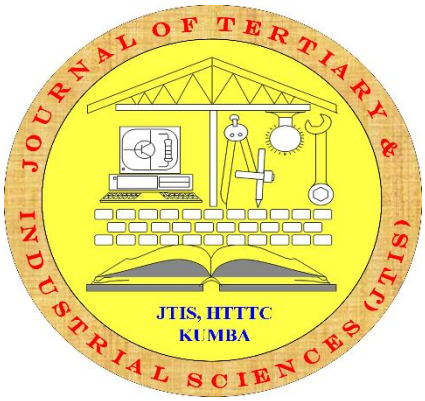
ISSN 2709-3409 (Online)

JOURNAL OF TERTIARY AND INDUSTRIAL SCIENCES

A MULTIDISCIPLINARY JOURNAL OF THE HIGHER TECHNICAL TEACHERS' TRAINING COLLEGE, KUMBA



VOLUME 3, NUMBER 1
MARCH, 2023

PUBLISHER: HIGHER TECHNICAL TEACHERS' TRAINING COLLEGE (HTTTC)
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Journal of Tertiary and Industrial Sciences *Vol 3, No. 1, 2023*
ISSN 2709-3409 (Online)

EDITORIAL BOARD

ISSN 2709-3409 (Online)

JOURNAL OF TERTIARY AND INDUSTRIAL SCIENCES
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ISSN 2709-3409 (Online)

HAND-MADE PAPER PRODUCED FROM PINEAPPLE LEAVES (*ANANAS COMOSUS*) AS A POTENTIAL MATERIAL FOR FOOD PACKAGING

By

ASOBA GILLIAN NKEUDEM[1,2], SAMUEL METUGE[5,6], KAZI FLORINE MABEL[5], TEH RENE NING[5], SUMBELE IRENE ULE NGOLE[5]

Abstract

Pineapple plants are very common in the tropical regions and very easy to extract fibres from its leaves. The utilization of natural fibres in paper making is a new source of material which can be eco-friendly, renewable and recyclable. The main objective of this study is to produce papers from Pineapple leaves as potential material for food Packaging. In this research 3 kinds of papers of different thicknesses were made from fresh Pineapple leaves using 1M, 2M and 3M NaOH. The Experimental research design and Survey research design were used for analysing consumer acceptance of the products. The sample size consisted of 50 participants. Papers were produced and questionnaires were distributed to collect data, using the direct delivery method. The data was analysed using the mean scores (Excel 2010). The results obtained showed that paper with thickness 2 mm, was more appreciated in terms of outer appearance, quality, overall characteristics and degree of interest, followed by paper of thickness 1 mm. Paper of thickness 0.5mm, was mildly appreciated indicating that adjustments are to be done to meet consumer expectation. Hence, Pineapple leaves could be used as an efficient and cost effective source of paper for food packaging. Based on findings some recommendations were made to policy makers, researchers and the community. Furthermore, suggestions for further research were also made.

Key words: **Fibre, Food packaging, Pulp, Paper production, Pineapple leaves.**

1. Introduction

Wood contributes to about 90% of the conventional raw material used for pulp and paper production in the world; however depleting forest resources to obtain wood had made a significant impact on the environment. In many parts of the world, local supplies of wood cannot support the demand for pulp, as a result the search for non-wood raw materials in the paper making industry, has been given more attention due to the rising consumption of wood resource for paper production (Waham *et al*., 2015).

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During the last decades, there has been a wide use of synthetic polymer materials which are artificial macromolecular substances originating from petroleum resources. They have become limited and most of the conventional ones are regarded as non-biodegradable and have caused serious environmental problems (Pawar *et al.,* 2013). This shows that papers from petroleum resources are not environmentally friendly.

Within the past few years, there has been a tremendous increase in the use of natural fibres as source of fibre for pulp and paper. The potential of natural fibre based paper using jute, kenaf, hemp, coir, sisal, pineapple, has received numerous attentions among researchers worldwide for their excellent specific properties (Nadirul *et al*., 2015). Therefore, the availability of abundantly inexpensive lignocellulosic natural fibres, such as pineapple leaf fibre (PALF) in tropical countries, such as Cameroon, provides a unique opportunity for exploring the possibility of its utilization as an inexpensive raw material for pulp and paper applications, because of their high tensile strength and high cellulose content.

