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Physico-chemical Properties and Sensory Attributes of Soap Formulations Containing Ethanolic Extracts of *Jatropha podagrica* Roots, *Solanum lycopersicum* Skin, and *Pandanus amaryllifolius* Leaves

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Abstract This study was conducted to produce and evaluate the physico-chemical properties and sensory attributes of herbal soap containing Jatropha podagrica roots, Solanum lycopersicum skin, and Pandanus amaryllifolius leaves. Plant materials used are locally found, grown, and harvested in Baco, Oriental Mindoro, Philippines. Crude extracts were acquired using ethanolic extraction from which three various concentrations (%v/v) were derived to proceed in herbal soap making. Herbal soap underwent testing for physico-chemical properties such as foaming propensity test, pH profiling, and emolliency test. Sensory profiling test using modified quantitative descriptive analysis was also administered. Foaming propensity test of three soap formulations showed that the soap with equal concentrations of J. podagrica, S. lycopersicum, and P. amaryllifolius (1.0671 % v/v) ethanolic extracts exhibits the strongest foam stability due to the combined viscosity of the three ethanolic extracts. The three treatments (T_1, T_2, T_3) demonstrated mild, moderate, and strong translucency respectively under the soap emolliency test showing that other than oil content, varying concentrations of the ethanolic extracts affected the emolliency property of the soap. Quantitative Descriptive Analysis (QDA) of the sensory attributes of the three soap formulations showed that difference exists between all the formulations in terms of color ($p = 0.00757$) and texture ($p = 0.03278$). No difference was observed for odor and lathering intensity attributes. Treatment 2 exhibited best result in foaming propensity test. All treatments demonstrated normal soap pH level. Meanwhile, Treatment 3 showed positive results in quantitative descriptive analysis. Further studies and laboratory tests like antimicrobial test were recommended.

Keywords: *emolliency test, foaming propensity test, Jatropha podagrica, Pandanus amaryllifolius, pH profiling, soap formulations, Solanum lycopersicum*

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1. Introduction

Being located in the tropics, the Philippines experiences a marine climate which is divided into rainy and dry season. Temperature and relative humidity in the country poses at 27-33°C and 77-83% respectively. These environmental factors and their correlation with age, occupation, genetic susceptibilities and immune responsiveness contribute to the high prevalence of skin diseases particularly fungi infections among Filipinos [1].

Accumulated data from the Department of Health-Research Institute for Tropical Medicine (DOH-RITM) on cases of superficial and deep fungal infections from 2000 to 2003 revealed that fungal infections rank second cause of patient consultations at the DOH-RITM. Among these fungal infections, pityriasis versicolor is the most common.

There are only 10 medicinal plants approved and recommended for use by the Department of Health in the Philippines. This is despite the many studies on medicinal plants supported by the Department of Science and Technology-Philippine Council for Health Research and Development and the National Research Council of the Philippines and other major academic institutions particularly the University of the Philippines and the University of Santo Tomas [2]. Two of these recommended medicinal plants are antibacterials, namely guava and akapulco.

Given the environmental, meteorological (particularly the increase of cases of tinea pedis during the rainy season probably due to extensive flooding in some areas), and

cultural (for instance the admiration of most Filipinos to western style of clothing which heavily promotes sweating during the dry season) factors contributing in the occurrence of fungal infections among Filipinos, the need for extensive research on unstudied medicinal plants for their possible efficacy and cheap production of pharmaceuticals against the mentioned prevalent and occasional skin diseases is ideal.

Jatropha podagrica is an ornamental plant which is also employed to cure various infections in traditional medicine [3]. *Jatropha podagrica* of family Euphorbiaceae is known for many biological activities such as antitumour, antimicrobial, molluscicidal and anti-insect properties [4,5]. This plant is also used as an antipyretic, diuretic, choleretic and purgative [6]. Limited phytochemical studies of this plant have resulted in isolation of various types of diterpenoids from its roots strengthening results of previous researches on the *Jatropha* species [4,7,8]. Its six diterpenoids, two of which are macrocyclic possessing lathyrane and jatrophane skeletons, have displayed anti-bacterial activity against various gram-positive bacteria [9].

