Exploring Sustainable Manufacturing Processes for Sanitary Items Utilizing Abundant Natural Resources: A Covid-19 Pandemic Response in Northern Samar, Philippines

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Abstract: The COVID-19 pandemic did not only bring millions of casualties but also diminished the supply of sanitary items. In Northern Samar alone, sanitary items such as facemasks, rubbing alcohol, and soaps run out of stock on the first week of the gradual closure of businesses. This means that those with fewer financial resources have difficulties acquiring such sanitary items to protect them from this deadly disease. Northern Samar is abundant when it comes to nipa resource which has a big potential as a raw material for production of bioethanol. Due to the shortage of rubbing alcohols and raw materials for the laboratory made ethyl alcohol, extraction of bioethanol from fermented *Nypa fruticans* was done. This created raw materials needed in the production of laboratory made ethyl alcohol that was distributed to its target beneficiaries. On the other hand, *Salacia korthalsiana* Miq. commonly known as Polipog, is a traditional plant used to treat different diseases. It is used as anti-inflammatory, antiseptic, and as antibacterial agent. The root part of the plant was used to produce an antibacterial bar and liquid soap. Thru the funding of the Commission on Higher Education (CHED), manufacturing of non-medicine products took place in the University of Eastern Philippines. These basic sanitary items were given to the provincial government of Northern Samar for distribution to local communities to combat the spread of COVID-19. A prepared biosynthesized zinc oxide nanoparticles were applied to the face mask through spraying the solution on the surface of the face mask. Results showed that the textile with nanoparticles inhibited the growth of pathogenic bacteria. Further researches is sought to properly utilize the promising results of the wonders of the natural resources found in Northern Samar.

Keywords: *Nypa fruticans, Salacia korthalsiana* Miq., COVID-19, sanitary items, bioethanol, bar and liquid soap.

1. INTRODUCTION

The province of Northern Samar has a population of approximately 700,000 that live in and subsist on the different island towns surrounded by species of palms, like ***Nypa fruticans* Wurmb (Nipa)**. Until this day, Nipa is an underutilized plant resource since the only use of the nipa leaves are for roofing. The fruit of nipa is still of no economic use to the people of Northern Samar. *Nypa fruticans*, commonly known as the nipa palm, is a species of palm native to the coastlines and estuarine habitats of the Indian and Pacific Oceans. It is the only palm considered adapted to the mangrove biome. This species is the only member of the genus Nypa and the subfamily Nypoideae, forming monotypic taxa (Hai, 2016).

Nipa is a locally known natural resource in Northern Samar (Dagalea *et al.,* 2022). Its leaves are used as roofing, but there is little too much information on its fruit. The fruit of the nipa palm generates starch that could be used for the biosynthesis of zinc oxide nanoparticles (ZnONps). ZnONps, when reduced to nano-sized is an effective antibacterial agent, killing gram-negative and gram-positive bacteria (Dagalea, Cui-Lim, 2018; Dianito *et al.,* 2022). Although there are other metal oxides present in the market today, ZnONps exhibit different properties and are easier than other metal oxides (Cui-Lim *et al.,* 2020; Dagalea, Cui-Lim, 2021).

After maturing, the fruits are usually pushed off from the infructescence by the developing plumule. They float on tidal water and start growing on a suitable substrate. The radicle is probably aborted and the first root that appears is likely to be the first adventitious root. The seedling is prostrate first, but after being attached to the substrate, the plumule becomes erect and additional adventitious roots arise from the lower part of the stem. In very young seedlings the

leaves are arranged distichously but later they become arranged spirally. At first, up to eight bladeless sheaths develop per plant, followed by the first juvenile foliage leaves 3-6 months after germination. During early growth the stem grows obliquely downwards until it is about 1 m deep in the ground (rhizome) (Hai, 2016).

Nypa fruticans undergo a fermentation process using yeast for at least 14 days to extract the bioethanol from it and was subjected to quality test. The technical grade ethyl alcohol and bioethanol from *Nypa fruticans* were the source as raw materials in making a laboratory made ethyl alcohol. These two raw materials were classified as to which it was distributed, the lab made ethyl alcohol from technical grade ethanol was supplied to the hospitals in the province to combat the shortage of rubbing alcohol, on the other hand, the lab made ethanol from *Nypa fruticans* was distributed to the other target beneficiaries. The Laboratory made ethyl alcohol is the sum composition of ethyl alcohol (technical grade or bioethanol), hydrogen peroxide, glycerol, and distilled water.

