

CHEMICAL PROPERTIES OF JATROPHA SOAP AND ITS EFFECTS ON REACTIVE DYED COTTON FABRICS AS COMPARED TO COMMERCIAL SOAPS

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ABSTRACT

Jatropha soap has been produced from oil which is obtained from the jatropha curcas. This is an oil-rich drought resistant shrub, originating from Central America but has been grown in many areas of the world including Zimbabwe. This research focuses on comparing the chemical properties of jatropha soap to commercial soaps and its effects on reactive dyed cotton fabrics. Jatropha soap was synthesised in the laboratory and chemical tests were carried out to compare its chemical properties with other commercial soaps. Three commercial soaps, Elangeni, O'key and Perfection soaps were used for comparing the performance of jatropha soap. Tests on alkalinity, solubility, lathering power, cleansing ability, reactivity in hard water and colour fastness to washing were carried out on the soaps. Results indicated that jatropha soap has comparable alkalinity, solubility, cleaning ability and foaming capacity in soft and hard water like the other commercial soaps. Colour fastness results showed that after washing with jatropha soap and the commercial soaps, there was no colour change on the dyed fabrics thus a rating of 5 was observed on the colour change grey scales. Colour staining was observed on the cotton section of the multifibre after washing with the four soaps and this shows that there may be some slight staining on adjacent cotton fabrics when washing with these four soaps. All the comparison tests indicate that jatropha soap has comparable properties to commercial soaps therefore its local production should be encouraged so as to boost the country's economy and rural communities.

Key words: jatropha, soap, washing, colour fastness, grey scales.

1. INTRODUCTION

In Zimbabwe, the local production of soap is one of the most economically attractive uses of jatropha oil. Jatropha oil has been used in making both washing and bath soaps, although other uses are available, for instance the manufacture of biodiesel [1]. Apart from Zimbabwe, jatropha soap is being produced by artisanal methods in a number of African countries including Mali, Zambia, Tanzania, Ivory Coast and Senegal, to mention a few. In various parts of Zimbabwe, which include Mutoko, Nyanga, Binga and Lupane, some women

have traditionally made jatropha soap by boiling jatropha oil with sodium hydroxide or soda solution [2]. The mixture is then poured into moulds of various sizes and shapes, in which it hardens into soap during cooling. However, literature does not indicate the properties of this soap produced from jatropha oil in Zimbabwe and the effects it may have on fabrics during laundering processes. From the textile manufacturers' point of view all various finishing processes that a fabric goes through, including washing,

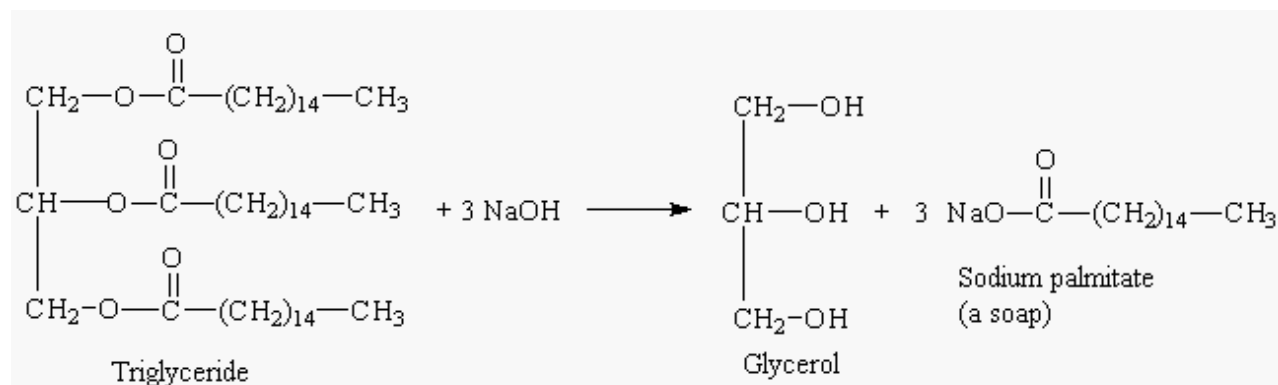


Figure 1 Saponification process

need to be assessed to ensure that there is minimum damage done on the fabric during processing and use. This is illustrated by the incorporation of care labels which is done to ensure that a garment is washed, dried and ironed properly so as to improve durability during wear. Since the type of detergent used during domestic laundering processes may affect the colour fastness of the fabrics it is therefore important to investigate the properties of jatropha soap so as to assess its effects on the colour fastness properties of dyed fabrics [3].