This is commonly found in Africa, Asia, and Latin America. Locally, this shrub is being used as an ornamental plant. In south western Nigeria, this plant is called *lapalapa funfun.* In the Philippines, this is oftentimes mistaken as *ginseng* due to the appearance of its roots thus making it popularly known in that name.

Meanwhile, *Pandanus amaryllifolius* is an evergreen perennial aromatic plant, a cultivated plant now found worldwide due to importation and human migration [10]. Leaves of *Pandanus amaryllifolius* are widely used to flavour ordinary rice with the characteristic Basmati aroma. 2-acetyl-1-pyrroline is said to be the compound which gives this characteristic aroma [11]. Studies on pandan-derived compounds and fractions revealed its antioxidant potential [12] and anticancer activity [13]. Various pandan species also demonstrate selective antibacterial and antiviral activity [14-16]. Present in *Pandanus amaryllifolius* crude extract are alkaloids, quaternary bases and/or amine oxides, free fatty acids, 2-deoxysugars, unsaturated lactones, flavonoids, fats and oils, and steroids [17]. These findings indicate that *P. amaryllifolius* leaves contains phytochemical compounds that are effective anti-bacterial agents. Meanwhile based on oxidative stability index, pandan extracts are capable of retarding oxidation, even at 0.1%. *P. amaryllifolius* extract was found to be capable of retarding oxidation in palm olein [18]. Given this, the potential use of *P. amaryllifolius* leaves as an antioxidant for food and probably health is likely feasible.

Solanum lycopersicum on the other hand is known to contain lycopene. It is a carotenoid present in human blood. The major sources of lycopene for the humans are tomatoes and tomato products. Its biological activities include antioxidant activity, induction of cell communication, and growth control [19]. Anti-allergic study on tomatoes using histamine-release assay showed that tomatoes, particularly its skin, exerts strong inhibition of histamine release because of a compound called naringenin chalcone (*trans*-2'4'6'4-tetrahydroxychalcone) with an IC_{50} value of 68 ug/ml [20]. These results indicate that tomato skin extract could inhibit allergic reactions.

Given these properties, the synergy of the three is an ideal combination in making a natural herbal anti-bacterial, anti-fungal, antioxidant, and anti-histamine soap.

This study was carried out to evaluate the physico-chemical properties of *J. podagrica* roots, leaves *of P. amaryllifolius,* and skin of *S. lycopersicum* ethanolic extract in a soap formulation of various concentrations.

2. Objectives of the Study

This study aimed to evaluate the physico-chemical properties of *J. podagrica* roots, leaves *of P. amaryllifolius,* and skin of *S. lycopersicum* ethanolic extract in a soap formulation of various concentrations. Specifically, it aimed to: (1) evaluate and compare the physico-chemical properties of soap formulation of various concentrations in terms of foaming propensity, pH, and emolliency propensity; (2) evaluate and compare the sensory characteristics of the soap formulation of various concentrations using Quantitative Descriptive Analysis (QDA).

3. Materials and Methods

3.1. Collection of *J. podagrica* Roots, *P. amaryllifolius* Leaves, and Skin of *S. lycopersicum*

Roots were obtained from mature *J. podagrica* plant. *P. amaryllifolius* leaves were also taken on the same day. Ripe *S. lycopersicum*, on the other hand, were procured locally from a backyard plantation in Baco, Oriental Mindoro. They were stored in plastic containers before they were subjected to extraction.