***Salacia korthalsiana* Miq.** commonly known as Polipog, is a traditional plant used to treat different diseases (Cui-Lim *et al.,* 2020). It is used as anti-inflammatory, anti-septic, anti-microbial, and others (Alvarez *et al.,* 2020; Ambida, Tonog, 2020; Somoray, Doncillo, 2020). *Salacia korthalsiana* Miq. is generally a climbing shrub with woody stems that twine into the surrounding vegetation and can be up to 18 meters long (Belga *et al.*, 2021). Occasionally the plant produces erect branches and then more shrub-like, or even a tree, growing up to 10 meters tall. The polipog plant is harvested from the wild for local uses as food and medicine.

The polipog plant is harvested from the wild for local uses as a food and a medicine. The extracts of *Salacia korthalsiana* Miq. (Polipog) was used in making the liquid and bar soap. The face masks produced were coated with these two components: biocomposite nanoparticles and polipog extract. These two components are proven to inhibit the bacterial growth of *E. coli, S. aureus* and *P. aeruginosa.* Face mask production was supervised by the concerned team in the University. Also, additional protective coatings were added to help the washable face mask combat the unnecessary bacteria present on the textile's surface. The protective coating is composed of biocomposite from nipa starch and nanoparticles. This nipa starch nanoparticle is proven to have a resistance to bacteria such as *E. coli, S. aureus* and *P. aeruginosa.* The disinfectant was composed of hypochlorite solution, distilled water and glycerine making it suitable for cleaning hard surfaces such as floors, tables, door and others.

Since the onslaught of the pandemic the College of Science have been distributing products such as disinfectants, lab made ethyl alcohol and polipog liquid soap to its internal working force. These products have been distributed to the provincial and local government, stakeholders and the UEP community. Each production has a keen manufacturing and sanitary procedures that were observed during the duration of this project. All products were submitted for physicochemical tests before distribution and use. The local government was tapped in distributing the products. This project however, does not end with the current pandemic. It is envisioned as a sustainable income-generating project of the University, once the situation normalizes, at no extra cost. It would also serve as a training ground for students of the College of Science particularly the BS Chemistry students. Also, the raw materials such as Nipa and Polipog plant sample is seen to be available since it is not fully utilized in the province.

2. MATERIALS AND METHODS

Collection and Preparation of Nipa palm fruit. The nipa palm fruit samples were collected from different municipalities in Northern Samar. The fruits were cracked and dried at 70°C to constant weight and then milled.

Extraction and purification of ethanol. The actual production of ethanol took place during fermentation. The enzymes, invertase (maltase), and zymase contained in the used yeast, as well as diastase contained in the malt (i.e., partially germinated barley) acted on monosaccharide and disaccharide produced during mashing and in the process degrades the saccharides to ethanol and CO_2. An amount of 15g of baker's yeast was measured and added to the yeast nutrient (Ammonia); this will then be added to each of the mixtures. The flask was corked with a rubber cork. The opening in the flask was blocked and allowed to ferment for a period of 12 days.

Distillation. Fractional distillation was carried out after fermentation. This is done because the ethanol fuel that will be collected during fermentation contains a significant quantity of water, which must be removed. This is achieved by using the fractional distillation process. The distillation process works by boiling the water and ethanol mixture. Since the ethanol has a lower boiling point compared to that of water, the ethanol turns into the vapor state before the water and can be condensed and separated.

Purification. The distillate was further purified by the use of lime (calcium oxide). Lime, a basic oxide, was added to the ethanol, an alkaline solution. The calcium hydroxide formed was separated from the ethanol by further distillation, which leaves absolute ethanol.

Bioethanol confirmatory test

Iodoform test. To test for the presence of alcohol, 3 mL of the mixture was transferred into a test tube, iodine and sodium hydroxide was added, and the mixture was maintained at 40°C. Yellow precipitate formed indicates the presence of ethanol. In Lieben's iodoform test, about 5 mL of the sample with 3 of mL iodine solution (Logul's solution) was placed in the beaker and was being warmed. The potassium hydroxide solution was added. the solution formed a yellow precipitate indicates the presence of ethanol.