1.1 Characteristics of jatropha oil

The term 'Jatropha' refers to the species *Jatropha Curcas*, although there are approximately 170 known species of the plant. Jatropha oil is vegetable oil produced from the seeds of the *Jatropha Curcas*, and this plant can grow in marginal lands and common lands with low nutrient content. *Jatropha Curcas* is a drought-hardy, tropical, native American tree with seeds that yield viscous oil [4]. Jatropha seed oil is approximately 80 % unsaturated and the amount of oil contained in the seeds is dependent on the species of jatropha and where it is grown. The range of fatty acids present in the jatropha seeds will differ from place to place, although the major fatty acids present in all jatropha oils are oleic acid, linoleic acid, stearic acid and palmitic

acid [5]. Most vegetable oils that are liquid at room temperature have a comparable fatty acid composition. Jatropha oil is rich in palmitic acid, with high levels of hydrophobicity, and makes a soft durable soap under even the simplest of manufacturing processes. According to the variety, 0.06% -6.7 % of the oil can be free fatty acids. The saponification value of jatropha oil ranges between 185-210 mg. This is the amount of sodium hydroxide required to make a solid soap and it depends on the type of fatty acids contained in the oil. [6]

1.2 Soap Manufacture

Soap is an anionic surfactant which consists of sodium or potassium salts of fatty acids. It is produced from the combination of fatty acids with alkalis and the nature of the soap is dependent on the type of alkali used to saponify the fats. Sodium soaps, prepared from sodium hydroxide tend to be harder whilst potassium soaps, prepared from potassium hydroxide are softer or often liquid. Jatropha soap is manufactured using the saponification process as shown in Figure 1 [7]. Although the reaction is shown as a one step reaction, it is in fact two steps and exothermic. On addition of alkali, the oil is broken down to the constituent fatty acids. These fatty acids then combine with the alkali to form soap. The glycerol turns back

to an alcohol and the fatty acid portion is turned into a salt because of the presence of a basic solution of NaOH. Different oils produce soaps of varying hardness, odour and lathering, so oils can be blended to produce a blend with the most desirable characteristics [8]. The type of fatty acid and length of the carbon chain determines the unique properties of various soaps. Bar soaps are usually manufactured using the hot-process method where sodium hydroxide and fat are boiled together at 80-100°C until saponification occurs. After saponification, the soap is sometimes precipitated from the solution by adding salt, and the excess liquid drained off. The hot, soft soap is then poured into a mould [9].

1.3 Colour Fastness to Washing

Colour fastness to washing is assessed with respect to changes in the colour of the specimen being tested and staining of undyed material which is in contact with the specimen during the test. A numerical assessment of each of these effects is made by comparing the changes with two sets of standard grey scales, one for colour change and the other for staining. During domestic laundering, fabrics are saturated with water and agitated or beaten in the presence of soaps or detergents which are designed to aid wetting, breakdown and removal of soils [10]. This is achieved by the soap that decreases the surface tension of water so as to loosen unwanted particles, emulsify grease, and absorb dirt and grime into foam to enable cleaning. Washing processes may contribute more to fabric damage than use and wear. The fabric changes that occur during washing such as colour fading and cross-staining by dyes are dependent on the washing process and the washing product used [11].

2. Materials and Methods

Soap manufacture and tests on chemical properties of soaps were done at ambient

temperature at the textile laboratory. Jatropha oil to produce soap was obtained from Lupane Women's Centre. Soap moulds were used to produce bar soaps. Plain woven cotton fabrics were obtained from David Whitehead.