After banana and Citrus, Pineapple (*Ananas comusus)* is the third essential tropical fruits in the world with annual production rates of about 25.1million tons (Arib *et al*., 2004). Commercially, pineapple fruits are very important and the leaves are considered as waste materials which are being used for producing natural fibres. Pineapple leaf fibre (PALF) has tremendous mechanical properties and can be applied in making of reinforced polymer composite, low density polyethylene composites, and biodegradable plastic composites. The main drawback of PALF is its hydrophilic nature; it does not make good bonding with hydrophobic matrix, particularly at high temperatures (Asim et al., 2015) It has shown its significant role as it is cheap, exhibiting superior properties when compared to other natural fibres like wood cotton, bagasse, rice husk, wheat straw, abaca sisal, jute, bamboo and banana (Jawaid *et al.,* 2011).

2. Literature Review

Thailand, Philippines, Mexico, Costa Rica and Nigeria are the leading pineapple producing countries in the world, with Nigeria ranked as the highest Pineapple producing Country in Africa (Hossain, 2016). Pineapple is produced in Cameroon all year round and there was a reported increase in production from 127.1 thousand tons in 2008 to 383.1 thousand tons in 2018 (FAO, 2019). Generally, in Cameroon pineapple is cultivated mainly for its fruit; it can be eaten fresh canned, juiced and are found in a wide array of food stuffs such as dessert, fruit salad, jam, yoghurt, ice cream, candy and as a complement to dishes. After harvest of the fruits the leaves which make up a greater portion of the pineapple plant is often allowed to rot which if not properly taken care of may constitute an environmental hazard. It has been observed that most pineapple farmers and some stakeholders have very little knowledge on the benefits that can accrue from the processing of pineapple leaf agro-waste into more useful products that can generate additional income for them.

The dependency of mankind on polythene has grown to larger extent because of its wide applications in storing food and also as carry bags but polythene is a non-

biodegradable material which when buried in the soil doesn't decompose. Because of this, the soil loses its fertility due to the toxic chemicals it releases by the action of temperature and also killing the microorganisms that are essential in the soil (Marella *et al*., 2014). In Cameroon about 40,000 tons of non-biodegradable plastics wastes are produced yearly in which 22,000 tons account for the category of plastic packaging (Barthelemy *et al*., 2016).

Observations in the field have indicated a lack of packaging material such as packaging papers in grocery stores and super markets with a corresponding hike in the prices of the permitted biodegradable plastics. Given the potential of Cameroon for pineapple production (171509 tons in 2013) it is expected that large quantities of fibres can be generated from the leaves which can be used to produce food packaging material in an effort to contribute to the resolution of the problem posed by the ban on the use of non-biodegradable plastics.

Paper industry is dominated by the Asia-Pacific region which witnessed more than 40 % growth rate in 2011, due to high demand in paper consumption. Approximately 90% of paper is produced from wood pulp (Anonymous, 2013a). The rising demand in paper product consumption which is about 400 million metric tons per year (2012) creates additional pressure on the world's forest resources since more wood need to be cut to satisfy the demand (Anonymous, 2014a). *The main important reason for choosing wood as a raw material for pulp and paper is its chemical composition.* The increase demand of paper consumption from virgin pulp is the main cause for the usage of wood species as the main raw material leading to massive deforestation and replantation. This has consequently altered the ecological balance and contributed to climate change. This increased awareness of pressuring the environment led many researchers worldwide to focus their researches on finding the potential alternative raw material for papermaking from non- wood resources (Latibari *et al*., 2011). The purpose of this research therefore is to produce papers from pineapple leaves as an alternative material to wood.