Litmus test. Litmus test was determined by dipping the piece of litmus paper into the small amount of the sample. *Ester test.* Ester test was determined by taking 1 ml of the sample into the clean dry test tube, adding 1 mL of glacial acetic acid and 2-3 drops of conc. sulfuric acid into the sample. Heat the mixture in a water bath for 10 minutes. Then poured the mixture into a beaker containing cold water. A fruity smell confirms the presence of an alcohol. *Flammability test.* Three watch glasses were being used to determine its flammability. The bioethanol produced was poured into the tree watch glasses. It was ignited one at a time with the use of a match. It was done for three trials, *Preparation of 70% lab-made ethyl alcohol (technical grade).* The 70% lab-made ethyl alcohol (technical grade) was prepared by using 833.3 mL of 95% ethanol. About 41.7% of glycerol was added in the above solution, and stir. After mixing, add 15.3mL of hydrogen peroxide, then add 252.7mL of distilled water. The same procedure was followed for the production of bioethanol from *Nypa fruticans* (Nipa).

Phytochemical Screening of Salacia korthalsiana Miq. (Polipog)

The root of polipog was collected from the following Municipalities in Northern Samar; Palapag, Mapanas and Gamay. About 1 kilograms of the plant sample was used for this procedure.

Test for Alkaloids. The Dragendorff's test was used. The sample was immersed for a minute in Dragendorff's reagent and then mounted in glycerine-water (10:90, v/v) solution. Appearance of golden yellow color in the cells showed the presence of alkaloids. *Test for Steroids.* Antimony trichloride was used in this test. The sample was immersed for a minute in Antimony trichloride and then mounted in glycerine-water (10:90, v/v) solution. Appearance of yellow color in the cells showed the presence of steroids. *Test for Tannins.* The sample was placed into a clean slide. The section was flooded with Toluidines's Blue reagent for a minute. The stain was gently removed by using a piece of filter paper. The section was flooded with water followed by its removal. It was repeated until there is no excess stain around the sections and a drop of distilled water was added. Excess mounting medium around the cover glass was removed by gently touching the edge of the cover glass with a filter paper then a cover glass was placed over the preparation, and it was made sure that there is no mounting fluid on the surface of the cover glass. Then the slide was examined under the microscope. The positive result of tannin will give a green, greenish blue or bright blue color (O'Brien *et al*., 1964). *Test for Terpenoids.* The 2,4-dinitro phenyl hydrazine test was used. The transverse section of roots, stem and roots was immersed for a minute in 2,4-dinitro phenyl hydrazine reagent and the mounted in glycerine-water (10:90, v/v) solution. Appearance of orange yellow color in the cells showed the presence of terpenoids. *Test for the presence of Saponin.* A 2 mL of sample with 20 mL of distilled water were agitated in a graduated cylinder for 15 minutes. The formation of 1 cm of foam indicates the presence of saponin.

Preparation of Antibacterial soap infused with Salacia korthalsiana Miq. (Polipog)

Preparation of lye solution. A 128 g of distilled water was weighed into a stainless steel or heavy-duty plastic pitcher. About 60 g of 6% of food grade lye was placed in a beaker and slowly the lye was added in the distilled water. The solution was gently stirred until the lye is completely dissolved. The lye solution was allowed to cool down around 30-40 minutes before mixing the oils. To a 71 g of 15.6% coconut oil was melted in a water bath or in a double boiler over a low heat. In a separate flask 340 g (75%) olive oil and about 43 g (9.4%) castor oil was measured and was

placed in soap making pot slowly adding the oil. The lye solution was slowly added to the mixture the solution was stirred using a blender.

Preparation of soap. The cold process for the preparation of soap was utilized in this study. In a separate flask weigh about 283.5 g of coconut oil, and 283.5 g of olive oil, 85.05 g of rice bran oil and 155.93 g of sunflower oil. After weighing, place all the measured oils into the crockpot. Work in a ventilated area. Turn the crockpot on high and melt all the oils. In a separate container weigh 708.75 g of distilled water and measure about 255.15 g of potassium hydroxide. The lye solution was mixed into the weighed distilled water. After stirring, the lye solution and polipog root extract was added to the oils. The solution was stirred using a blender. The soap mixture was placed in a molder and allowed to cure to 4 to 6 weeks After unmolding the loaf of fresh soap, slice it into bars and allow them to cure in the open air for at least 4 to 6 weeks. The final product was stored in a cool area away from excess heat, sunlight and humidity.

