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An Explorative Investigation of the Application of *Cissus Populnea* (Dafara) Powder as an Admixture in Concrete Production

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ABSTRACT
This research was aimed at investigating the behavior of concrete made with powder extracted from bark of cissus populnea (dafara) as an admixture. To achieve this, the chemical properties of the extract, workability, compressive and flexural strength test of the concrete produced were conducted. A mix of 1:2:4 was adopted with the addition of 0.2%, 0.3%, 0.4% and 0.5% of cissus populnea to mass of the cement as admixture in the concrete. The samples subjected to compressive strength test after 3, 7, 21 and 28 curing days. Water absorption test on cubes and flexural strength test at 28 days of curing was carried out on concrete beams. From the chemical analysis of the admixture cissus populnea, its SiO_2 *and* Fe_2O_3 *content were 1.65 and 0.91 addition to mass of cement content, this were in excess of the requirement, however this contributed to strength development and prolong setting time while excess* AlO_3*, CaO and MgO content were 4.59, 5.77 and 2.44 respectively, this contribute negatively to strength development in concrete. Dafara also act as retarder by delaying or slowing the initial setting rate of concrete. It was also found that the average strength of concrete produced with 0.2% cissus populnea powder which is the optimum dosage gave a strength higher than the control mix and also attained the minimum strength required at 28days by the BS1881 (1983b) part 116 which is 21N/mm*^{2}*, with the highest flexural strength of 5.17N/mm*^{2}*, water absorption at 4.79 percent, a slump of 12 mm and compacting factor of 0.93, which is medium workability. Base on the results and observations, dafara powder can be regarded as a retarder which equally checks segregation and bleeding in concrete.*
Keywords: *Explorative, Investigation, Cissus populnea, Admixture, Concrete*

INTRODUCTION
Concrete is a major component of most of our infrastructural facilities today, because of its abundance and versatility in use. Concrete is a very strong and versatile moldable construction material. It is used more than any other man-made material in the world (Anosike, 2011). Anosike (2011) further explained that as of 2006, about 7.5 cubic kilometers of concrete were made each year, more than one cubic meter for every person on earth. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year and humans consume no material except water in such a tremendous quantity, (Montero and methta, 2012). It is a manmade building material that looks like stone. The word concrete comes from the Latin word concretus (meaning compact or condensed), the past participle of concresco, from com- (together) and cresco (to grow), meaning "to grow together." Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in hard matrix material (the cement or binder), that fills the space among the aggregate particles and glues them together (Li,2011). Admixtures are commonly use in modern practice to alter the characteristics of concrete to achieve an aim, thus have become an essential component of contemporary concrete. An admixture is defined as a material other than water, aggregates, cement, and reinforcing fibers that is used in concrete as an ingredient, and added to the batch immediately before or during mixing. Neville (2011) defined chemical *admixture* as materials in the form of

powder or fluids that are added to concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement and are added to the concrete at the time of batching/mixing (Neville, 2011).

The admixture, Cissus populnea is a plant 2 to 3m high semi-climber which grows in the savannah and is widely distributed in Senegal, Sudan, Uganda, Abyssinia and Nigeria. (Hutchinson and Dalzie, 1958). It is commonly known as 'Okoho' by the Idomas, Igbo and Igala tribes of Nigeria, 'Dafara' (Kano, Zaria); Latutuwa (Katsina) by the Hausa language of the indicated towns of northern Nigeria (Gbile, 1980); 'Ajara' or 'Orogbolo' by the Yoruba tribes of northern and southern Nigeria. Economically, the fruits are edible in soups. The stem bark is also used in preparation of soup and other foods as bean cake. The roots or stem are used in building (Irvine,1961). Other work on Cissus populnea shows that it is being used to treat many ailments locally, such as venereal, stomach and skin infections, and also use as laxative or purgative. Economically it has been used as binder in food and in lining dye pits (Ibrahim, Madau, Ahmed, and Liyas, 2011). Also Owuno, Eke-Ejiofor and Wordu (2012) worked on the stem of cissus populnea plant and evaluated the viscosity of the Gum, this was used as additive in wheat-cassava bread, and the viscosity in Pascal was 0.46 for the gum. Over the years Cissus populnea has been used locally as a binder in mud plaster in Bachi District of Riyom Local Government Area of Plateau State.

MATERIALS AND METHODS

This study intended to assess the viability, workability, compressive strength and flexural strength of concrete made when powdered extracted from the back of cissus populnea is used as an admixture in concrete production.

MATERIALS

The materials used for this project work include cement, fine aggregate (sand) coarse aggregate (gravel), powder extracted from the back of dafara and water.