Sodium hydroxide was used for the saponification process. Elangeni, O'Key and Perfection commercial bar soaps obtained from local supermarkets were used to carry out the comparison tests with jatropha soap. The wash fastness tests were carried out at the Standards Association of Zimbabwe (SAZ). Distilled water was used for chemical property tests and borehole water obtained from Sunninghill (Bulawayo) and Battlefield (Bubi, Matebeleland South) was used to carry out the reactivity to hard water tests. Used pump oil was acquired to carry out the cleansing power tests. Two reactive dyes, namely Reactive Red HE3B and Reactive Navy HER were used to dye cotton fabrics for carrying out colour fastness to washing tests. Dyeing auxiliaries used were NaCl, Na₂CO₃, wetting agents, sequestrant and detergent. A wash wheel with a thermostatically controlled water bath and an SDC Multifibre DW (Acetate, Bleached Cotton, Nylon, Polyester, Acrylic and Wool) were used for the colour fastness to washing tests. A colour matching cabinet and grey scales (colour stain and colour change) were used for observing staining and colour change of the dyed fabrics.

2.1 Saponification Process

Jatropha soap was produced using the hot-process method [7]. 100ml of jatropha oil was heated to 70°C. Thirteen grammes of sodium hydroxide was measured and 50ml of water slowly added to it and the mixture stirred till all the alkali dissolved. The jatropha oil was heated to 70°C and the sodium hydroxide was then added in a thin stream while stirring continuously. The mixture was brought to the boil whilst stirring

continuously until the soap started to thicken. The stirring was done in one direction to prevent the oil from separating from the water. The heating was continued till two layers were not observed and everything was in one phase. The thick mixture which is the soap was poured into soap moulds and placed in a cool place to allow the soap to harden. The soap was left in the moulds overnight then removed from the moulds and allowed to harden for two days.

2.2 Solubility test

Distilled water (10 ml) was used to dissolve 1 g of each of the four soap shavings (Elangeni, O'Key, Perfection and Jatropa soap). Observations relating to which soap dissolved first and the cloudiness of the four soap mixtures were noted down.

2.3 Lathering action

The method reported by Warra *et al* [5] for synthetic detergents was used. 0.2 grams of each of the four soap shavings was added to a 100 ml measuring cylinder containing 10 ml of distilled water. The soap mixtures were shaken vigorously so as to generate foam. After shaking for about 2 minutes, the cylinder was allowed to stand for 10 minutes. The height of the foam in the solution was measured and recorded.

2.4 Test for pH

The alkalinity of the soaps was measured using a pH meter. 5 grams of each of the four soap shavings was dissolved in 100 ml of distilled water. The pH meter electrode was inserted in of each of the four soap solutions and the pH was then recorded.

2.5 Cleansing ability

A drop of used pump oil was placed on four separate thin strips of filter paper. These filter papers were immersed into test tubes containing the four soap solutions. The filter

paper was removed after 2 minutes of continuous shaking in the test tube and rinsed with tap water. It was then assessed whether the oil stain was washed off/dispersed from the filter paper.

2.6 Reactivity in hard water

Soap (0.2 g) was dissolved in 10ml of each of the two samples of hard water. The solution was continuously shaken for 2 minutes. The test tubes were allowed to stand undisturbed for 5 minutes and observations on the cloudiness and precipitates were noted down.

2.7 Reactive Dyeing

Two different colour shades were used for the dyeing process namely Reactive Red HE3B and Reactive Navy HER. For each shade two different depths of shade were also used, 2 % depth of shade and 0.2% depth of shade. The hot dyeing system for reactive dyes was used where dyeing was carried out at temperatures between 80-90°C. The electrolyte (salt) and soda ash were added in two portions. The dyeing procedure was carried out for 1 hour after which a hot wash followed by a cold wash were done using a detergent.

2.8 Colour fastness to washing

The test on colour fastness to washing was carried out using the ISO 3 Wash fastness standard test method. A specimen of 100 mm by 40 mm of the dyed woven fabric and a piece of 40 mm wide multifibre were cut and sewn together to form a composite specimen. A 2 grams sample of the respective soap was dissolved in 500 ml of tap water and the soap solution poured into a cylinder. The composite specimen was placed into the cylinder and the cylinder cover clamped and fastened vertically into the holders on the rotor of the wash wheel. The test cycle was run for 30 minutes after which the specimen was rinsed and dried

overnight. The specimens were assessed in a colour matching cabinet under D65, artificial daylight. Colour staining on the multifibre and change of shade on the original specimen were assessed using grey scales.