Preparation of Biocomposite solution as facemask coating

Synthesis of Zinc Oxide Nanoparticles. Zinc oxide nanoparticles (ZnONPs) was prepared by using Zinc nitrate and sodium hydroxides precursors and polipog extract as stabilizing agent. About 0.1g of polipog extract was dissolved in 500mL of lukewarm distilled water. About 14.84g (0.1 mol) of zinc nitrate was added in the above solution, and it was followed by constant stirring for 1 hour using magnetic stirrer to completely dissolve the zinc nitrate. After complete dissolution of zinc nitrate, 0.2 mol of sodium hydroxide solution were added drop by drop under constant stirring. The reaction was allowed to proceed for 2 hours. After the completion of reaction, the solution was kept overnight and the supernatant solution were carefully discarded. Rest of the solution were centrifuged at 10 rpm for 10 min and the supernatant was discarded. Thus, the nanoparticles were obtained, and it was wash thrice using distilled water. Washing was carried out to remove the by-products and the excessive starch bound with nanoparticles. After washing, the nanoparticles were dried at 80° C overnight.

3. RESULTS AND DISCUSSION

The Philippine Commission on Higher Education (CHED) approved the university's proposal to increase the production of alcohol, soap, and disinfectants for distribution to pre-identified healthcare and frontline institutions and organizations down to the barangay level. Before the raw materials were used it was subjected to quality test.

Bioethanol from Nypa fruticans (Nipa palm fruit)

A confirmatory test was done with the extracted bioethanol from nipa palm fruit, shown in Table 1. It was done through iodoform test, litmus test, ester test, and flammability. The results revealed that the extracted bioethanol from *Nypa fruticans* are indeed ethanol. It yielded positive results for ester, iodoform, litmus, and flammability test which are the basic parameters to confirm the presence of ethanol.

Table 1. Confirmatory Test for Ethanol

Sample	Parameters			
	ESTER	**IODOFORM**	**LITMUS TEST**	**FLAMMABILITY**
Bioethanol from *Nypa fruticans*	positive	positive	positive	flammable

Phytochemical Profile of Salacia korthalsiana Miq. (Polipog) Root Extract

In phytochemical test for the roots sample shown in Table 2, only the terpenoids indicates a negative result. In alkaloids test the appearance of golden yellow color in a cell observed. Then for steroids test, appearance of yellow color in a cell of the plant sample also observed. In tannins test, a green and greenish color of the cell was also show a positive indication of a test. The foam persisted for 30mins with 1cm height indicates that saponin is present in the plant sample.

Table 2. Phytochemical Profile of the Polipog Root

Active components	Observation	Interpretation
Alkaloids	Appearance of golden-yellow color in a tissue	Positive for Alkaloids
Steroids	Appearance of yellow color in the cells	Positive for Steroids
Tannins	Appearance of green, greenish color in the cells	Positive for Tannins
Terpenoids	No change of the color was observed	Negative for Terpenoids
Saponin	1cm height for 30mins	Positive for Saponin

Salacia korthalsiana Miq. (Polipog) soap was tested on three different bacteria, namely *Enterobacter aerogenes*, *Pseudomonas aeruginosa* and *Staphylacoccus aureus*. Results showed that the antimicrobial sensitivity test of the Polipog soap against the three bacterial strains. The Polipog soap can inhibit the growth of *P. aeruginosa* and *E. aerogenes*. Considering that both (*P. aeruginosa and E. aerogenes*) bacterial strains are classified as gram negative. Polipog soap did not show any inhibitory effects against *S. aureus* strain due to the absence of the formation of zone of inhibition. It implies that polipog root extract does not have antimicrobial potential towards gram positive types of bacteria (with thicker cell walls) such as *S. aureus.*

Table 3 shows the result of antibacterial sensitivity test of the decocted root of Polipog. After three trials, the result for the *P. aeruginosa* and *E. aerogenes* showed that the decocted root of Polipog was positive, this implies that the Polipog can inhibit the growth of *P. aeruginosa* and *E. aerogenes*. It has the zone of inhibition in the sample disc. The present study found complementary to those reported by Tamberkar *et al*. in which they showed that the *P. aeruginosa* has a weak inhibition against some plant extracts. While the result of the *S. aureus* is negative. It implies that the S. aureus cannot inhibit the growth of Polipog. The control which is the chloramphenicol has the zone of inhibition in *P. aeruginosa* and *E. aerogenes* while in *S. aureus* do not have zone of inhibition which indicate that the *S. aureus* cannot inhibit the growth of the bacteria.