3.2. Preparation of *J. podagrica,* Pandan Leaves, and Tomatoes

The roots of *J. podagrica*, leaves *of P. amaryllifolius,* and skin of ripe *S. lycopersicum* were collected on November 11, 2019. Immediately after collection, they were cut into small pieces, approximately 2 cm per piece. Then, they were washed using tap water to remove the dirt and other unwanted particles. 200 grams of each sample were macerated separately by soaking in 250 ml 95% ethanol for 48 hours. Using Whatman filter paper no. 41, the crude extract was filtered from the solution. It was then stored in a refrigerator with a controlled temperature of -6 degrees Celsius before it underwent evaporation and testing for physico-chemical properties and sensory evaluation.

3.3. Preparation of Soap Formulations

Table 1 shows the composition and proportion of the soap formulations.

The organic materials (extracts of the *J. podagrica* roots, *P. amaryllifolius* leaves, and skin of *S. lycopersicum* in various proportions), laboratory tools and equipment (50 mL beaker and 100 mL graduated cylinder), soap making ingredients (450 mL lye solution [1 kg caustic

soda + 2.5 L of water], 1000 mL base oil, 1.5 mL coco diethanolamide (bubble enhancer), 1 drop of sodium benzalkonium chloride (antibac), 20 mL sodium silicate (hardening agent), 1 pinch sodium benzoate (preservative), 5 mL colorant, and 20 mL eucalyptus scent), and other supplies (plastic pail, plastic pitcher, chopping board, kitchen knife, grater, plastic molds, strainer, hand gloves, surgical mask, vegetable oil, virgin coconut oil, and distilled water) were prepared prior to the actual soap making.

A lye solution was prepared first. 1 kg of caustic soda flakes was added to 2.5 L of water. It was stirred continuously in one direction until the cloudy mixture was gone. The mixture was labelled and was set aside to cool.

Next, the specified ingredients were measured. The lye solution was added and mixed thoroughly in one direction. The extract and other remaining ingredients except the fragrance oil were blended and mixed. Then the fragrance oil was added next. The mixture was then transferred to the plastic molds and was set aside for 2-4 hours to solidify.

The hardened soap was then ejected from the molds and was cut to desirable sizes using the soap cutter. Next, the powdery surface of the soap was scraped and the sharped edges were buffed using a cloth. Lastly, the soap was cured for 1-3 days to remove the remains of the lye solution.

Table 1. Composition of soap formulations

Ingredients	Composition attributes/ Formulation codes/ Ingredient quantities (%v/v)		
	T_1	T_2	T_3
J. podagrica (Jp)	2.13	1.07	0
S. lycopersicum (Sl)	0	1.07	2.13
P. amaryllifolius (Pa)	1.07	1.07	1.07
Lye Solution (LS)	28.84	28.84	28.84
Base Oil (BO)	64.09	64.09	64.09
Bubble Enhancer (BE)	0.96	0.96	0.96
Antibac (A)	0.01	0.01	0.01
Hardening (H)	1.28	1.28	1.28
Preservative (P)	0.02	0.02	0.02
Colorant (C)	0.32	0.32	0.32
Scent (S)	1.28	1.28	1.28

3.4. Determination of Physicochemical Properties of Soap Formulations

All the soap base formulations prepared were tested for their physico-chemical properties.

3.4.1. Foaming Propensity Testing

A 1 g portion of each soap formulation was dissolved in 10 ml of tap water. The test tube was shaken for 1 min and then left to stand undisturbed. The time taken for the soap solution to defoam was recorded.

3.4.2. pH Determination Test

One gram portion of each soap formulation was subjected to pH determination test using a digital pH meter. Results were tabulated.

3.4.3. Emolliency Propensity Testing

This test was conducted to test the occlusiveness of the soap samples. Two grams portion of each soap was smeared into a white sheet of paper in approximately 5 cm^2 surface area and was left to stand for 24 hours. The degree of translucency for all soap samples were graded into three-level ranking namely, mild, moderate, and strong.