3. Materials and Methods

3.1. Materials

Fresh pineapple leaves were harvested from a pineapple plantation in Buea, Fako division of the SOUTH WEST REGION of Cameroon. 40g, 80g and 120g Sodium hydroxide (NaOH) was used for pulping

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Figure 1: Freshly harvested Pineapple leaves

(Source: fieldwork Kazi Florine Mabel, 2021)

Method

3.2 Paper production

3.2.1. Pulping

After harvest of fruit, freshly harvested pineapple leaves were washed with tap water several times to remove all contaminants present in it and chipped into smaller pieces

Boiling

For 40g NaOH

Molarity number of= moles/volume

Number of moles =molar weight/ weight of substance

Molar weight of NaOH= 23+16+1= 40

Number of moles= 40/40=1mole

Molarity= 1mole/1litre= 1M

For 80g NaOH

Number of moles= 80/40= 2moles

Molarity=2moles/1litre= 2M

For 120g NaOH

Number of moles=120/40=3moles

Molarity= 3moles/1litre= 3M

1M, 2M and 3M NaOH was dissolved in water and made up to 1litre to give required concentration of cooking liquor. The liquor was brought to boiling point and 90g,

180g, and 270g of fresh pineapple leaves respectively, were added and boiled for 10minutes, 20minutes and 30minutes respectively. Boiled mixture was set aside to cool for 10minutes.

Filtration and washing

The boiled leaves were poured in a stainless steel bowl and tap water added to dilute the NaOH solution. The mixture was washed with tap water carefully and filtered using a cloth of very fine pore size to obtain stock (retained pulp) and liquor (waste containing NaOH content and lignin) followed by addition of 1% Hydrochloric acid solution to neutralize the remaining alkali. The process was repeated 5 times with 1000ml of water until cooked fibres became clear.

Bleaching

Bleaching was done with sodium hypochlorite (NaOCl) in the Liquor: substrate ratio of 10:1, 10:2, and 10:3 respectively for 90minutes as seen below

Figure 2: Bleached PALF

Figure 3: Unbleached PALF

(Source: fieldwork Kazi Florine Mabel, 2021)

1000ml of tap water was measured to completely dissolve NaOCl into a stainless steel pot. The solution was put on the fire for 5mintes. The squeezed fibres were introduced when the temperature of the solution was stable with that of the fibres. The fibres were then poured into the NaOCl solution and Stirred for 90minutes.The fibres were thoroughly washed with cold tap water and squeezed (Atanga et *al.,* 2018).

iv Blending

Cooked fibres were poured into a kitchen blender and 900ml of water was added to it and blended for 10minutes until it reached a pulpy consistency (uniform), followed by addition of starch.

3.2.2 Paper moulding

The paper making process was adopted and modified from Aremau et al., 2015. Paper sheets were made with the pulp using handmade paper mould and deckle. The blended mixture (pulp) was stirred and poured on the mould screen placed up and the deckle evenly placed on top of the mould, and immediately a quick shake back and forth, and left and right movement was made to align the pulp on the paper mould, in order to produce a uniform sheet. The tips of the fingers were also used to evenly distribute the pulp on the paper mould.

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Draining

Mould and deckle were placed horizontally and water was allowed to drain completely for 2hours

Drying

The wet pulp was transferred to a board for drying under the sun and when the paper was completely dried, the edge of the dried paper was peeled off from the paper mould.

3.3 Research Design

Ojong (2004) defined research design as the study related to the plan which the researcher intents to utilize to attack the problem. The research design employed for the study is the Experimental research design and Survey research design.

Area of the study

This study was carried out in Buea, SOUTH WEST REGION of Cameroon

Method of data collection

Papers were produced from pineapple leaves and 50 questionnaires were distributed to participants. The questionnaires consisted of three parts which are: a) Demographic information, b) Knowledge and attitudes of consumer towards the product, c) consumer acceptance in specific characteristics such as outer appearance, paper quality, texture, smell, overall characteristic, and degree of interest.

3.4. Statistical analysis

Data generated from the questionnaires were evaluated using the frequency distribution table and expressed as mean using Excel 2010.

4. Results and Discussion

4.1. Presentation and interpretation of results

Table 1: Questionnaires distributed and usable questionnaires

Distributed	Return	Return rate	Incomplete	Complete	Adjusted return rate
50	50	100%	0	50	100%

The table above indicates that out of 50 questionnaires administered, all were returned giving a return rate of 100%. From the number returned, all were completely filled, giving an adjusted return rate of 100%.