Table 3. Antibacterial test in three trials with zone of inhibition

Bacterial Strain	Sample		
	Lab made soap with polipog extract	Commercially available soap (+ control)	Negative Control
Enterobacter aerogenes	5.7 mm	3.7 mm	0 mm
Pseudomonas aeruginosa	2.3 mm	0 mm	0 mm
Staphylococcus aureus	0 mm	6.8 mm	0 mm

Antibacterial test of ZnONps biosynthesized from Nypa fruticans (Nipa palm fruit)

Nipa palm fruit starch is an interesting substrate to produce cyclodextrin, an important polysaccharide due to its unique hydrophobic interior cavity and hydrophilic surface. It can encapsulate hydrophobic organic substances and aid its solubilization in water. This property is useful in food, pharmaceutical, cosmetic, agricultural, textile and packaging applications because of its economic and environmental potentials. Modification is usually carried out to overcome the unstable properties of nipa palm fruit starch and improve its physical properties during processing. Incorporation of zinc oxide into biocomposite materials has attracted a great deal of attention due to its ability to enhance its properties. The combination of the unique properties of nipa palm starch and zinc oxide make it an interesting material for the development of practical applications as facemask coating with antimicrobial properties.

The result of the antimicrobial test for synthesized zinc oxide nanoparticles (ZnONps) against the bacteria *Staphylococcus aureus* and *Escherichia coli* is presented in Figures 1 and 2.