3. RESULTS AND DISCUSSION

All tests were carried out three times and the means were recorded.

3.1 Solubility tests

Table 1 shows that jatropha soap had high solubility as compared to other soaps during washing.

Table 1 Solubility characteristics

Soap sample	Solubility
Elangeni	Highly soluble
Jatropha	Highly soluble
Perfection	Moderately soluble
O'Key	Slightly soluble

The solubility of any soap gives an indication on the ease with which the soap will dissolve in water under washing conditions. The amount of cloudy film formed gives an indication on the number of micelles (soap molecules) formed by the soap in water. The cloudier the soapy water becomes the more micelles are formed. The number of micelles formed can be attributed to the cleaning action of a particular soap..

1.4 Lathering power

Lathering power refers to the amount of foam that soap forms and it is related to the cleaning ability of soap. Foam helps to suspend dirt by creating greater surface tension in water and trapping dirt for easy removal through rinsing. Foam, which is generated by agitating surfactant solutions, cushions fabrics against the beating and rubbing that occurs during domestic laundering, thereby reducing fabric damage.

Excessive foam cushioning may however, reduce soil removal. The foam height of jatropha soap was 2.7 cm which was lower than Elangeni soap but superior to the other two soaps (Table 2).

Table 2 Foam height

Soap sample	Foam height (cm)
Elangeni	2.9
Jatropha	2.7
Perfection	2.3
O'Key	2.2

Foam generation has little to do with cleansing ability but it is of interesting importance to the consumer and is therefore considered as a parameter in evaluating soaps[6].

1.5 pH level

Alkaline conditions are essential in fabric washing operations that call for the saponification of fatty soils. The ability of a cleaning chemical to neutralize fatty soils and, in some cases, saponify them (convert them to soap) for better removal depends on the alkalinity of the soap in question. Jatropha soap had the highest pH (Table 3) which means the greatest cleaning ability and on the other hand, the greatest damage to cotton fabrics.

Table 3 pH level

Soap sample	pH level
Elangeni	9.5
Jatropha	9.6
Perfection	8.8
O'Key	9.2

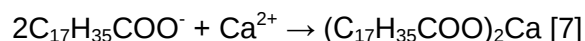
Since mild alkali, in the absence of air, has no effect on cellulose the damage on cotton fabrics would be expected to be minimal due to cotton's resistance to alkali.

1.6 Cleansing power

It was observed that the oil stains were washed off by the four tested soaps. The jatropha soap is therefore comparable to the other three soaps in terms of its ability to emulsify oily dirt from clothing. The cleansing ability of soap is due to the chemical structure of soap molecules, where one end is lipophilic and the other is hydrophilic. This dual polarity enables the soap to exhibit its cleaning ability.

1.7 Reactivity in hard water

All four tested soaps formed a white precipitate suspended in the soap solutions (scum) when added to hard water. Hard water has high concentrations of Ca^{2+} and Mg^{2+} ions. With hard water, soap solutions form a white precipitate instead of producing lather. This effect arises because the surfactant properties of the soap are destroyed by forming a solid precipitate. A major component of scum is calcium stearate, which arises from the reaction of calcium in hard water and the fatty acid component of soap:



1.8 Colour fastness to washing

Fabric changes that occur during washing can be analysed by considering two aspects which are colour change and colour staining. For colour change, the grey scales gave a rating of 5 for all the four tested soaps on all the depths of shade. This indicates that there was no significant fading observed in the test specimen after the washing process hence the dye concentration in the fabric did not change. Since colour change generally refers to fading then, from the Figure 2, all the four tested soaps will be expected not to accelerate the rate of fading of the cotton fabrics. The colour fastness results show that when washing with cold water, all four

