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Viscometric study on the Hydrocolloids of Brachystegia eurycoma and Detarium microcarpum at varying temperature for use as stabilizers, binders and thickeners

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Abstract— *Brachystegia eurycoma (achi) and Detarium microcarpum (ofor) are leguminous plants and their seed powder forms hydrocolloids with water and these hydrocolloids are widely used in Nigeria as soup thickeners, paint emulsifiers, material and tablet binders. They also have medicinal uses when ingested such as the reduction of blood cholesterol, diabetes, treatment of tuberculosis, meningitis, diarrhea etc. These applications of Brachystegia eurycoma and Detarium microcarpum hydrocolloids are related to their respective viscosity at different temperatures. Despite the numerous application of these hydrocolloids from the seed powder of these leguminous plant, little is known on how the viscosities of the hydrocolloids changes with varying temperature and how it affects the thickening, binding and emulsifying properties of the seed powders when used. This research work varied the viscosities of the hydrocolloids of these powders at temperature range (40 ^{o}C, 50 ^{o}C, 60 ^{o}C, 70 ^{o}C, 80 ^{o}C, 90 ^{o}C & 100 ^{o}C) and also determined their gelatinization temperature, swelling index and bulk density which indicated what powder functions better as thickener, binder and emulsifier. From the experiment carried out, the viscosities of the hydrocolloids increases with increasing temperature and Detarium microcarpum had higher viscosities compared to Brachystegia eurycoma at the temperature ranges. Detarium microcarpum also had higher peak gelatinization temperature of 65 ^{o}C and swelling index of 5.32 compared to Brachystegia eurycoma. The high gelatinization temperature shows that starch in Detarium microcarpum seed powder resist gelatinization compared to Brachystegia eurycoma and the high swelling index accounts for the high viscosity recorded in Detarium microcarpum compared to Brachystegia eurycoma at the same temperature range. At temperature above 100 ^{o}C gel is formed on both hydrocolloids. The formation of gel is faster in Detarium microcarpum compared to Brachystegia eurycoma which shows that there is high degree of dissociation of the double helices in the crystalline regions of Detarium microcarpum powder hydrocolloid and expansion of its granules compared to Brachystegia eurycoma as their polymer hydrates. The formation of gel is also influenced by air, quantity of powder and water used. Thus the seed powder of Detarium microcarpum is a better choice for use as thickener, binder and as an emulsifier varying temperature range.*

Keywords— Brachystegia eurycoma and Detarium microcarpum; seed powder; Hydrocolloid; Viscosity; Gelatinization and swelling index

1. INTRODUCTION

Brachystegia eurycoma and Detarium microcarpum also known as achi and ofor respectively in Igbo language in Nigerian are both leguminous plants belonging to family caesalpiniceae, phylum spermatophyte and order of fabaceae. Their fruit seed powder forms viscous dispersion in water also known as hydrocolloids. Hydrocolloid is a colloid system made up of colloid particles that forms hydrophilic polymers when dispersed in water. In Nigeria the hydrocolloids of Brachystegia eurycoma and Detarium microcarpum are heated or their powder dispersed in heated water as soup thickeners, material and tablet binders and also as emulsion stabilizers. Research have also shown that the hydrocolloid forms of these leguminous plants when taken as drink or food, function as soluble fibre in human body and helps in the reduction of blood cholesterol levels and diabetics [1]. They are also used as an alternative to fat, sugar and functions as gelatinization substances [2] [3].

The fruit of Brachystegia eurycoma is dark and purplish brown in colour and contains flats seed. The seed are known to be rich in protein (9%), carbohydrate (56%), crude fat (15%), crude fiber (2.9%) and ash (4.5%) [4][5], it is also known to contain bioactive compounds such as flavonoids, alkaloids, phenolic compounds, saponins and tannins as reported by Uhegbu [5].

The fruit of Detarium microcarpum is fleshy and edible and its seed is known to contain flavonoids, steroidal saponins which are antimicrobial agents [6]. Its roots and barks are found to have medicinal applications such as in the treatment of diseases such as tuberculosis, meningitis, diarrhea and itches [7].