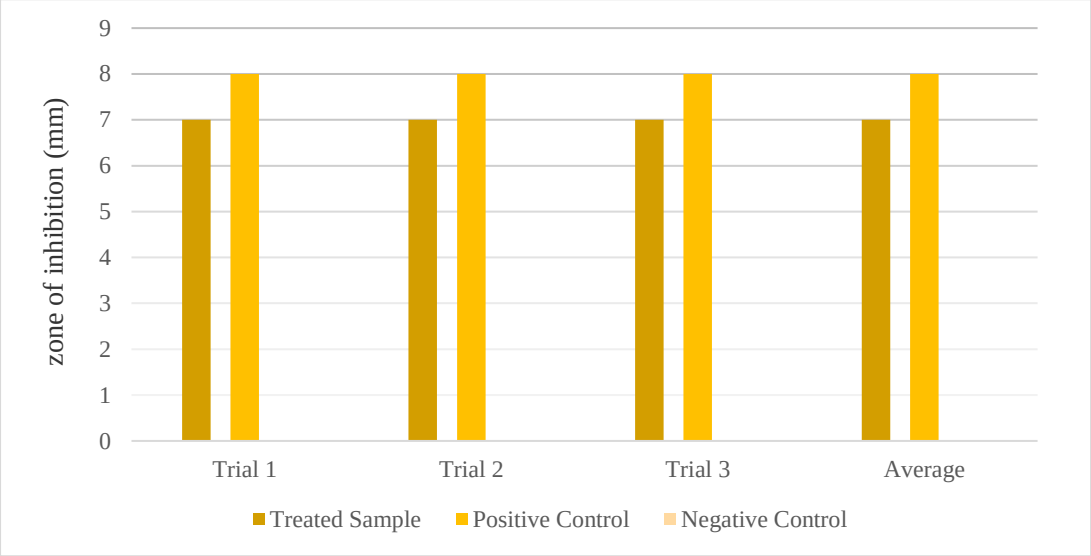

Figure 1. Comparative Chart on the Zone of inhibition for *S. aureus.*

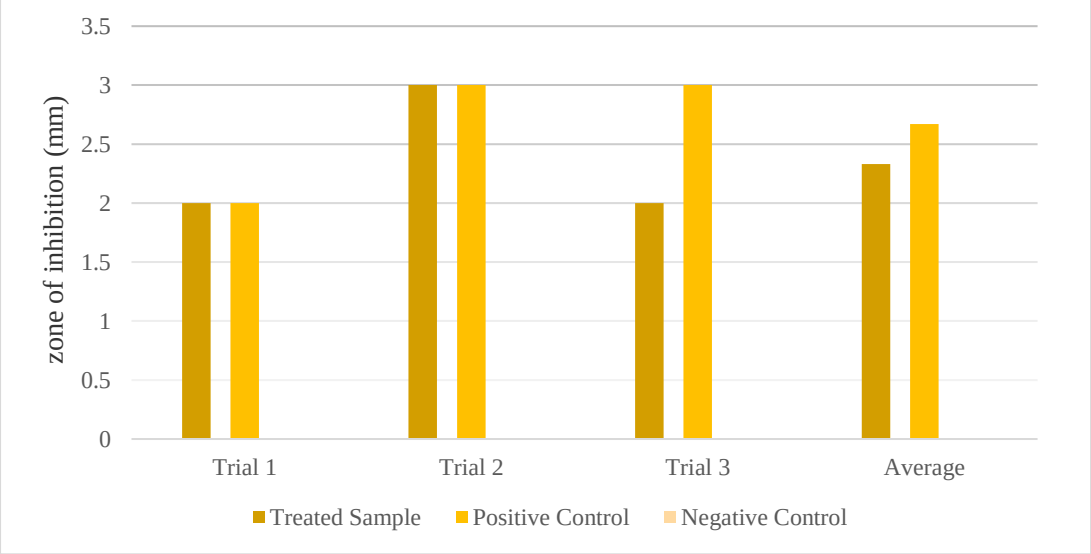

Figure 2. Comparative Chart on the Zone of inhibition for *E. coli.*

As presented in the figures above, the result shows that ZnONps exhibits an antimicrobial activity against both *S. aureus* showing a clear zone of inhibition of 3.67 mm mean in all treatments and *E. coli* showing a zone of inhibition of 2.33 mm mean in all treatments, this implied that the sample have the potential in inhibiting the growth of *E. coli* and *S. aureus* bacteria, indicated by the presence of clear zone of inhibition. Absence of any clear zone suggest that the organisms were resistant to the chemical agent present in the disc. On the other hand, result of the positive control reconstituted powder of chloramphenicol was expected for a clear zone of inhibition.

A face mask is a loose-fitting device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. Face masks may also help reduce exposure of one's saliva and respiratory secretions to others. While a face mask may be effective in blocking splashes and large-particle droplets, a face mask by design does not filter or block very small particles in the air that may be transmitted by cough, sneezes, or certain medical procedures. In this study, the results exhibited that ZnONps as coating in reusable fabric facemasks showed an antimicrobial activity. The layers of the face mask are made of non-woven textile, which blocks dust and large particles and the outer layer of the facemask that was coated with ZnONps, exhibited an enhanced mechanical, thermal and antibacterial properties of the cloth facemask. The scanning electron micrographs of the coated cloth facemask showed that after several washings the ZnONps still adheres to the cloth as presented in Figure 3.