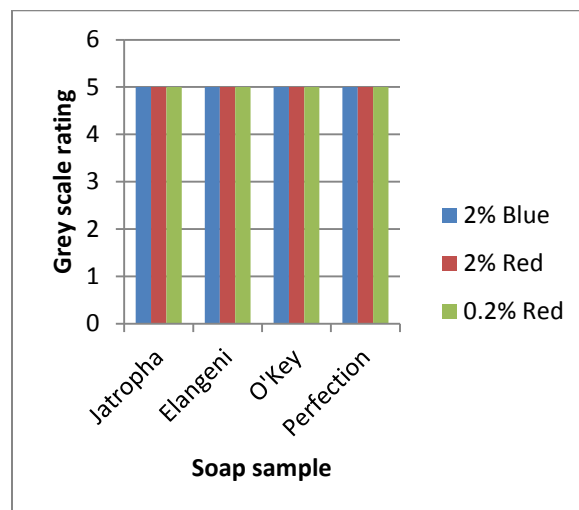


Fig 2 Colour fastness

soaps do not significantly affect the fading of reactive dyed cotton materials. An accelerated rate of fading in dyed materials is very much undesirable to the consumer. It can be seen from these results that jatropha soap also gave a rating of 5 on the colour change grey scales. The 2 % depth of shade represents the dark colours whilst the 0.2 % depths of shade represent the light colours. However, it cannot be assumed that this would be the case when washing with a raised temperature. It should be noted that colour change in textile materials can also be attributed to other factors like sunlight. It may be assumed therefore that an accelerated rate of colour change in cotton fabrics subsequently washed with jatropha soap may be due to other aspects other than the chemical effects of the jatropha soaps.

Figures 4 to 6 show colour staining from the four soaps studied here. Colour staining is caused by the movement of a dye from one material to another, usually during the washing process. From the obtained results it can be seen that all staining was observed on the cotton section of the multifibre. All other fibre sections gave a rating of 5 on the