3.5. Sensory Evaluation of the Soap Formulations

Quantitative Descriptive Analysis [21] was used to test the intensity of the sensory attributes of the soap formulation. To record the intensity of each attribute, respondents made a vertical mark on a 6-inch horizontal line at that point that represents the intensity. The line has two word anchors, placed 0.5 inches from each end and respondents are reminded that they can mark beyond the anchors. The mark on each scale is converted into a numerical value by measuring the distance from the far left end of the scale to the mark. Results were then tabulated.

3.6. Statistical Analysis

One-Way ANOVA or Single-Factor Analysis of Variance was used to know if a difference exists between all soap formulations for a certain sensory attribute. The results were computed using Microsoft Excel 2016.

4. Results and Discussion

4.1. Foam Stability of Soap Formulations

The time it takes for the foam of the aqueous solution of soap samples to disappear or collapse varied per formulations. Triplicate tests were conducted for each set of ingredient concentrations. Greater foam persistence was observed for the first test trial of Treatment 2 which accounts to 42 minutes. Relatively, Treatment 2 accounted for the greatest foam persistence within all trials with 41 minutes for both the second and the last trial giving an over-all foam stability mean of 41.33 minutes. Treatment 3 took 35, 34, and 35 minutes for tests 1, 2, and 3 respectively. This results to a foam stability average of 34.67 minutes. Meanwhile, Treatment demonstrated the least foam stability with an average time for foam collapse of 30 minutes. Overall, Treatment 2 took the longest time to defoam with an average defoaming time of 41.33 minutes, followed by Treatment 3 and Treatment 2 with 34.67 and 30 minutes respectively (Figure 1).

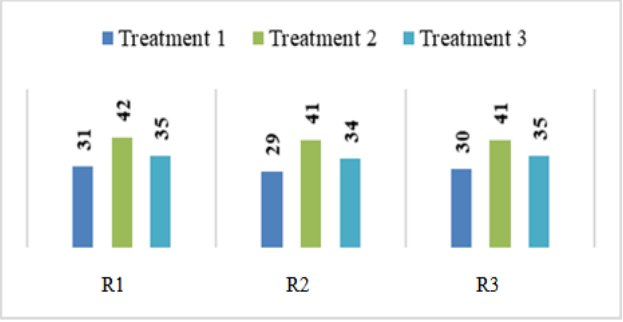

Figure 1. Foaming stability of soap formulations in three test replication

Motion plays an important aspect in the fracturing of foams. When foam stops moving, gravity will cause the free fluid in the foam to drain. This drainage can cause foam instability issues [22]. Viscosity is a factor in the drainage of foams. Gelling agents or thicking agents increases the viscosity of a substance (not considerably), but will improve proppant transport and fluid-loss control [22]. Given this, the viscosity of the extracts used directly affected the foam stability of the formulation in its post-production phase. Moderate viscosity was observable on the *S. lycopersicum* extract during pre-production because of its gelatinous attribute [23] while the *J. podagrica* demonstrated a mild viscosity. As a result, foam stability was yielded the highest on Treatment 2 which contains 1.0671 % v/v of *J. podagrica, S. lycopersicum, and P. amaryllifolius.* This was followed by Treatment 3 with 2.13419 % v/v of *S. lycopersicum* and Formulation A with 2.13419 % v/v of *J. podagrica.*

4.2. pH Profile of Soap Formulations

pH profile determination of the three soap treatments revealed that Treatment 1 and Treatment 2 has the same pH value at 7.8 while Treatment 3 resulted into a slightly higher pH value of 7.9.