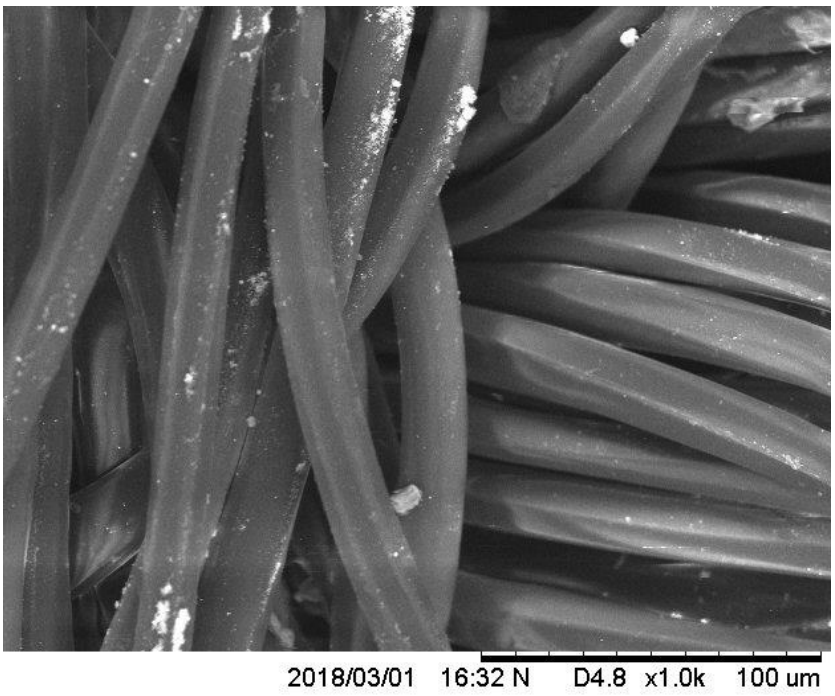

Figure 3. Surface Morphology of textile coated with ZnONps

Utilizing the resources of Northern Samar, this research and development initiative aims to assist the local community during the pandemic and beyond. The university intends to extend its community work through this project, which will provide much-needed security to the people of our province in their fight against COVID-19. In the future, once the pandemic has passed, the university plans to implement an extension program that will teach local government units how to make antimicrobial cloth facemasks using the resources available in the province.