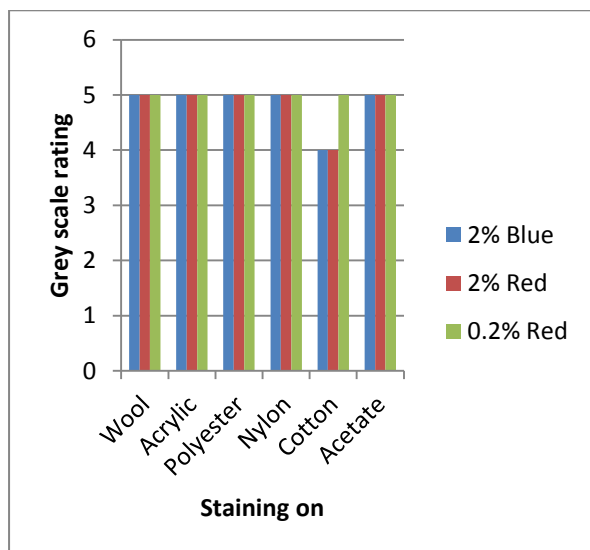


Figure 2 Colour staining from jatropha soap

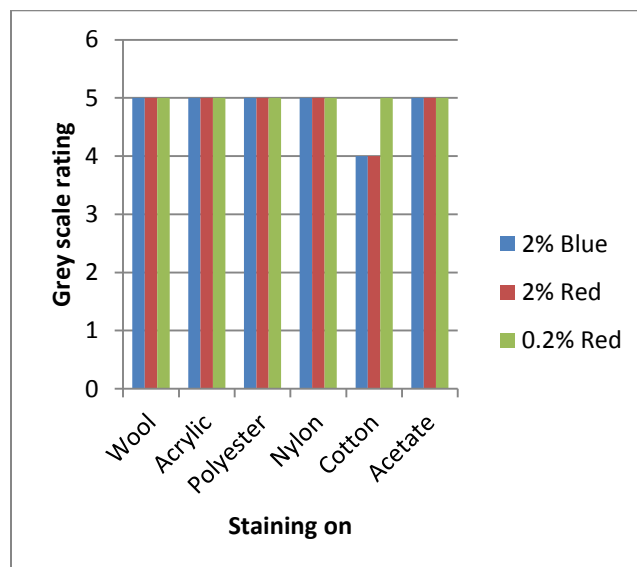


Figure 4 Colour staining from O'Key soap

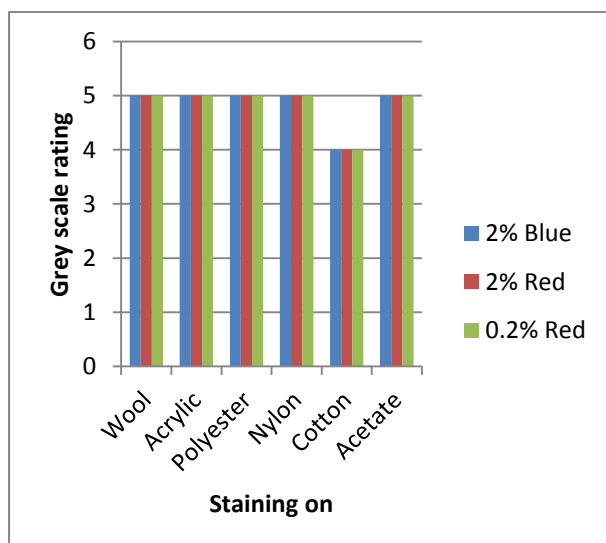


Figure 3 Colour staining from Elangeni soap

staining grey scales hence no staining was observed on these sections. O'key, Jatropha and Perfection soaps gave similar results from the staining grey scales. The grey scales for staining gave a rating of 4 for the

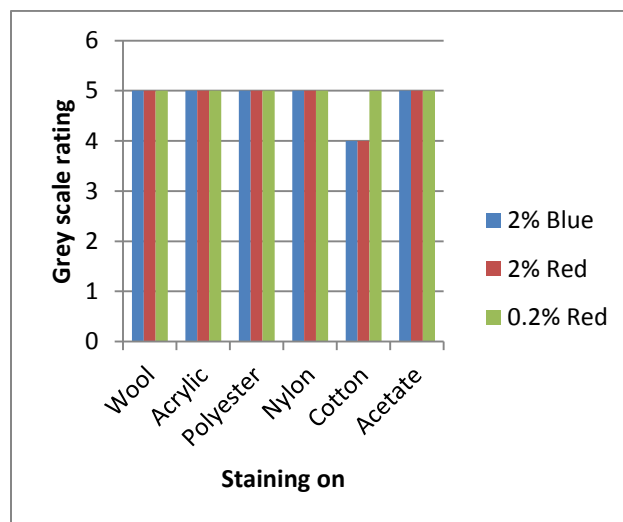


Figure 5 Colour staining from Perfection soap

the dark shades that is on the 2 % Red and the 2 % Blue specimens. No staining was observed on the light shade that is 0.2 % Red hence the rating of 5 for the soaps. The rating of 4 on the grey scales means that there was slight staining on the multifibre.

This indicates that when washing reactive dyed cotton substrates with other cotton substrates using these three tested soaps, there may be some slight staining on the adjacent fabrics. However this slight staining may not be quite visible to the individual conducting the washing process. The staining on the cotton section rather than the other sections of the multifibre may be due to the fact that reactive dyes have a very high substantivity for cotton substrates compared with other fibre substrates. Elangeni soap gave an all round rating of 4 for the three different fabric specimens. It indicates some cross staining on the cotton section even with the light shade of 0.2% Red. Since domestic laundering is similar to a mild scouring process, the type of detergent used in the laundering process greatly affects colour fastness properties of the dyes incorporated in textiles [10]. Therefore the staining on observed on adjacent fabrics may be due to the superior cleaning ability of the soaps. Fastness to washing is dependent not so much upon the structure of the dye molecule as upon the tenacity with which it holds on to the substrate. This tenacity is however under constant attack during washing by the action of detergents, especially as the detergent industry is constantly introducing new and more efficient products. These efficient products may have the disadvantage of causing damage to the textile substrate.

2. CONCLUSION

From the results on alkalinity, solubility, lathering power, cleansing power and reactivity in hard water it can be concluded that jatropha soap has comparable performance properties to other commercial soaps. From the colour fastness results it can also be concluded that jatropha soap does not impose any accelerated fading of

cotton fabrics. Since all performance properties of jatropha soap that were tested were comparable with commercial soaps it can be seen that exploitation of jatropha oil can be made extensive for empowering the rural communities in the country through soap making. Therefore, jatropha soap is as good as and even better than other commercial soaps. Efforts for exploiting the jatropha oil in biodiesel manufacture have been made but have not been very successful due to the large amounts of land required to obtain enough oil for use as fuel. This area of soap making could be a good opportunity since soap making is not as complex as biodiesel making hence it can be taught to anyone.

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