



FORMULATION AND PRODUCTION OF PRINTING INK USING AFRICAN BLACK PLUM (*Vitex Doniana Sweet*) LEAVES

ABSTRACT

Society is so dependent on mass communication; therefore, the techniques of printing process are very important.

Printing is a technology; it expands and amplifies the human need to communicate. Inks are in huge demand despite in electronic age; hence, this study seeks to produce printing ink using black plum leaves. In this work, 1125ml of black plum was extracted from 216g of the plum

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Introduction

Ink is a liquid paste that contains pigments or dyes and is used to colour a surface to produce an image, text, or design. It is used for drawing or writing with a pen, brush or quill. Thicker inks, in paste form, are used extensively in letterpress and lithographic printing (Gorziza *et al*, 2019). Ink can be a complex medium, composed of solvents, pigments, dyes, resins, lubricants, solubilizers, surfactants, particulate matter, fluorescents and other materials. (NIIR Board of consultants & Engineers, 2015)

Inks are found in almost every aspect of human activity. We read newspapers, magazines, and books on a daily basis and then gradually moving to our work places – schools or offices, we make piles of photocopies and print lots of pages from our computers. We buy countless packaged consumer products printed with ink. We use stamps and money, again printed with ink ([http: www.prota.org](http://www.prota.org)).

Generally, ink is an organic or inorganic pigment or dye dissolved or suspended in a solvent. However, chemically it is viewed as a colloidal system of fine pigment particles,



leaves using 2000ml of distilled water. The pH of the extracted pigment was 2.88. Five different formulations were analyzed and printing ink was produced. Tests such as conductivity, viscosity, drying rate and pH were carried out. The produced ink quality showed a little variation when compared with commercial values. However, the results indicate that inks from formulation A having a viscosity of 4.5, with the drying rate on cardboard to be 4.5×10^3 while its pH was 3.8 gave the best results. The results obtained from this study has shown that black plum pigments exhibit promising properties suitable for sustainable ink development.

Keywords: Printing ink, Black Plum, Pigment, Formulations

colored or uncolored, dispersed in an aqueous or organic solvent. The first inks were fruit or vegetable juices; protective secretions from cephalopods such as squid, cuttlefish, and octopus; blood from some type of shellfish; and tannin from galls, nuts, or bark from trees (Senefelder, 1996). The first man-made ink appeared in Egypt about 4,500 years ago and was made from animal or vegetable charcoal (lampblack) mixed with glue. Modern inks are complex formulations. Along with the pigment, they also contain some additional ingredients collectively known as ‘vehicle’ in varying levels (<http://www.prota.org>).

Today’s inks are divided into two classes: printing inks and writing inks. Printing inks are further broken down into two subclasses: ink for conventional printing, in which a mechanical plate comes in contact with or transfers an image to the paper or object being printed on; and ink for digital nonimpact printing, which includes ink-jet and electro photographic technologies (Shahid & Mohammed, 2025). According to (Flemin, 1999), printer inks differ from writing inks in that they are applied to the substrate by means of a printing press.

As been made into dyes, the *Vitex doniana* can be an alternative ingredient for printing ink (Colombe et al, 2012) The plant commonly known as black plum is a deciduous tree with a heavy rounded crown; it usually grows up to 20metres tall in tropical Africa (Usher, 1974). Modern research has shown that the plants have a range of uses. It is a very useful multi-purpose tree providing food, medicines and materials. The blackish extract obtained by boiling the leaves, bark, roots and/or fruits is used as ink and as dye for clothes (Okigbo, 2015).



From the foregoing, the printer's ink is indispensable as far as industrial, societal and human development is concerned and therefore, deserves a good study. Typically, with the increasing demand for environmentally sustainable alternatives to synthetic dyes and inks, natural pigments have gained significant attention (Purnamasari *et al.*, 2021). Synthetic inks often contain toxic compounds that are harmful to both human health and the environment. Natural pigment on the other hand, are biodegradable, non-toxic, and renewable (Mei, 2004)). *Vitex Doniana* (African black plum), known for its rich black color due to anthocyanin content, presents a promising natural source of pigment. Thus, this study focuses on extracting the natural pigment from black plum for use in eco-friendly ink formulation.

MATERIALS AND METHOD

Pre-treatment Process of Raw Material

The raw material (black plum leaves) was obtained from Bida, Niger state. Size reduction was carried out by grinding in a mortar and pestle, to increase the rate of diffusion of the pigment. It was then washed to remove some particles such as dust and sand for accuracy in result. Thereafter, it was weighed using an electronic balance so as to know the quantity of black plum used for the production.

