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Preliminary Investigation on Production of Brown Ink from *Gmelina arborea* (ROXB) Fruit Extract

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Abstract

The study was carried out to assess the potential of producing brown ink from *Gmelina arborea* fruit extract and to compare the ink produced with commercial ink using ink flotation test. The *Gmelina arborea* fruit extract was gotten by soaking the fruits in water for two hours, after which they were squeezed manually to extract the juice. Five different concentration levels (100%, 80%, 60%, 40% and 20%) of the ink were produced using ethanol as diluent and coconut vinegar as additive to preserve the ink from biodegradation and to enhance its stability and permanence on paper once it has dried. The prepared ink was compared with the commercial ink (control) to determine the best concentration level for optimal ink penetration on selected paper surfaces. The results showed that 40% concentration level of the prepared ink has the best penetration time of 5.29±0.43sec and 1.55±0.46sec for cardboard and writing paper respectively. These values compared favorably with 5.70±0.71sec and 1.50±0.42sec being the respective penetration time for the control ink on cardboard and writing paper.

The data obtained were analyzed using Analysis of Variance (ANOVA) at 0.05 probability level. The results obtained from the analysis of variance showed that there were significant differences in the treatments and surfaces.

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From the foregoing, it can be concluded that despite the subjective nature of the ink floatation test in which the end point is determined at the discretion of the person performing the test based on visual assessment, production of brown ink from *Gmelina arborea* fruit extract is feasible. Hence, the use of Gmelina fruits often considered to be of no direct value should be encouraged, as a cheap and readily available eco-friendly raw material for ink production.

Keywords: Cardboard, coconut vinegar, ethanol, *Gmelina arborea* fruit extract, ink**,** ink floatation test, paper, penetration time, writing paper.

1. Introduction

For over five century back, the global importance of ink has been on the increase. However, the hazardous effect of ink on human health has also not been overlooked. Worldwide today, ink is used in offices, workstations and in academic institutions especially for paperwork and other related activities. Ink is a liquid or paste that contains pigments or dyes. It is used to colour a surface to produce an image, text or design as well as for drawing or writing with a pen, brush or quill [1].

Ink in its widest signification is the medium employed for producing graphic tracings, inscriptions, or impressions on paper or similar materials. Ink can be a complex medium, as a fluid or as a glutinous adhesive mass, composed of solvents, pigments or dyes, resins, lubricants, solubilizers, surfactants, particulate matter, fluoresces, and other materials. The components of ink serve many purposes; the ink's carrier, colorants, and other additives affect the flow and thickness of the ink and its appearance when dry [2, 3]

Paper is a pliable material used for writing, packaging and a variety of specialized purposes. It is made of pulp fibres, normally from wood or other vegetable fibres which are felted together from aqueous slurry on a wire or forming fabric by hydrogen bonding [4]. Paper as a base for application of ink, is a versatile material with many uses. Whilst the most commonest use is for writing and printing, it is also widely used as a packaging material for many products in a number of industries, and even as a wrapping material for food ingredients, particularly in Asian cultures [5].

As writing and printing material, there is high demand for ink but its shortage has been a militating factor in the chain of supply. There is a misconception that ink is non-toxic even if swallowed. Certain inks such as those used in digital printers, and even those found in common writing pens can be harmful. Though ink does not easily cause death, inappropriate contact can cause effects such as severe headache, skin irritation, or nervous system damage. These effects can be caused by solvents, or by pigment ingredient such as p-anisidine which helps create the ink colour and shine. In other to enjoy continuous services of ink, it is globally observed that ink should be produced from non-toxic material [6]. Therefore, finding an alternative but readily available raw material from such plant source as *Gmelina arborea* fruit, a non-toxic material [7] for ink production, will go a long way in reducing the scarcity of writing ink in the market while upholding an eco-friendly environment.

Chromatography analysis of *Gmelina arborea* fruit extract (oil) gave one hundred components which accounted for 92.7% of the oil including 24 trace compounds. The ubiquitous terpenes occurred in lesser amount. The fruit oil was characterised by the abundance of (Z)-3-hexenol (17.9%), 1-octen-3-ol (8.4%) and hexenol (6.1%) among the aliphatic alcohol; heptacosane (5.6%), pentacosane (3.8%) and 1- pentacosane (3.2%) among the hydrocarbon; and nonanal (8.7%) and (E) -2-decenal (3.0%) as the main aldehyde constituents [8].

In addition, *Gmelina arborea* fruit extract which at initial state (fresh green) is orange in colour, turns brown on little exposure to air, and consists of some pigments or dyes. In this study, effort has been made to evaluate the potential of producing brown ink from *Gmelina arborea* fruit extract, using "ink flotation test method" [9] to determine the penetration time of the ink produced at different ink concentration levels of 100%, 80%, 60%, 40% and 20% on selected paper surfaces. This is with a view to determining the best concentration level of the produced ink for use in comparison to conventional commercial ink in the market**.**

2. Materials and methods

2.1 Preparation of Coconut Vinegar

Coconut water, sugar, yeast, and red wine were locally procured and used for the production of coconut vinegar. The coconut shell was broken and the water inside it collected, while the edible part of the coconut was removed and sliced for easy blending. The blended pulpy suspension was sieved in other to separate the particles from water. 40 g of white sugar was mixed with 4 litres of coconut water and stirred thoroughly. The mixture was cooked for about 30 minutes and allowed to cool before transfer to a bowl, where 2 g of yeast was added after which the entire mixture was left tightly covered for two weeks for fermentation. At the expiration of two weeks, the mixture was decanted to separate the solvent from the whitish residue. 5 ml of red wine was added to the decanted solvent to hasten the period of fermentation [10], and then left covered for another two weeks.