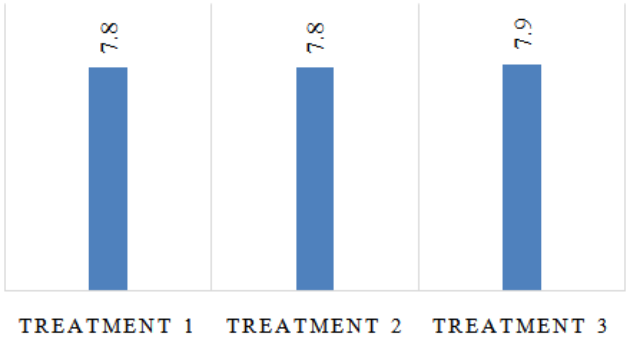

Figure 2. pH profile of the soap treatments

pH profiling of the soap formulations showed that Treatment 3 has the highest pH value among the three formulations at 7.9. Meanwhile, Treatment 1 and Treatment 2 resulted to equal pH value of 7.8. These results fall between the normal pH values for soap*)* as the soaps commonly used by the population at large have a pH ranging between 7 and 9 [24] and is lower than 10.2 which is the level of alkalinity that promotes the reduction of stratum corneum cell layer and caused attrition of intercellular lipids in individuals suffering from skin diseases like atopic dermatitis [25]. This damage to the skin barrier function could result in increased colonization of gram-positive bacteria. Although these are positive results, the use of the three soap formulations is not recommended for people who have skin types that are prone to irritancy as agents with slightly acidic or neutral pH, nonionic surfactants, and minimal skin residue may be preferable for people who are at increased risk for irritancy reactions [26].

4.3. Emolliency of Soap Formulations

While it is given that oil content directly affects the soap's translucency (and the same amount of oil was used for all soap formulations), emolliency test was conducted as the differing concentrations of *J. podagrica*, *P. amaryllifolius*, and *S. lycopersicum* could be a factor.

Table 2. Emolliency of soap formulations

Formulation	Translucency		
	Mild	Moderate	Strong
T1	X		
T2		X	
T3			X

Treatment 1 (2.13419% Jp; 0% Sl; 1.0671% Pa) demonstrated mild occlusiveness when compared with the other two formulations. Treatment 2 (1.0671% Pj; 1.0671% Sl; 1.0671% Pa), on the other hand, displayed moderate translucency. Meanwhile, the strongest translucency was observed with Treatment 3 (0% Jp; 2.13419% Sl; 1.0671% Pa).

The degree of emolliency of soaps is directly affected by its oil content. Soap formulations with high oil concentrations tend to be more translucent [27]. Although the soap formulations in this study used the same amount of oil, emolliency test was still conducted as the varied concentrations of *J. podagrica and S. lycopersicum* could be a factor. Result of the test showed that Treatment 2 which has 2.13419 % v/v of *S. lycopersicum* demonstrated the highest intensity of translucency. This could also be attributed to the gelatinous make-up of its pericarp [28].

4.4. Quantitative Sensory Analysis

Quantitative Descriptive Analysis (QDA) was conducted to test the perception-based sensory attributes of the soap formulations. Appearance, odor, texture, and lather intensity were tested. Figure 3 shows the mean results obtained from the intensity line scale.

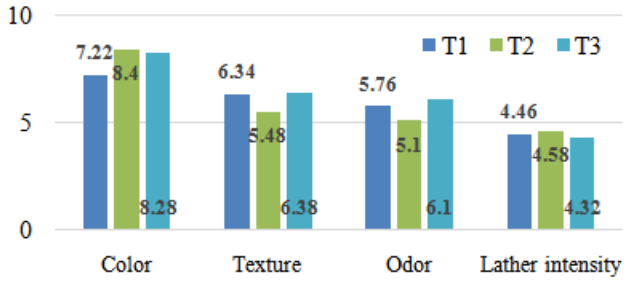

Figure 3. QDA results of soap formulation

The highest intensity of color was observed for by Treatment 2 with mean intensity of 8.4 followed by Treatment 3 and Treatment 1 with 8.28 and 7.1 mean intensity respectively. Treatment 3 showed the highest texture intensity with an average of 6.38 from all the respondents, intermediate texture intensity was recorded for Treatment 1 while the lowest was Treatment 2 with 5.48. Treatment 3 demonstrated the strongest odor with an average of 6.1 followed by Treatment 1 with 5.76 and the weakest with 5.1 for Treatment 2. Meanwhile, the highest lather intensity was demonstrated by Treatment 2 with 4.58 followed by Treatment 1 and Treatment 3 with 4.46 and 4.32 respectively.