Extraction and Concentration of Black Plum

216g of the plum leaves was taken and soaked in 2000ml of water and then heated for 40 minutes at a minimum temperature of 120°C on a heating mantle until the pigment completely diffuses into the bulk of the water. A black colour was then obtained. The mixture was sieved to separate the residue from the coloured extract; the solution obtained was 1125g. The extracted solution was then concentrated by evaporation. This was done by placing the solution into a pot and heated directly and evaporation took place gradually. In the process, the maximum temperature attained was 105°C in 25 minutes. It was then allowed to cool and its concentration was measured using a colorimeter, which gave a value of 0.7.

Procedure for the Production of Printing Ink

The mixing was carried out according to five different formulations given below;



Table 1: FORMULATIONS A

VOLUME (ML)	INGREDIENTS
90.0	Black plum (extract)
90.0	Methanol
18.0	Nitrocellulose thinner (vehicle)
2.0	Paraffin wax
	Water
	Liquid paraffin (trace)
	Oleic acid (trace)
	Cobalt II Chloride (trace)
200.0	

Table 2: FORMULATIONS B

VOLUME (ML)	INGREDIENTS
80.0	Black plum (extract)
60.0	Methanol
30.0	Nitrocellulose thinner (vehicle)
20.0	Paraffin wax
10.0	Water
	Liquid paraffin (trace)
	Oleic acid (trace)
	Cobalt II Chloride (trace)
200.0	

Table 3: FORMULATIONS C

VOLUME (ML)	INGREDIENTS
100.0	Black plum (extract)
50.0	Methanol
36.0	Nitrocellulose thinner (vehicle)
10.0	Paraffin wax
4.0	Water
	Oleic acid (trace)
	Cobalt II Chloride (trace)
200.0	



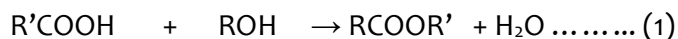
Table 4: FORMULATIONS D

VOLUME (ML)	INGREDIENTS
70.0	Black plum (extract)
60.0	Methanol
40.0	Nitrocellulose thinner (vehicle)
20.0	Paraffin wax
10.0	Water
	Cobalt II Chloride (trace)
200.	

Table 5: FORMULATIONS E

VOLUME (ML)	INGREDIENTS
110.0	Black plum (extract)
50.0	Methanol
24.0	Nitrocellulose thinner (vehicle)
10.0	Paraffin wax
6.0	Water
	Oleic acid (trace)
200.0	

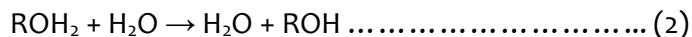
Mixing of black extract and an alcohol is a typical esterification reaction (reaction between organic acid and alcohol). The reaction equation is given below;



Black extracts → methanol → methyl → water

Organic acid alcohol methanol ester

The reaction (i.e., esterification) as shown is due to the formation of water by reducing the number of available hydrogen ions e.g.



The RCO- is the group derived from the acid and -OR is the group derived from alkanol.

To achieve this, 90.0 mls of black extract was poured to an empty beaker and an equal amount of methanol (90.0 mls) from a measuring cylinder was then added to it drop wise and the beaker was stirred after which esterification process was allowed to take effect for twenty (20) minutes until a characteristic smell of ester was recorded at



20°C. Thereafter, 18.0mls of nitrocellulose thinner (vehicle) was added in the same manner as above, then 2.0ml of water was added, oleic acid and cobalt chloride was also added in trace quantity and it was stirred thoroughly. Little coagulation was observed which was sieved, the extract was then heated moderately to 78°C after which it was allowed to cool and then covered tightly in a bottle container.

In formulations B to E, paraffin was dissolved in nitrocellulose thinner. Black extract was then added drop wise and at the same stirred thoroughly, followed by the addition of methanol, oleic acid, cobalt II chloride and water in their correct proportions based on their respective formulations as shown on the tables given. Each time, coagulation occurred, it was sieved and the weight of each residue and that of the ink were recorded appropriately.

Quality test

These tests were done to compare the quality of the ink produced. Each test includes: Viscosity, pH, conductivity and rate of drying.

TESTS

FORMULATION A

PROPERTIES	VALUES
Viscosity (Ns/m ²)	4.5
pH	3.8
Conductivity	1100
Rate of drying	142.38

FORMULATION B

PROPERTIES	VALUES
Viscosity (Ns/m ²)	4.3
pH	3.7
Conductivity	1000
Rate of drying	4.680×10^{-3}

FORMULATION C

PROPERTIES	VALUES
Viscosity (Ns/m ²)	3.9
pH	3.5
Conductivity	850
Rate of drying	5.140×10^{-3}



FORMULATION D

PROPERTIES	VALUES
Viscosity (Ns/m ²)	3.4
pH	3.4
Conductivity	750
Rate of drying	6.120×10^{-3}

FORMULATION E

PROPERTIES	VALUES
Viscosity (Ns/m ²)	3.0
pH	3.0
Conductivity	600
Rate of drying	6.791×10^{-3}