Cement

The cement type used for this project is Dangote cement of ordinary Portland cement (OPC), grade 42.5, manufactured by Dangote Cement factory, which conforms to Type 1 cement as specified by BS 12 (1978).The cement used was obtained from the open market at Katako. Cement is a binder, a substance which sets and hardens independently and can bind materials together (Neville, 2011).

Fine Aggregate

The fine aggregate used in the research was sand, with well graded spherical shape and low absorption. This was obtained locally from sabon gida river in Zawang Jos south L.G.A and conduct the sieve analysis before use, the sieve size of 4.75mm was used. The fine aggregate also used had a fineness modulus (FM) of 1.61, a specific gravity of 2.65, average bulk density for uncompacted of 1420kg/m^3, for compacted is 1510kg/m^3 and a percentage of voids of 5.2%.

Dafara Powder

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The admixture used in this research is powder extracted from stem of cissus populnea which was collected from Shonong village of Bachi district of Riyom L.G.A in plateau state where it is in abundance. The stems were cut, pilled as shown in Plate 4 and sundried for eight (8) days before it was pulverize to powder at Nigerian Mining Corporation (NMC) Jos, by their pulverizing machine. The chemical analysis of the admixture was equally carried out at NMC, result presented in chapter 4 in tabular form. The pulverize powder was used as an admixture to the concrete in a percentage ranging from 0.2% to 0.5% weight of cement.

Water

Water fit for drinking was used to mix the concrete components.

Mix Proportioning

Mix proportioning for concrete is the process of selecting suitable constituents for concrete and determining their relative quantities.
In achieving this, mix ratio (Batching by weight) of 1:2:4 and a water-cement ratio of 0.5 was used.

Test Sample

A total of 75 cubes and 15 beams were cast for the purpose of this study. The cubes were removed from the mould after 48hrs and then immersed in water for the period of curing as the setting of the concrete was delayed by the addition of the admixture. All cubes cast were labeled before curing for identification during crushing.

Test Procedures

Compressive Strength Test

Cubes to be crushed were removed from the curing tank, surface dried and were placed with the smooth faces in contact with the lower and upper plate of the crushing machine. The load was then applied slowly until the cube failed, the loads at failure were recorded..The compressive strength was now calculated by dividing the failure load by the surface area of the cube.

$$\text{I.e. compressive strength} = \frac{\text{Load at failure (N)}}{\text{Surface area (mm}^2\text{)}}$$

Cube Density Test

The cube whose densities were to be determined were placed individually on the weighing balance and the weight of each recorded to calculate the density. The weight of the cube is then divided by its volume.

$$\text{Density} = \frac{\text{mass (kg)}}{\text{Volume (m}^2\text{)}}$$

Flexural Test

Beams were tested using symmetrical two-point loading until failure occurs because the load points are spaced at one third of the span. The test is called a third-point loading test. The theoretical maximum tensile stress reached on the bottom fiber of the test beam is known as the modulus of rapture and is thus equal to:

$PL/(bd^2)$

Were p = maximum total load on the beam
L = span
b = height of the beam
d = depth of the beam

Measurement of Workability

There are many tests for workability, the most important being the slump test and compacting factor test. Other known methods are flow table, V-B consistometer, power apparatus, but only the slump and compaction factor test were used for this study.

The Slump Test

The slump test is prescribed BS 1881: 103:1993. The mould for the test is a frustum of a cone, 300mm high. It is place on a horizontal smooth surface with the smaller opening at the top and then filled with concrete in three layers, each layer is tapped 25 times with a standard 16mm diameter steel rod rounded at the end, the mould was firmly held against its base during the entire operation. The surface is then leveled off and the cone lifted vertically allowing the unsupported concrete to settle or collapse. The difference between the original and final height represents the slump of the mix.

Compacting Factor Test

The upper hopper is filled with concrete gently so that no work is done on the concrete to produce compaction. The bottom door of the upper hopper is then released and the concrete falls into the lower hopper, this is smaller than the upper one and is therefore filled to overflowing. The bottom door of the lower hopper is then released and the concrete falls into the cylinder. Excess concrete is cut off by two floats slid across the top of the mould and the net mass of concrete is then determined by weighing. The density of the concrete in the cylinder is now calculated:

$$\text{Compaction factor} = \frac{\text{Density of free fall concrete}}{\text{Density of fully compacted concrete}}$$

Density of fully compacted concrete is gotten by filling the cylinder with concrete in four layers, each tapped or vibrated.

WATER ABSORPTION TEST

Water absorption test is a test to determine the amount of water absorbed by the concrete cubes, this was done according to BS 1881-122:2011.