2.2 Preparation of Brown Ink from Gmelina Fruit Extract

Fruits of *Gmelina arborea* collected for extraction were soaked for two hours, and afterwards squeezed manually to extract the juice. 200 ml of the Gmelina fruit extract mixed with 40 ml of coconut vinegar in the ratio 5:1 was cooked for 30 minutes and allowed to cool before transfer for subsequent use. The procedure was repeated to ensure sufficient amount of brown ink was obtained as shown in Fig. 1.

2.3 Preparation of Writing Samples for Ink Test

Selected writing samples (cardboard and writing paper) were cut into 60 by 60 mm squared sheets. 150 ml of the produced ink at different concentration levels of 100%, 80%, 60%, 40%, 20% and control (market ink) was respectively applied on the cardboard and paper samples (Fig. 2). A stopwatch was set to determine the time taken for the upper surface of the test samples to become fifty percent discoloured by penetration of the ink, using visual assessment. The procedure was replicated 4 times in each case. This test is quite subjective because the end point is left to the discretion of the person performing the test. It is a good indicator of penetration times, however, and is fairly reproducible if the same person runs the test from day to day. The method is of greater value for paper than paperboard, due to the excessive penetration times of the latter

2.3 Experimental Procedure

The experiment was a 2 by 6 factorial in a completely randomised.design (CRD) as shown in the experimental procedure in Table 1. Analysis of variance (ANOVA) was conducted to examine the level of significance of the treatments applied on the test samples at different levels of treatment based on the time taken.

Table 1: Experimental procedure

Treatment	100% of Ink T_1	80% of ink +20% ethanol T_2	60% of ink +40% ethanol T_3	40% of ink +60% ethanol T_4	20% of ink +80% ethanol T_5	control T_6
Cardboard	4 replicates	4 replicates	4 replicates	4 replicates	4 replicates	4replicates
Writing paper	4 replicates	4 replicates	4 replicates	4 replicates	4 replicates	4 replicates

Fig. 1: Brown ink produced

Fig. 2: Ink Flotation Test

3. Results and discussion

Table 2 shows that the average penetration time of the ink produced from extract of *Gmelina arborea* fruit on the selected writing surfaces is 8.88±11.00 sec. From the table, it was observed that cardboard has the highest mean value of 13.55±13.29 sec compared to writing paper with 4.20±5.00 sec. This is due to difference in furnish composition and/or grammage of the writing paper and cardboard as enunciated by William *et al* [9]. Also, it was observed that the ink produced at 100% has the highest mean value of 27.50±13.36 sec compared with ink produced at 20% with the least value of 2.96±1.42 sec.

The results also showed that 40% concentration level of the prepared ink has the best penetration time of 5.29±0.43 sec and 1.55±0.46 sec for cardboard and writing paper respectively. These values compared favourably with 5.70±0.71 sec and 1.50±0.42 sec, being the respective penetration time for the control ink on cardboard and writing paper.

Table 2: Mean values of penetration time of *Gmelina arborea* ink on cardboard and writing paper.

Concentration	Cardboard	Writing paper	Mean (sec)
100%	40.00±0.40	15.00±0.08	27.50±13.36
80%	20.00±1.26	3.64±0.71	11.82±8.79
60%	6.19±0.50	1.75±0.41	3.97±2.40
40%	5.29±0.43	1.55±0.46	3.42±2.03
20%	4.16±0.88	1.75±0.24	2.96±1.42
Control	5.70±0.71	1.50±0.42	3.60±2.31
Mean (sec)	13.55±13.29	4.20±5.00	8.88±11.00

Table 3: Analysis of variance for penetration time test

Source of Variance	Degree of Freedom	Sum of square	Mean square	Fcal	Sig
Surface	1	1050.567	1050.567	2707.035*	0.00
Concentration	5	3776.774	755.355	1946.352*	0.00
Surface × Concentration	5	848.465	169.693	437.255*	0.00
Error	36	13.971	0.388		
Total	47	5689.777			

*Significant at 0.05 level of probability

At 0.05 level of probability, it is observed that there is significant difference between the cardboard and writing paper, between the concentration levels and interaction between the surface and concentration.

Table 4: Duncan multiple range test showing the mean penetration time of the ink produced with respect to concentration.

Concentration	Mean
Control	3.6025[ab]
20%	2.9600[a]
40%	3.4250[ab]
60%	3.9738[b]
80%	11.8238[c]
100%	27.500
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Mean with the same alphabet are not significantly different

4. Conclusion

The investigation has provided basic information on the production of brown ink from *Gmelina arborea*

fruit extract using ink floatation test. Based on the results obtained, it was observed that 40% ink concentration is optimal with the best penetration time of 5.29±0.43 sec and 1.55±0.46 sec for cardboard and writing paper respectively. These values compare favourably with the penetration time of 5.70±0.71 sec and 1.50±0.42sec for the commercial ink on cardboard and writing paper respectively. The ANOVA results in Table 4, confirmed the significant effect of the diluent on ink produced at different concentration levels. However, "the ink floatation test" method is subjective as the time for the upper surface of the tested sample to become fifty percent discolored by the penetrating ink is left to the discretion of the person performing the test based on visual assessment. However, in comparison to the commercial ink, the ink produced from *Gmelina arborea* fruit extract was found to be very effective on writing paper. Hence, the test method is of greater value for paper than paperboard, due to the excessive penetration time of the latter. Nonetheless, production of brown ink from extract of *Gmelina arborea* fruit at 40% concentration level using ethanol as diluent should be encouraged, while more research into innovative production techniques, usage of other diluents, durable and non-leachable preservatives compatible with ink processing, should be carried out to engender enhanced ink yield and improved ink viscosity, as dictated by end-use applications.

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