RESULTS AND DISCUSSION

RESULT

Table 1: Results obtained from ink formulations

Ink formulation	Weight of ink (g)	Weight of residue (g)
A	142.3	15.58
B	149.54	24.88
C	147.28	31.08
D	137.6	28.40
E	149.60	20.00

Table 2: Summary of Result

Ink formulation	Viscosity	pH	Conductivity	Drying rate (g/cm ² , min)
Formulation A	4.5	3.8	1100	4.850×10^{-3}
Formulation B	4.3	3.7	1000	4.680×10^{-3}
Formulation C	3.9	3.5	860	5.140×10^{-3}
Formulation D	3.4	3.4	500	6.120×10^{-3}
Formulation E	3.0	3.0	600	6.791×10^{-3}

Table 3: Standard Properties of Printing Ink

PROPERTIES	VALUES
Viscosity (Ns/m ²)	10 - 300
pH	3.5 - 5.0
Conductivity	800 - 1500
Rate of drying (g/cm ² min)	4.50×10^{-3}



DISCUSSION OF RESULTS

In the cause of production, five different formulations were used and while mixing was carried out for each formulation, there were coagulations which were filtered and the values of the filtrates and residue are given in table 3.1 above.

From the results on table 2, the value of the drying rate of formulation A on cardboard was 4.85×10^{-3} , formulation B had 4.680×10^{-3} which falls within the standard range values when compared with the commercial printing ink, while formulations C, D and E had lower drying rates. This is as a result of the excess nitrocellulose thinner (vehicle) which had not been reacted with the black extract and due to its high volatility, it dried up the surface area of the ink quickly. From the different tests carried out, formulations A and B gave a better-quality ink when compared with the standard values of printing ink. However, the viscosities appeared to be very low when compared with standard and this can be attributed to the fact that liquid inks frequently undergo filtration to remove the dirt, coagulants and other impurities but the type of filter used can affect the final end properties of the ink, especially its viscosity, another problem which arises is the clogging of the filter, which builds up pressure in the ink (Smeriglio, et al., 2009). The components of inks serve many purposes; the inks carrier, colorants, and other additives affect the flow and thickness of the ink and its appearance when dry.

CONCLUSION AND RECOMENDATION

The present study, production of printing ink using black plum was carried out using five different formulations. The primary function of the manufacture of printing ink is the dispersion of the pigment (the solid portion) in the vehicle (the liquid portion). There are many characteristics which determine the quality of a printing ink and from the tests carried out formulation A compared favorably well to commercial printing ink with a drying rate of 4.5×10^{-3} g/cm².min i.e. It dries faster than the others. Thus, black plum is a viable source of natural pigment for potential use in eco-friendly ink production.

However, it is recommended that further studies be carried out on economic feasibility for large-scale production and stabilization techniques like encapsulation should be explored.

REFERENCES

- Colombe, D, Achille, E.A, Belarmain, F (2012). Retrieved from <https://www.Fruits.Journal.Org>.
- Ferreira, C.D., et al. (2022). Production of powdered anthocyanin colorant via spray drying of black plum extract. Food Bioproducts processing.



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- Fleming D. (1999). Flexographic Printing Department of Paper Engineering, Chemical Engineering and Imaging, Western Michigan University.
- Gorziza R.P., Carvalho, C.M.B., Kordonfor, R.S., Gonzalez, M. (2019). Blue and Black ballpoint pen inks. A systematic review for Ink Characterization and Data Analysis, 8, 113-138 <http://www.prota.org>
- Mei, J. (2004). Formulation and Processing of Conductive Inks for Ink Jet, M.S. Mechanical Engineering, Tsinghua University, Pittsburgh
- NIIR Board of Consultants & Engineers (2015). Modern Technology of Printing and Writing Inks (with Formulae & Processes) 2nd Revised Edition, Asia Pacific Business Press Inc. pg480
- Okigbo N.R. (2003). Fermentation of Black Plum (*Vitex Doniana* Sweet) Juice for Production of Wine. Fruits 58 (6), 363-369
- Purnamasari, R., et al. (2021). Co-pigmentation of jamblang fruit anthocyanins with alum and acetic acid. IOP Conference Series: Earth and Environmental Science.
- Senefelder, A. (1996). Printing Processes and Printing inks, IARC Monogr.Eval. Carcinog. Risks to Humans 65, 33 – 147
- Shahid, M., & Mohammed, F. (2025). Green extraction and characterization of anthocyanin from *Syzgium cumini* for natural dye and ink application. Journal of Cleaner Production.
- Smeriglio, A, et al., (2009). Chemical studies of anthocyanins: A review. Food Chemistry.
- Usher G. (1974). A dictionary of Plants Used by Man. Constable ISBN 0094579202