

Full Length Research Paper

Evaluation of the effect of ginger modified cassava starch as thickener in the formulation of water based paint

Udonne J. D* and Obiokwu A. C.

Department of Chemical and Polymer Engineering, Lagos State University, Lagos, Nigeria.

Accepted 22 April, 2013

Raw cassava starch has been used as thickener and binder in the formulation of water based paint, but with a problem of loss of viscosity in a very short period. This study evaluates the modification of cassava starch using active component of ginger extract and its use as a water- based paint thickener. 150 g of starch in 200 mL of water was modified using different concentrations (1, 5, 10, 20, 30, 40, 50 and 60 g) of active components of ginger root and the intrinsic viscosity of the modified starch was investigated. The modified starch was used as thickener in the formulation of water based paint and the results were compared with those of paint produced using unmodified starch and commercial thickener. The Intrinsic viscosities of ginger modified starch (0.2 to 0.4 cp) are greater than that of unmodified starch (0.1 cp). Ginger modified starch also showed high swelling power (9.4 to 14.3) compared to unmodified starch with low swelling power (9.1). It was noticed that preparing of the thicker in its viscoelastic stage gives the best thickening agent and that the samples modified with 10, 20, 30 and 40 g of ginger root were best for thickening agent in the formulation of water based paint.

Key words: Active component of ginger, cassava starch, intrinsic viscosity, swelling power, starch preparation, paint formulation.

INTRODUCTION

Unmodified starch has been used in the formulation of water based adhesive, where it measures both as thickener and binder. Combinations of materials like acrylic, bentonite and starch have also served as a thickener in water based coating (emulsion paint) (Van der et al., 1989).

The scope of starch application is both enhanced and limited by its unique molecular structure. For instance, the compact arrangements of molecules in the crystalline regions inhibit water or chemical reagents from making contact with the molecules in the crystalline region. As a result, the gelatinization temperature is higher and chemical reactivity of starch is decreased. Meanwhile, the relative large molecular mass and the extensive network formed

by hydrogen bonds lead to high gelatinization temperature and lower fluidity. For many purposes, the market prefers starch with less extensive crystalline regions, resulting in improved physico-chemical properties and increased reactivity for planned applications. Therefore, there is great interest in methods to modify the structure in the crystalline region, or decrease the size of crystalline regions (Fiedorowicz et al., 2001; Liang et al., 2004). The main methods of decreasing starch crystalline regularity include chemical processes, such chemical treatment as acidolysis (Nakazawa et al., 2003), oxidation (Wang et al., 2003), enzymatic degradation processes (Zhang et al., 1999), radioactive degradation (Bertolini et al., 2001) and heat- moisture treatment (Gunaratne and

*Corresponding author. E-mail: udonne.joseph@gmail.com.

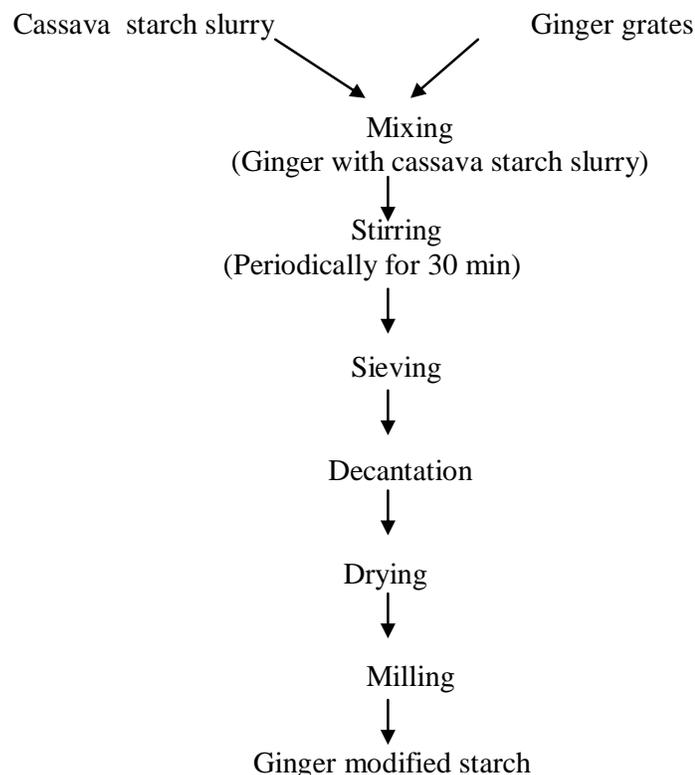


Figure 1. Flow chart for the preparation of ginger modified cassava starch.