In the southern part of Nigeria, the powders obtained from the seeds of Brachystegia eurycoma and Detarium microcarpum are often used by families as soup thickeners because of their availability, nutritional and medicinal importance. And some aside using it as soup thickener also use it as tablet binders and as emulsifier in paint production. Despite their availability and applications, little is known about the viscosity of these seed powders hydrocolloids when in use and how varying temperature affects its application mostly as soup thickeners and as binding agents. Although various research work have been carried out on Brachystegia eurycoma and Detarium microcarpum, but the research have been focused on the proximate, physic-chemical and rheology properties of Brachystegia eurycoma [8-10] and Detarium microcarpum [11] [5] [12].The viscosity of the hydrocolloids of the seed powders of Brachystegia eurycoma and Detarium microcarpum gives us information about the quality and particular type of starch in the hydrocolloids and these gives an insight on the stability of the paste formed from these seed powders and it also indicates the ability of the seed powders to form viscous paste or gel after cooling which are essential for use as stabilizers and binders.

This research work looks at studying the effect of changing temperatures on the viscosity of the hydrocolloids of Brachystegia eurycoma and Detarium microcarpum, and their point of gelatinization, swelling index and wettability which relates to their thickening, binding, and emulsifying ability. This work will give users of the powder of Brachystegia eurycoma and Detarium microcarpum insight on the best temperature for use of their powders as soup thickeners, stabilizers and binders.

2. MATERIALS AND METHOD

2.1 Determination of viscosity

The viscosity of Brachystegia eurycoma and Detarium microcarpum was carried out by measuring 20 and 40 grams of their respective powders and added to 100 ml of distilled water in a 200ml beaker and stirred for 2 hours at room temperature. The duration of 2 hours allowed for the formation of homogeneous hydrocolloid solution. The corresponding viscosity of the hydrocolloids where measured in millipascal seconds (mpa.s) using Amatek Brookfield DV-E viscometer at temperature 40-100^{o}C and spindle number of 3.

2.2 Determination of gelatinization point

The determination of gelatinization temperature/point of Brachystegia eurycoma and Detarium microcarpum followed similar procedure adopted by Onwuka [13]. Briefly 10 grams of Brachystegia eurycoma and Detarium microcarpum respectively where dispersed in 100 ml of distilled water in a 200 ml beaker and stirred with a magnetic stirrer. The mixture was heated and a digital thermometer placed in the beaker held by a standing clip to measure the gelatinization point of Brachystegia eurycoma and Detarium microcarpum respectively. .

2.3 Determination of bulk density

The bulk density of Brachystegia eurycoma and Detarium microcarpum were also determined following similar procedure adopted by Onwuka [13]. Two empty10 ml graduated cylinder was weighed and then filled with powders of Brachystegia eurycoma and Detarium microcarpum respectively to the 10 ml mark without diminution of the powders. The corresponding weight of the cylinder and powder content measured. The equation below was applied for calculating the bulk density.

$$\text{Bulk density} = \frac{\text{weight of sample (g)}}{\text{Volume of sample (ml)}}$$

2.4 Swelling index

The swelling index of Brachystegia eurycoma and Detarium microcarpum were determined following similar procedure adopted by Onwuka [13]. The process involves leveling 1g of their powders respectively in 50 ml cylinder and adding 10 ml of distilled water. The mixtures is stirred and allowed to stand for 60 minutes to observe the change in volume of the mixture every 15 minutes. The swelling power of the sample is calculated as the multiple of the original volume.

2.5 Wettability

The wettability of the samples is a measure of how long it takes the sample to completely wet. The wettability of Brachystegia eurycoma and Detarium microcarpum were determined using the method adopted by Onwuka [13].

3. RESULT AND DISCUSSION

Table 1 and 2 shows how the viscosity of Brachystegia eurycoma and Detarium microcarpum changes with varying temperature for two different mass of sample (20 and 40 grams). The result showed that the viscosity of both Brachystegia eurycoma and Detarium microcarpum increases with increasing temperatures and at higher temperature, no significant change in viscosity is observed. The change in viscosity is affected by the quantity of powder used and the amount of water added to form hydrocolloids such that the higher the amount of water added to the powder, the lower the viscosity and the higher the quantity of powder added the higher the viscosity as shown in table 1 and 2 for 20 and 40 grams respectively. Detarium microcarpum had higher viscosity under the same condition compared to Brachystegia eurycoma at the varying temperature ranges. This might be due to the swelling index of Detarium microcarpum which is higher than that of Brachystegia eurycoma. The swelling index indicates the water absorption index of the powder during heating which is also a measure of the particular quality of carbohydrate present in the powder. At temperature above 100 ^{o}C, they form solid (gel). The formation of gel is influenced by air such that when exposed to air they easily solidify. Detarium microcarpum solidifies faster than Brachystegia eurycoma in the presence of air and the gel of Brachystegia eurycoma is found to be slimy.

