in soap making technology.

The study reveals that the values for the all the analyzed parameters exhibited remarkable and desirable changes when the ratio, PO: PKO was 1.00. The quality of the produced soap was also observed to improve within this ratio and above the ratio. This implies that for the production of optimum quality soap of grade B standard, the combining ratio of PO: PKO should be equal to or greater than 1.00. In conclusion, suitable combination of PO and PKO can be used in producing high quality soap of B grade.

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