Demographic information

The survey was conducted in Buea, South West Region of Cameroon. After gathering information from the survey, it was found that 45% of the participants were males,

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and 55% were females. 21% of the participants were at the range of age 15-30years, 43% of participants were at the range of age 31-50years and 36% of the participants were at the range of age 51+ respectively.

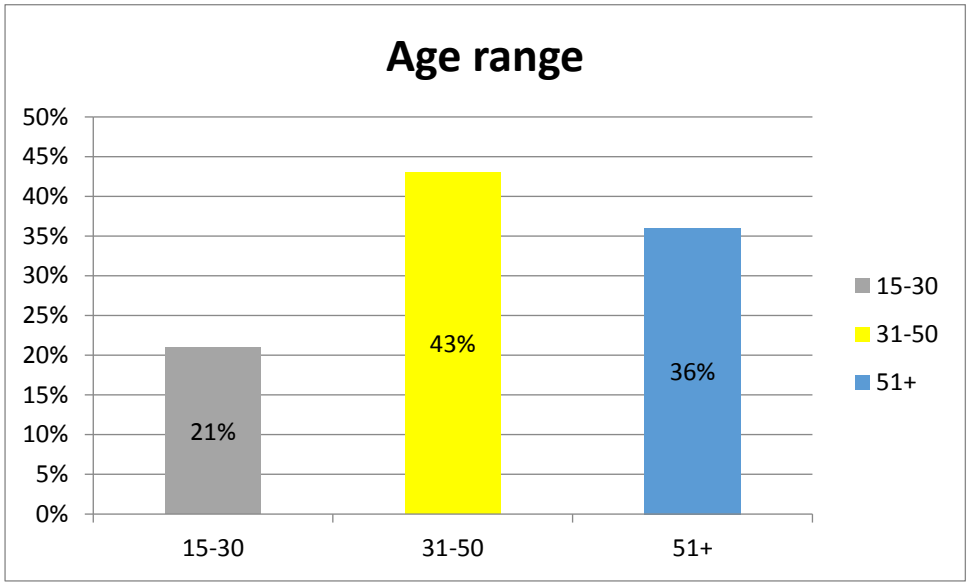

Figure 4: Age range of participants

48% of the participants were farmers, 22% of the participants were students and 30% of the participants were traders