Hoover, 2002).

MATERIALS AND METHODS

Cassava roots with low cyanide content and high yield aged 13 months at harvest were obtained from one of the farms in the premises of metallurgical training institute Onitsha. Ginger was purchased from Ose market in Onitsha. All the chemicals used in the formulation of the paint were for industrial purposes.

Preparation of cassava starch

Native cassava starch extraction was carried out using a method described by Benesi (2005) with a little modification for larger quantity. 2 kg of the fleshy tuberous cassava roots were washed, peeled, crushed and homogenized with 2 L of 1 mol L⁻¹ NaCl solution to aid the release of starch. The mixture was then stirred with a stirring rod for 2 min and filtered using a muslin cloth. The filtrate was allowed to stand for 1 h to facilitate starch sedimentation and the top was decanted and discarded. The starch was washed with 2 l of distilled water and allowed to settle for 1 h for three consecutive times. The starch was air dried at room temperature in an aluminum pan for two days and stored in plastic air tight container (Benesi, 2005).

Preparation of ginger modified cassava starch

Cassava Starch was modified with ginger grates at concentration of 1, 5, 10, 20, 30, 40, 50 and 60 g following the method of Daramola

and Osanyinlusi (2006) with a little modification. Ginger roots were cleaned, peeled and grated. Starch-water suspension (150 g of starch in 200 mL) was prepared. The ginger grates were mixed with starch-water suspension and stirred periodically for 30 min at room temperature, followed by sieving out ginger grates to obtain the starch milk. The starch milk obtained was then washed with distilled water and dried at room temperature for three days. The starch was milled into powder and packaged for subsequent analysis. Figure 1 shows the flow chart for the preparation of ginger modified cassava starch.

Methods of analysis

Determination of proximate composition

AOAC (1980) was used to determine the moisture content, total ash content, protein and crude fat of the samples. Carbohydrate was obtained by difference. All results were the average of duplicate analyses.

Determination of swelling power

A sample of 1 g was weighed into a weighed test tube into which 50 mL of distilled water was added and heated in a water bath at temperature of 60°C for 30 min. This was continually shaken within the heating period. At the end, the test-tube was centrifuged for 15 min in order to facilitate the removal of the supernatant, which was carefully decanted and the mass of the starch paste taken. Swelling power was calculated as follows:

$$\text{Swelling power} = \frac{\text{Mass of starch paste}}{\text{Mass of dry starch sample}}$$

Determination of intrinsic viscosity

A paste of 5 g of starch and 100 mL of f water was made at 100°C and allowed to cool for about 2 h, after that 3 g of the starch water solution was dissolved in 20 mL of water. This procedure was repeated using 6, 9, 12 and 15 g of the starch solution to get starch-water concentrations corresponding to 6.25 x 10⁻³, 0.011, 0.015, 0.018 and 0.021 gmL⁻¹ (0.625, 1.1, 1.5, 1.8, and 2.1 g dL⁻¹). The same procedure was repeated for eight different samples of ginger modified starch. These samples were used to get the viscometric values using ubbelohyde viscometer of uniform cross section. The concentration of the samples and the efflux time were recorded.

Preparation of starch thickener

50 g of dried starch was made to be in its viscoelastic form by adding water in drops and the amount of water at which the dried starch exhibit its viscoelastic property was noted, the viscoelastic starch was then mix with 164 g of hot water at 100°C. 138 g of the prepared starch was then used as thickener in the formulation of paint. The amount of starch in the thickener was determined using the formula below:

$$\text{Mass of dried starch in thickener used} = \frac{50 \text{ g} \times 138}{W}$$

Where, W = mass of dried starch + mass of cold water + mass of hot water.