Water absorption was then expressed as increase in weight percentage, that is:

$$\text{Water Absorption, \%} = \frac{Wet\ Weight - Dry\ Weight}{Dry\ Weight}\ x\ 100$$

PRESENTATION AND DISCUSSION OF RESULTS

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Chemical Constitunts

Table 1: Chemical Constituents of cissus populnea (Dafara) powder

Constituent Percentage (%)	Plant extract
SiO_2	1.65
Al_2O_3	4.59
Fe_2O_3	0.91
TiO_2	N.D
CaO	5.77
MgO	2.44
LOI	82.80

Workability

Table 2: Workability of Concrete with Cisus Populnea Powder (Slump and Compacting Factor Test) using water-cement ratio of 0.5

Percentages (%)	Slump (mm)	Degree of Workability	Compacting Factor	Degree of Workability
Control Mix (0)	11	Very Low	0.91	Low
0.2/CP	12	Very Low	0.93	Medium
0.3CP	8	Very Low	0.90	Low
0.4CP	6	Very Low	0.91	Low
0.5CP	5	Very Low	0.9	Low

A dosage of 0.2% of the admixture is the optimum dosage required as it provided medium workability for the concrete as shown in the table above.

DENSITY OF CUBES

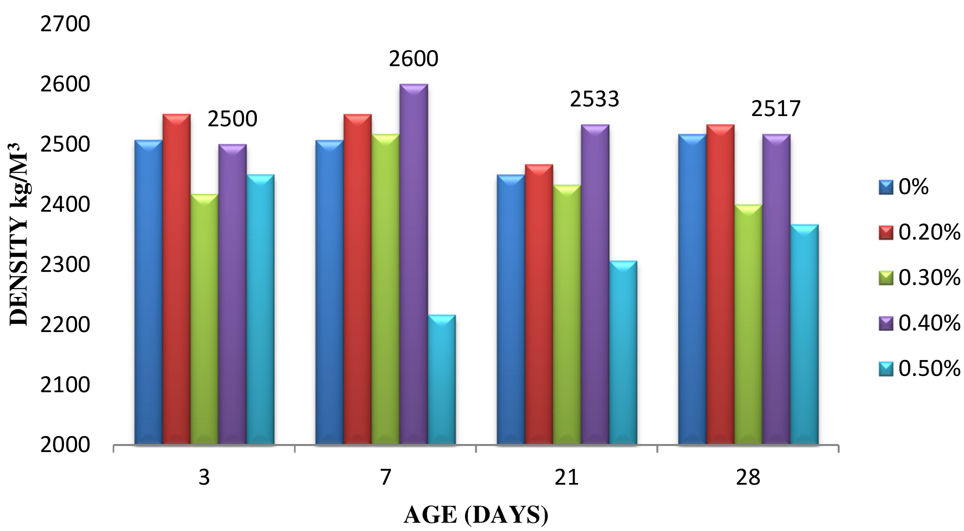

Figure 1: Variation of Cube Density against hydration period

In relating the density values obtain to the compressive strength at 28days which are 2517, 2533, 2400, 2517 and 2367kg/m^3 for 25.17 N/mm^3, 25.5 N/mm^3, 21.33 N/mm^3, 20.00N/mm^3 and 17.83N/mm^3 shows strength increases with density, except for thr 0.4 percentage cissus populnea dosage which had a high density but low compressive strength compared to others.

COMPRESSIVE STRENGTH OF CUBES

Table 3: Result of Compressive Test of Cubes.

AGE DAYS	STRENGTH (N/MM²)		ADDITION PERCENTAGE (%)							
		0		**0.2**		**0.3**		**0.4**		**0.5**
	16.00		16.5		13.50		14.00		13.50	
	15.50		14.50		11.50		13.50		14.00	
3	15.50	**15.67**	14.00	**15.02**	14.00	**14.17**	14.5	**14.00**	14.00	**13.83**
	18.00		17.00		2.60		16.50		15.00	
	18.50		16.50		2.45		14.50		14.00	
7	17.50	**18.00**	17.00	**16.83**	2.50	**16.33**	15.00	**15.33**	13.50	**14.17**
	19.50		21.00		19.00		18.0		16.50	
	20.50		20.50		20.00		17.0		17.00	
21	20.00	**20.00**	21.00	**20.80**	20.50	**19.80**	17.5	**17.50**	16.50	**16.67**
	25.0		26.00		20.50		19.50		17.00	
	25.50		25.00		21.50		20.00		18.00	
28	24.00	**25.17**	25.50	**25.50**	22.0	**21.33**	20.50	**20.00**	18.50	**17.83**