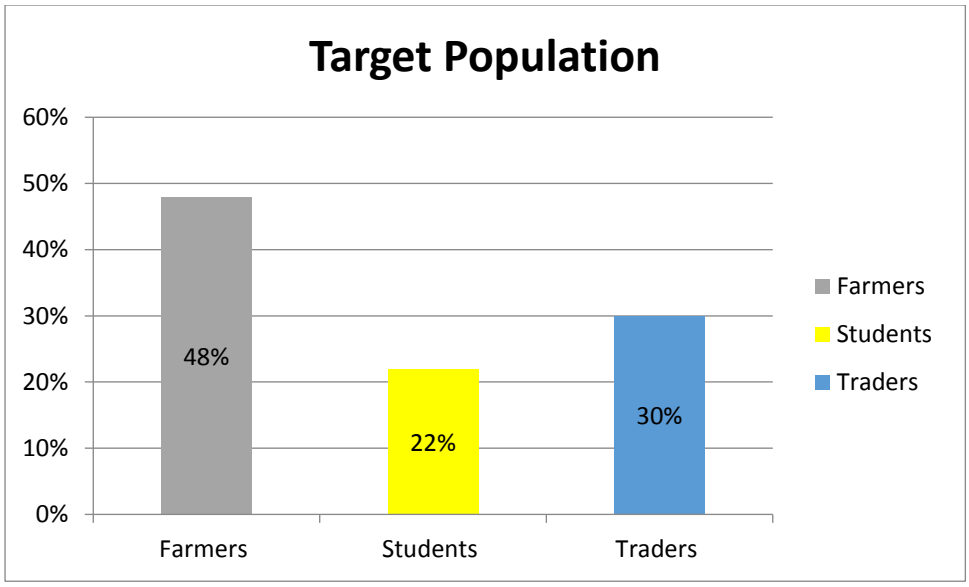

Figure 5: Targeted Population

Knowledge and attitude of the participants towards the product

In terms of knowledge and attitudes of the participants toward the products, 100% of the participants have packaged food in paper. 72.16% of the participants considered to package food in paper because of the attractiveness, 20% of the participants considered from their colourfulness, 31% of the participants considered because they are biodegradable, 37% considered from their cheapness. 66% of the participants have cultivated pineapples and 34% of the participants had never cultivated pineapple. 66% of the participants used the waste (pineapple leaves) as manure to enrich the soil, 20% of the participants used the waste for medicinal purposes, while 14% of participants had no use or idea of the use of Pineapple leaves. 100% of the participants were not aware that papers can be produced from pineapple leaves.

Consumer acceptance in specific characteristics

Participants tested the three papers and rated the likelihood in some specific characteristics (Texture, quality, smell, outer appearance, degree of interest and overall characteristics). The value of each rate was 7extremely like, 6 moderately like, 5 like, 4 neither like or dislike, 3 dislike, 2 moderately dislike, 1 extremely dislike.

Table 2: mean score of paper produced from Pineapple leaves

Sample/characteristics	Texture	Quality	Smell	Degree of interest	Outer appearance	Overall characteristics
A	5.4	5.4	6.2	5.54	5.54	5.86
B	5.2	6.3	6.1	6.22	6.34	6.06
C	5.02	6.6	6.0	6.6	6.46	6.74

Key

Sample A: 0.5mm

Sample B: 1mm

Sample C: 2mm

7= Extremely like

6= Moderately like

5=like

4= Neither like or dislike

3= Dislike

2= Moderately dislike

1= Extremely dislike

Descriptive statistics for all indicators of the study and verification of hypothesis

The presentation that follows is the research findings in relation to the research questions as well as the verification of the hypothesis and interpretation of results from participants

Table 3: Outer appearance of Sample A, B, and C

Sample/code	7	6	5	4	3	2	1	X
A	12	24	9	5	0	0	0	5.54
B	18	31	1	0	0	0	0	6.34
C	23	27	0	0	0	0	0	6.46

Source: field research work 2021 using excel 2010

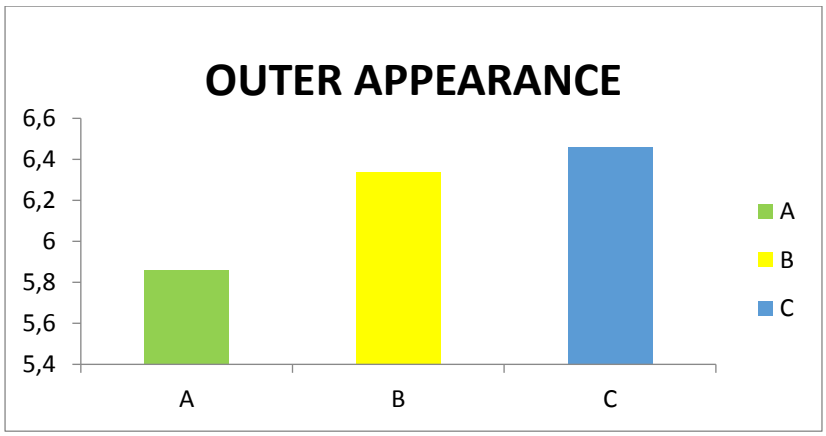

Figure 6: Frequency distribution sample for outer appearance

From figure 6 above, it shows that, sample B and C were whiter than sample A. This was as a result of the quantity of NaOCl used in bleaching. Sample C was more appreciated than samples A and B because of its hardness and appearance in the finished product. Sample B was moderately appreciated while Sample A was mildly appreciated, which means sample A can be used but will require more adjustment in order to reach a certain level of appreciation in the Market. This tie with the findings of Asmanto *et al.*, 2018, who obtained papers with shiny appearance from Banana pseudo-stem fibres with increased NaOCl concentration and a firmer finished product with increase in fibre quantity.