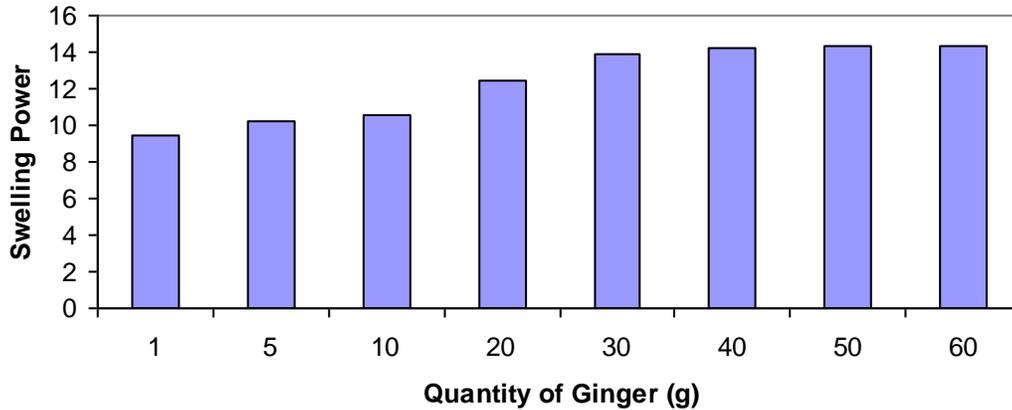


Figure 2. Variation of swelling power with quantity of ginger.

Formulation of emulsion paint using ginger modified cassava starch

The modified and unmodified starches were used as thickener in the formulation of emulsion paint using varied formulation of emulsion paint as shown in Table 1. The results of the experiment were compared against formulation with commercial thickening agent, hydroxyl ethyl cellulose (HEC).

Paint properties assessments

Opacity

Opacity (hiding power) of the paint was measured by visual assessment; five different observers rated the degree of opacity of the paint formulations.

Extent of mildew attack

Paint films were cast using crown cocks in order to obtain films of equal thickness. The films were exposed to damp environment (bathroom for three days) and the extent of mildew attacks was recorded.

Sagging on a vertical wall

The paints were applied on a vertical wall and the extent of vertical wall sagging was ascertain by visual assessment.

Drying time

Drying time of the paints on a vertical wall was observed and recorded.

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of the native cassava starch was: fat, 0.08%; protein, 0.57%; ash, 0.50%; moisture, 11.9%; and carbohydrate, 85.95%. These findings are in agreement with the earlier report of Agboola et al. (1990).

Swelling power

The results of the research as illustrated in Figure 2, shows that the swelling power (9.4 to 14.3) of ginger modified cassava starch increased as the concentration of active components of ginger increased, and it was higher than that of unmodified cassava starch (9.1) (Figure 2). This is a measure of hydration capacity. This also explains why the amount of water needed to change a given amount of starch from its powdered form to its viscoelastic form keep increasing with increase in the concentration of active component of ginger. The results of the swelling power of this research are in agreement with the result obtained by Daramola and Osanyinlusi (2006).

Intrinsic viscosity

Solvent efflux time

$$t_0 = \frac{120+118+123+120}{4} = 120.25 \text{ s} \dots\dots$$

From the results of the experiment, the intrinsic viscosity of the ginger modified starch (0.2Cp - 0.4Cp) was greater than that of unmodified cassava starch (0.1Cp). These results can be observed from the trend in Tables 2, 3 and 4, as well as Figures 3 and 4 respectively. As the concentration of active components of ginger increased, the intrinsic viscosity of the ginger modified cassava starch tend to increase from 0.39 to 0.4 Cp and then decreased to 0.2 Cp and finally increased again to 0.38 Cp with (5 g of ginger and 30 g of ginger samples) having the highest and lowest intrinsic viscosity respectively.

It was noticed that there were three options available for the preparation of starch thickener: (1) the starch powder could be dissolved directly in hot water, (2) hot water could be poured on the starch in its viscoelastic form, and (3) the hot water could also be poured in the starch liquid