Quantitative Descriptive Analysis [21] sswas used to evaluate the sensory attribute namely, color, texture, odor,

and lather intensity of the three soap formulations. Assuming that all formulations are equal in terms of a certain attribute, the analysis of variance was conducted to determine whether this is correct or a difference exists. Hypothetically, $\mu_1 = \mu_2 = \mu_3$.

Table 3. Result of single-factor Analysis of Variance (ANOVA)

Attributes	*p-value*
Color	0.00757
Texture	0.03278
Odor	0.05177
Lather intensity	0.66073

Table 3 shows the significant differences of the attributes. ANOVA of the color attribute showed an F value of 7.53993 versus the F critical value of 3.88529 *(P = 0.00757).* This means that the null hypothesis is rejected because the F critical is of lower value. Given this, a difference in terms of color exists between the three soap formulations. This is despite the same amount of colorant (and other ingredients except the *P. amaryllifolius* extract) was used for all set-ups. This implies that the varying amount of concentration of either the *J. podagrica* or *S. lycopersicum* in the three formulations directly affected the color of the soap. Color has been found to play a significant role in consumers' attitudes toward products in retail settings [29]. Quantitative Descriptive Analysis results showed that Treatment 2 was rated with the highest color intensity. This implies that possible customers will likely choose darker colors of soap.

Meanwhile, a difference also exists between all the soap formulations in terms of the texture attribute. F value is at 4.6057 which is higher that the F critical value of 3.88529 *(P = 0.03278).* The difference was caused by the human-induced (pouring angle, magnitude of compression in the molder, etc.) inconsistencies during the production process. Also, the texture of soap depends on the nature of its fatty acids composition, length of hydrocarbon chain and number of double bound determines the hardness or softness of the soap. The most probable explanation to the variation in the texture of the soap could be due to the presence of glycerol and some impurities in sample of the soap [30]. It has been studied that product with the undesirable texture was the least popular among personnel [31]. This implies that Treatment 2 with the lowest texture intensity which inclines to roughness will likely not be chosen by customers. Treatment 3, on the other hand, will be most preferred as per the results of the Quantitative Descriptive Analysis.

The F value and F critical differs by a very thin margin after the analysis of variance resulted to 3.82823 and 3.88529 *(P = 0.05177).* This thin marginal difference means that no difference exists between all the soap samples in terms of the odor attribute and the concentration of the extracts used in this study did not directly affect the soap in its post-production phase. This is due to the fact that the same amount of fragrance was used for all the set-ups and that the *J. podagrica* or *S. lycopersicum* yielded an insignificant amount of odor after the ethanolic extraction.

In addition, no difference was found between all the soap samples in terms of their lathering intensity after the analysis of variance showed an F value of F value of 0.42905 versus the F critical value of 3.88529 *(P = 0.66073).* This means that all formulations are the same in terms of their intensity and capability to form foam and coat a desired skin surface area.

5. Conclusion and Recommendation

This study showed that varying concentrations of ethanolic extracts of *J. podagrica, S. lycopersicum,* and *P. amaryllifolius* directly affects the foaming intensity and emolliency property of soap with Treatment 2 exhibiting best result in foaming propensity test. No significant difference was observed on the pH values of the treatments despite the varying concentrations. Quantitative Descriptive Analysis (QDA), particularly the intensity line scale, done for the three soap formulations for their sensory attributes showed positive results. This implies not only the difference between the treatments but also customer perceptions which is helpful in the possible production and marketing of a new soap formulation containing ethanolic extracts of *J. podagrica, S. lycopersicum,* and *P. amaryllifolius.*

Foaming stability of herbal soap may be improved by increasing the concentration of S. lycopersicum because of its high viscosity. Different amounts of oil can be incorporated in different treatments to determine which amount will provide the soap with greater emolliency. Further study on this matter may include antimicrobial activity of the extracts.

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