Table 4: Texture of Sample A, B and C

Sample/code	7	6	5	4	3	2	1	X
A	15	20	8	5	2	0	0	5.4
B	12	18	11	5	2	2	0	5.2
C	6	15	15	5	9	0	0	5.02

Source: field research work 2021 using excel 2010

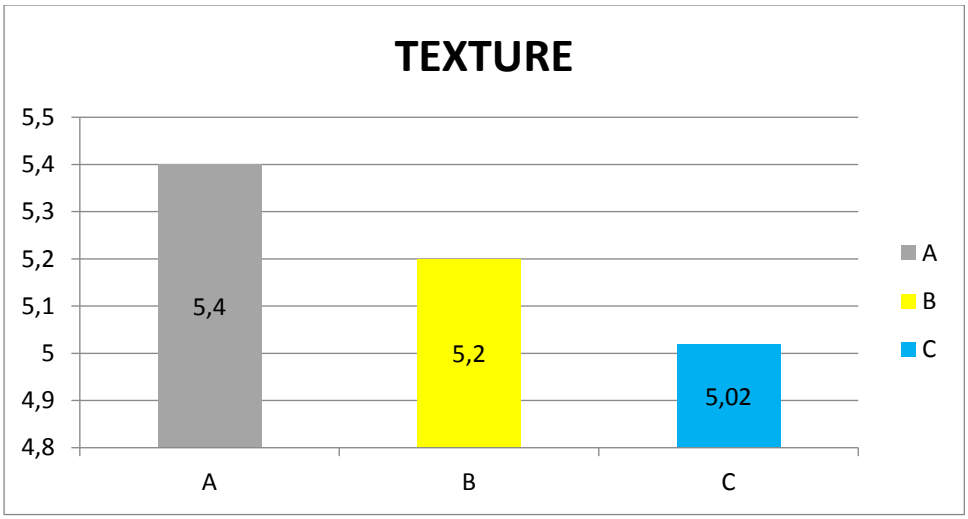

Figure 7: frequency distribution table for texture

Figure 7 indicates that sample A was best appreciated than samples B and C. The quantity of pineapple leaves that were blended to produce sample A was 90g, so it could easily blend giving the smoothest texture. To produce sample B, 180g of Pineapple leaves were used to give a smoother texture which was moderately appreciated. For sample C, 270g of Pineapple leaves were used to produce a slightly rough texture which was mildly appreciated, which means some modification could be done in terms of the machinery and time used in blending the pulp in order to have a pulpy consistency. This is in line with the findings of Nayan *et al.*, (2013) who revealed that papers produced from Malaysian pineapple leaves with a lower quantity had a more uniform texture after mercerization of the PALF.

Table 5: Smell of Sample A, B and C

Sample/code	7	6	5	4	3	2	1	X
A	12	23	10	8	0	0	0	6.2
B	11	24	11	7	0	0	0	6.1
C	15	2o	15	0	0	0	0	6.0

Source: field research work 2021 using excel 2010

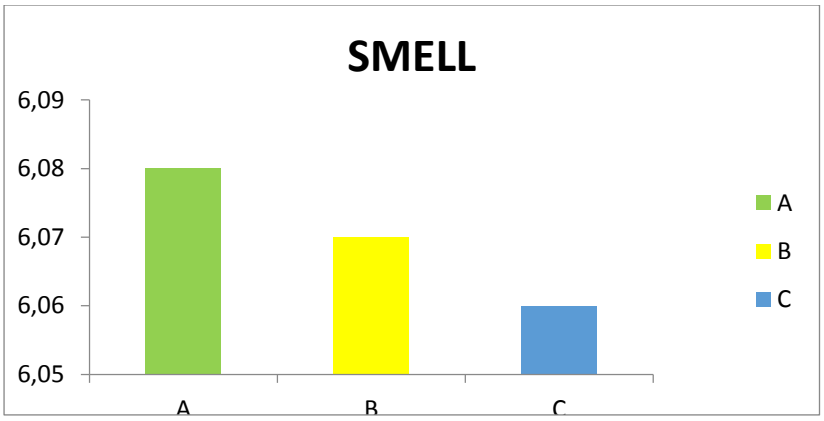

Figure 8: Frequency distribution sample for smell

From figure 8 above, the result of the difference in smell of the three samples, indicated that the samples were not significantly different from each other since the same chemicals were used to produce the three samples. This is in agreement with the findings from John *et al.*, (2015) who used Banana peels as alternative material for paper production and had a very acceptable odour-free paper even at different concentrations. According to the above analysis based on smell, it can be concluded that these products are good for commercialization since the odour of the paper will not affect the flavour of the packaged food.