The table above shows that the increase in compressive strength over time was not linear across mixes and over individual mix. However, the rate of increase in strength increased slightly with hydration period over a particular mix. The ratio of 7 to 3 days and 28 to 21 days strength were 1.15 and 1.26 for the control mix and 1.12 and 1.23, 1.15 and 1.08, 1.10 and 1.14, 1.02 and 1.07 for the 0.2, 0.3, 0.4 and 0.5 percentage addition of cissus populnea respectively. It was observed that the rate of strength gain on ratio basis was greater for the control concrete than for the concrete containing dafara powder addition. Considering the ratio of 7 to 3 days and 28 to 21 days strength were 1.15 and 1.26 and 1.12 and 1.23 for the 0% and 0.2% cissus populnea respectively shows that plain concrete has higher values. However, considering the strength attained after 28days of hydration where the plain concrete is 25.17 N/mm2 and 0.2% addition of dafara powder attained 25.5N/mm2, this phenomenon was only exhibited by the 0.2% addition. However, looking at 7 to 3 hydration period, it is observed that, the control sample had a higher strength gain than the sample with dafara powder addition, that is 15.67 as against 15.02, 14.17, 14.00 and 13.83N/mm2 for 0, 0.2, 0.3, 0.4 and 0.5 percentage addition of cissus populnea (dafara) powder. This is viewed as the result of retarding nature of the dafara powder from initial setting as also

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noticed during demoulding and pilot test were much quantity of about 1.2% addition of dafara, keep the concrete wet for a longer period than the plain concrete.

DENSITY OF BEAMS

Table 4: Result of Density of Beams at 28 days

Density (kg/m³)	percentage (%) of Addition								
0		0.2		0.3		0.4		0.5	
2,570		2,520		2,510		2,400		2,440	
2,440		2,480		5,580		2,510		2,320	
2,540	**2,517**	2,500	**2,500**	2,545	**2,540**	2,475	**2,475**	2,800	**2,380**

A comparison of the density to the flexural strength obtain as present shows that density obtained decreased with decrease in flexural strength except for the 0.3% dosage

FLEXURAL STRENGTH OF BEAMS

Table 5: Result of Flexural strength of Beams taken at 28 days.

Strength (N/mm²)	percentage (%) of Addition								
0		0.2		0.3		0.4		0.5	
5		5.5		4		4		3.5	
4.5		4.5		4		4		3.5	
5.5	**5.0**	5.5	**5.17**	3.75	**3.92**	3.5	**3.83**	3.7	**3.58**

The values of flexural strength tests as extracted from the table above were 5.0, 5.17, 3.92, 3.83 and 3.58 for 0, 0.2, 0.3, 0.4, and 0.5 percentage of dafara powder addition to the concrete for water/cement ratios of 0.5 respectively. These results were for the 1:2:4 mix for the 28 days hydration period. The result shows a decrease in flexural strength with increase in dosage of cissus populnea powder.

WATER ABSORPTION OF CUBES

Table 6: Result of Water Absorption Test on Cubes at 28 days.

Water absorption (%)	percentage (%) of Addition								
0		0.2		0.3		0.4		0.5	
4.65		6.63		5.61		6.75		5.82	
4.78		6.68		5.20		6.90		5.40	
4.79	**4.74**	6.70	**4.79**	5.78	**5.41**	6.78	**5.53**	5.01	**6.81**

The results above show that concrete with admixture of cissus populnea has higher percentage of water absorption (4.77, 5.41, 5.53 and 6.8 percent) for 0.2, 0.3, 0.4 and 0.5 percentage addition of admixture than the controlled sample with 4.74 percentage of water absorption.

SUMMARY

The retarding nature (prolong setting time) which keep the admixture concrete workable for longer than the plain concrete is the effect of excess of SiO_2 in the concrete. The loss in strength as observed with higher addition of the admixture is as a result of the combined effect of AlO_3, CaO, and MgO.From the early strength development of the compressive strength test, chemical analysis, demoulding and physical observation of the effect of the power on concrete, it can be concluded that cissus populnea behaves a retarder as it delayed the setting time of the concrete for a longer period than the plain concrete.

The admixture cissus populnea helped to check segregation and bleeding in concrete, by absorbing excess water from the mix.

CONCLUSION

Based on the test results, analysis and observation carried out, the following conclusions were drawn: The physical properties revealed that the dafara powder can be used to check segregation and bleeding in concrete. This is advantageous when pumping concrete. The Cissus populnea powder delayed the initial setting time of the concrete as observed during demoulding and during the pilot test. It thus can be used to counteract the accelerating effect of hot weather on concrete were high temperature often causes an increased rate of hardening. In order words the admixture is useful in concreting in hot weather when the normal setting time is shortened by the higher temperature and in preventing cold joint formation. The optimum dosage as seen from this study is 0.2% as the concrete developed a higher strength than the plain concrete used as control. Hence, it can be used to improve concrete quality. From the chemical properties revealed, SiO_2 and FeO_3 in excess contributes to strength development and prolong setting time, while excess of AlO_3, CaO and MgO contributes negatively to strength development when added to ordinary Portland cement (OPC) Concrete.

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