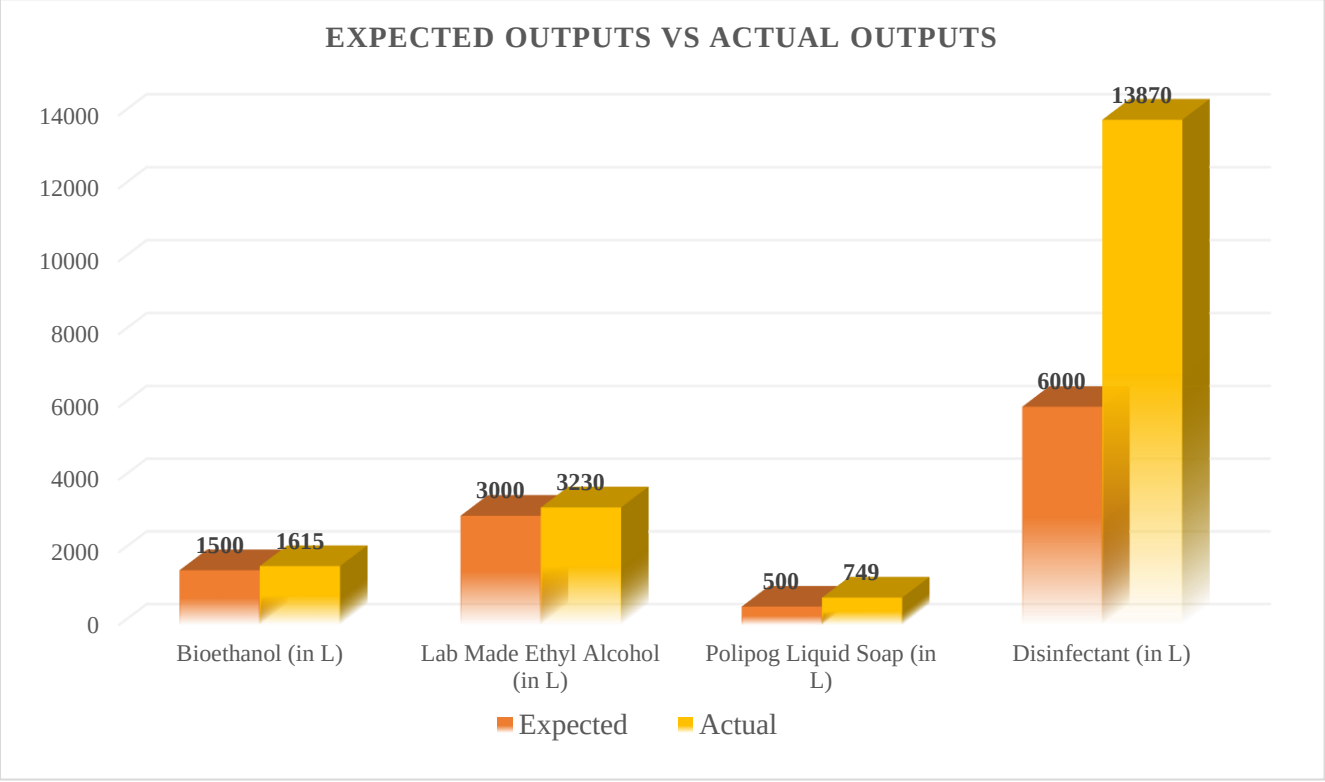

Figure 4. Visual representation of the produced sanitary items

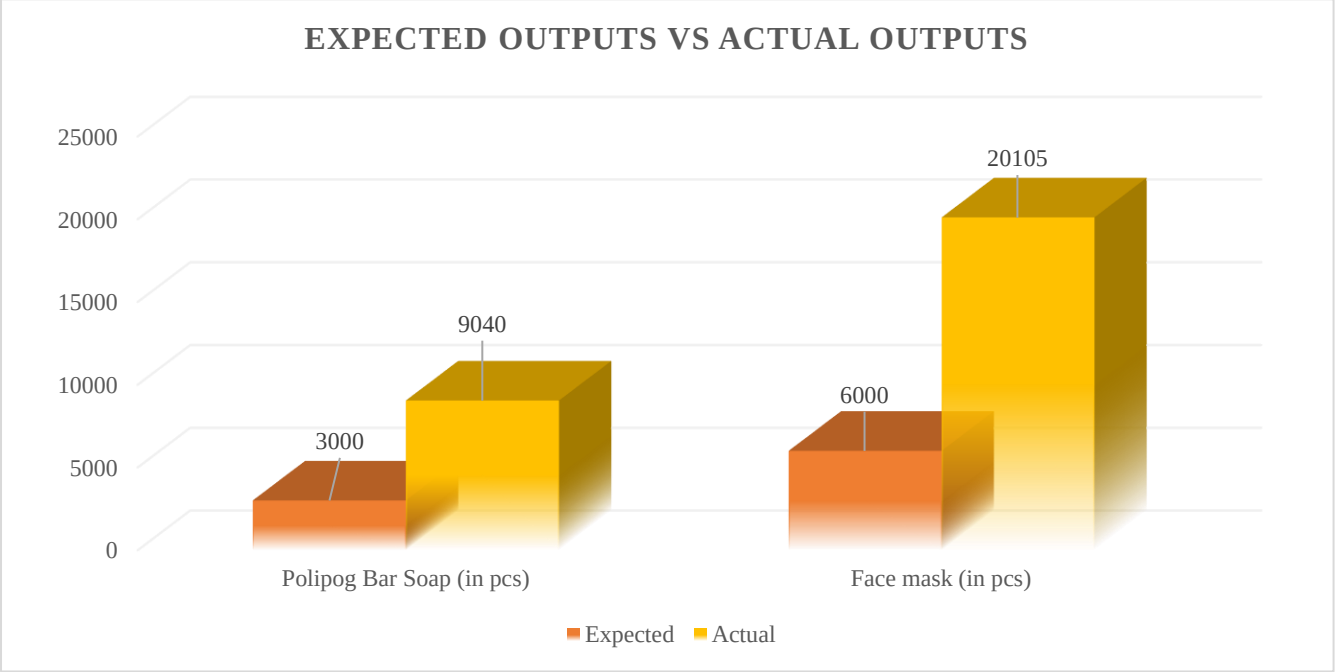

Figure 5. Visual representation of the produced sanitary items

As seen in Figures 4 and 5, the project exceeded the expected outcome. In the bar soap alone there is a 200% increase in production so the face masks had a 235% increase from their original expected output. This is because of the support of the university administration and the grant from the Philippine **Commission on Higher Education**. These sanitary items were distributed to the local communities in Northern Samar to help them combat the spread of COVID-19, luckily, with the help of the Provincial Government of Northern Samar (PGNS), distribution was soft and with ease.

4. CONCLUSION

In the fight to combat the spread of this deadly virus, COVID-19, local resources in Northern Samar plays a vital role. *Nypa fruticans* and *Salacia korthalsiana* Miq. were manufactured to produce the necessary sanitary items such as bioethanol, liquid soap, bar soap, and face mask coated with antibacterial solution. Harnessing the potentials of these local natural resources could give a strong impact to the local communities. Data shows also that with the additional funding from CHED increases the target output of project. A 200% increase on bar soap and face masks were seen. Manufactured sanitary items were distributed to the local communities who needed it most with the help of PGNS.

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