Table 6: Quality of Sample A, B and C

Sample/code	7	6	5	4	3	2	1	X
A	15	25	7	3	0	0	0	5.4
B	26	15	9	0	0	0	0	6.3
C	42	6	2	0	0	0	0	6.6

Source: field research work 2021 using excel 2010

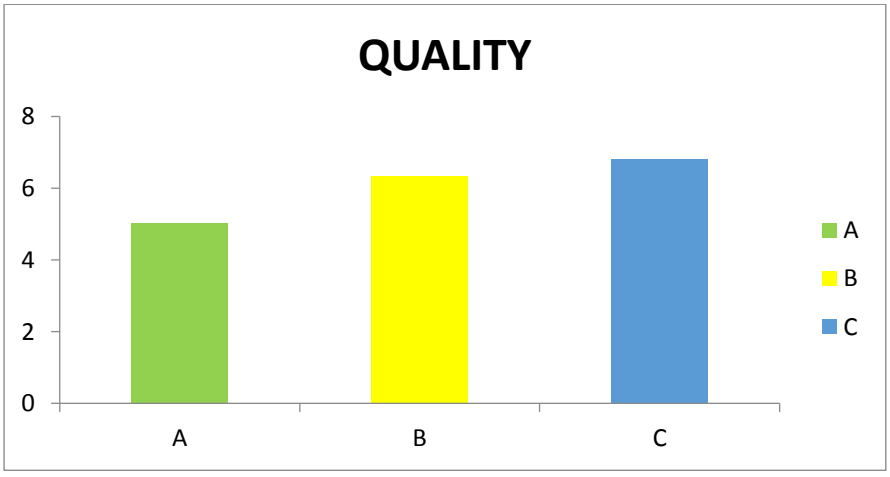

Figure 9: Frequency distribution sample for quality

Figure 9 above illustrates greater quality for sample C followed by sample B and then Sample A. Paper quality depends on some factors like brightness, whiteness, weight, eco-friendliness, among others. Sample B and C were whiter than sample A, but sample C had greatest weight than samples A and B. The increased weight accounts for the durability of the paper while preserving its biodegradability as well as offering security in a package. This result ties with the findings of Charles *et al*., (2006) who obtained good quality papers by using the cortex of cornstalk and found that the increased weight of cornstalk produced a more durable paper. Researchers can continue in the production and improvement of the quality of these products.

Table 7: Over all characteristics of Sample A, B and C

Sample/code	7	6	5	4	3	2	1	X
A	15	19	1o	8	0	0	0	5.86
B	33	13	3	1	0	0	0	6.06
C	37	13	0	0	0	0	0	6.74