Table 1: Viscosity of Detarium microcarpum at weight 20 and 40 gram

Sample mass (g)	Temperature (^{o}C)	RPM	Viscosity (mPa.s)
20	0	30	36.40
	40	30	418.6
	50	30	536.9
	60	30	1138.0
	70	30	3640
	80	30	3686
	90	30	3731
	100	30	3738
40	0	30	54.60
	40	30	620
	50	30	816
	60	30	1125
	70	30	7221
	80	30	7295
	90	30	7340
	100	30	7345

Table 2: Viscosities of Brachystegia eurycoma at weight 20 and 40 grams

Sample mass (g)	Temperature (^{o}C)	RPM	Viscosity (mPa.s)
20	0	30	409.5
	40	30	418.6
	50	30	436.8
	60	30	464.1
	70	30	526.4
	80	30	630.3
	90	30	636.3
	100	30	640.5
40	0	30	510.1
	40	30	520.3
	50	30	579.5
	60	30	592.3
	70	30	734.3
	80	30	795.8
	90	30	810.3
	100	30	816.2

Table 3, shows some of the functional properties of Brachystegia eurycoma and Detarium microcarpum which affects the viscosity of their powders. From table 3 it was observed that Brachystegia eurycoma and Detarium microcarpum have similar initial gelatinization temperature of 40^{o}C, which indicates that both powders of Brachystegia eurycoma and Detarium microcarpum have stable granule structure at varying temperature and orderly granule starch structure and thus, their resistance to gelatinization. But Detarium microcarpum had a higher peak gelatinization temperature of 65^{o}C which shows that it had more resistance to gelatinization which is as a result of the interaction between the starch in Detarium microcarpum and the other constituent in the powder compared to Brachystegia eurycoma. Research have shown that heating the powders of Brachystegia eurycoma and Detarium microcarpum converts their starch content to a semi-crystalline form and later to amorphous form. This process involves hydrating the amorphous region and mobility of amorphous region resulting in reversible swelling and this reversible swelling causes dissociation of the double helices in the crystalline regions and expansion of the granules as the polymer hydrates [14]. This also allows for the powders to disperse homogeneously in liquid at varying temperatures as observed in cooking process. Figure 1 (a) and (b) shows the powdered Detarium microcarpum and Brachystegia eurycoma and their gels (c) and (d) after experiment respectively.

Fig. 1: Powdered Detarium microcarpum (a) and Brachystegia eurycoma (b) and their gels (c) and (d) respectively

Table 3 also showed that Detarium microcarpum had higher bulk density and swelling index than Brachystegia eurycoma which also accounts for the high viscosity recorded for Detarium microcarpum compared to Brachystegia eurycoma using the same quantity of sample and water under the same temperature. Although Brachystegia eurycoma had higher wettability value of 45 min, 10 seconds compared to Detarium microcarpum (50 min, 2 seconds,), this does not really affects the viscosity measurement because both samples where well agitated for a long time for homogeneous colloid to form before viscosity measurements.

Table 3: Functional properties of Brachystegia eurycoma and Detarium microcarpum measured

Functional Properties	Brachystegia eurycoma (defatted)	Detarium microcarpum (defatted)
Bulk density	0.83 (g/ml)	0.94 (g/ml)
Gelatinization point	40 (^{o}C) and peak 45 (^{o}C)	40 (^{o}C) and peak 65 (^{o}C)
Swelling index	3.65	5.32
Wettability (min)	45 min, 10 sec	50 min, 2 sec

4. CONCLUSION

In conclusion it was observed that the viscosities of the hydrocolloids of powders of Brachystegia eurycoma and Detarium microcarpum increases with increasing temperature with Detarium microcarpum having higher viscosities compared to Brachystegia eurycoma. At temperature above 100^{o}C gel is formed on both hydrocolloids. The formation of gel is faster in Detarium microcarpum compared to Brachystegia eurycoma indicating high expansion of the granules of Detarium microcarpum as their polymer hydrates. The gel formation is influenced by air, quantity of powder and water used. Detarium microcarpum had higher peak gelatinization temperature of 65^{o}C and swelling index of 5.32 compared to the Brachystegia eurycoma. Indicating it resisted gelatinization due to the type of starch in it and the high swelling index and bulk density of Detarium microcarpum also accounts for the high viscosity recorded compared to Brachystegia eurycoma at the same temperature range. In general Detarium microcarpum will perform better as a thickener, binder and as an emulsifier at the varying temperature range compared to Brachystegia eurycoma.

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Author's picture should be in grayscale.

Picture size should be absolute 3.18cm in height and absolute 2.65cm in width

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