Source: field research work 2021 using excel 2010

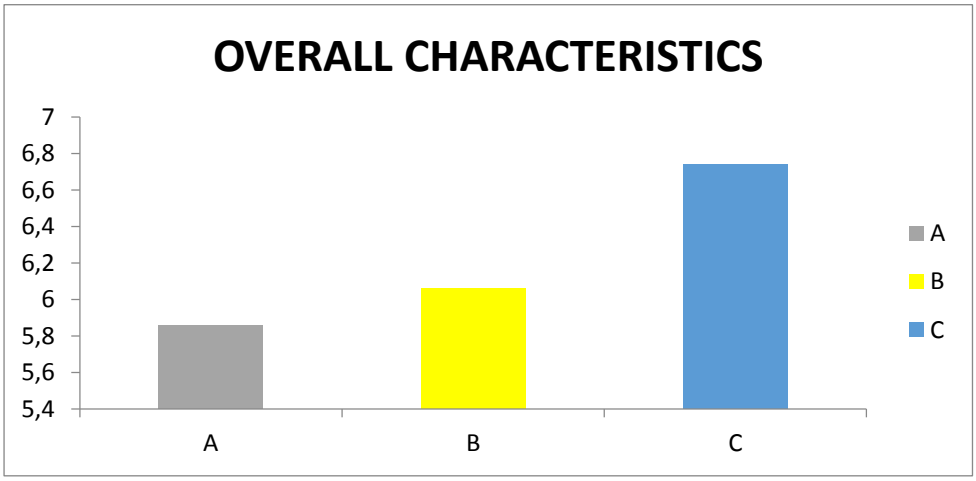

Figure 10: Frequency distribution sample for overall characteristics

Judging from the responses on overall characteristics from figure 10, sample C showed greatest appreciation in terms of outer appearance and quality, followed by sample B which did not use the same amount of Pineapple leaves as Sample C. Sample A did not also used the sample quantity of Pineapple leaves as Samples B and C. Findings from the field therefore revealed that papers produced from Pineapple leaves were generally accepted by the consumers, because even though the papers have different qualities, they can be used for different purposes. These findings tie with the views of Jarinya *et al*., (2013), who indicated that water repellent Pineapple leaf papers were

generally accepted by consumer after appreciating the texture, outer appearance, quality and overall characteristics. To be able to improve the utilization and value of Pineapple plant in Cameroon especially in the South West Region, people are encouraged to fully explore Pineapple leaves not only for it use as manure, but also for paper production

Table 8: Degree of interest for Sample A, B and C

Sample/code	7	6	5	4	3	2	1	X
A	4	24	19	4	0	0	0	5.54
B	21	22	4	3	0	0	0	6.22
C	36	10	2	0	0	0	0	6.6

Source: field research work 2021 using excel, 2010

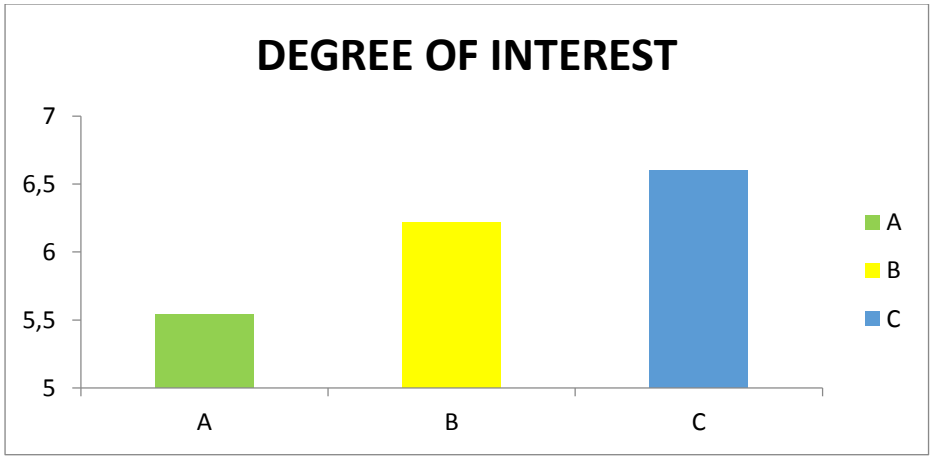

Figure 11: Frequency distribution sample for Degree of interest

Judging from how interested the participants were in the three samples from figure 11, it was revealed that Sample A was least appreciated due to the softness of the product. Sample B did not offer the same smoothness as in A but was more durable than A therefore giving more interest than A. for C a slightly rough product was realized but offered more security in the package than A and B therefore, more participants were interested in sample C since it is more durable and can be used for multiple purposes. This findings fall in line with Jarinya *et al*., (2013), who stated that durability of the product in a package pushed participants to have a better interest Sample A was least appreciated with regards to degree of interest due to the softness and less security offered. Also B did not offer the same security as C, therefore, more participants were interested in sample C since it is more durable and can be used for multiple purposes.

5. Conclusion

At the end of this study, it showed that Sample C (2mm) had the best result in terms of paper quality, acceptability, outer appearance and degree of interest followed by sample B (1mm) and the least was sample A (0.5mm). The Survey research on the target population revealed satisfactory results as 85% of participants were very interested in the product compared to 5% who showed little interest in the product. Papers produced from Pineapple leaves will be an innovative product to the population of Buea on order to gain more income and help their local area grow.

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