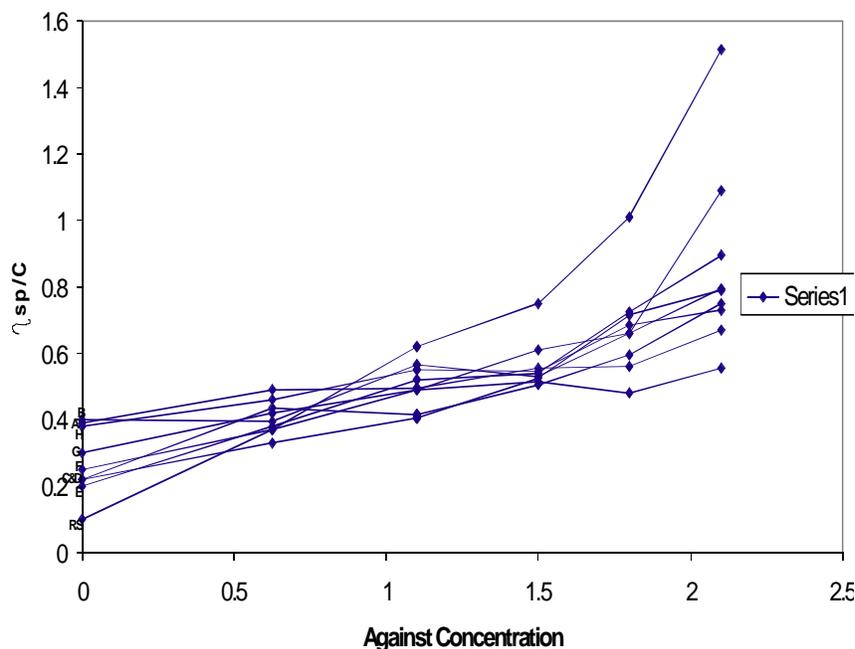


Figure 3. The graph of η_{sp}/C against concentration.

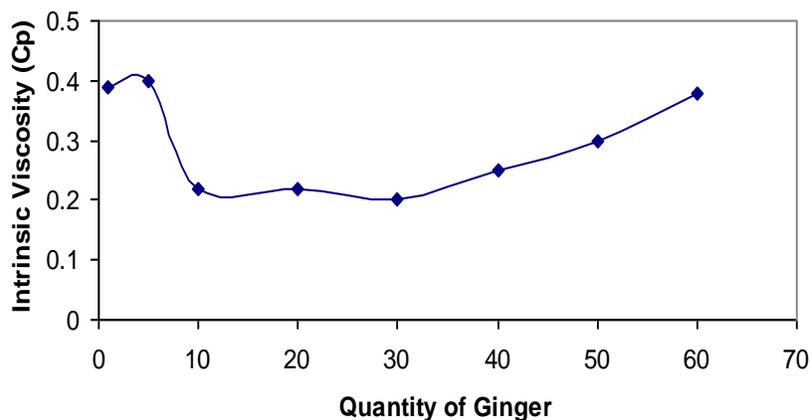


Figure 4. Intrinsic viscosity against quantity of ginger.

state. The first one did not yield good result as thickener in paint formulation as there were a lot of undissolved starch particles given rise to rough paste. It also requires larger quantity of water to form paste given rise to paste that was not stiff. The second one gave a nice smooth, stiff and requires lesser amount of water in forming paste, and it was suitable as thickener in paint formulation. The last but not the least, gave smooth paste but require a lot of water making the paste weak to serve as thickener. This implies that for a modified cassava starch paste to serve as a thickener it has to be smooth, stiff and contains lesser amount of water.

From the results in Table 5, the samples with 10, 20, 30 and 40 g respectively withstood the test of time of about

25 days, while the thickening strengths of lower concentration and concentration higher than 40 g failed after five days of storage. That of unmodified starch failed before five days. The adhesion of the paint with modified starch on the wall was somewhat better than the commercial thickener. The paint with modified thickener show little or no chalking some days after application, while paint with commercial thickener chalks immediately after drying in the absence of binder. This shows that the modified cassava starch plays a dual role first as a thickener and secondly as a binder. Mild dew resistance was low in modified starch thickener when compared with commercial thickener. This indicates that in the presence of mild dew resistant additive, ginger modified cassava starch

Table 1. Paint formulations.

Component	Formulation								
	1	2	3	4	5	6	7	8	9
Titanium dioxide	50	50	50	50	50	50	50	50	50
Calcium carbonate	300	300	300	300	300	300	300	300	300
Vinamil (PVA)	40	40	40	40	40	40	40	40	40
Sodium hexametaphosphate	10	10	10	10	10	10	10	10	10
Ammonia solution	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Surfactant	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Deformer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Formalin	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hydroxyl ethyl cellulose (HEC) commercial thickner	4.2	0	0	0	0	0	0	0	0
Ginger modified starch	0	30.0	30.8	30.8	30.5	30.4	30.1	30.1	29.9
Unmodified starch	31.0	0	30.8	30.8	30.8	30.5	30.4	30.1	30.1
Water	300	300	300	300	300	300	300	300	300

Table 2. Efflux times of samples.

Time (s)	Raw starch							
	A	B	C	D	E	F	G	H
148	157	150	145	153	149	148	152	155
202	186	195	174	175	189	185	185	193
256	220	216	215	211	216	213	230	219
339	241	263	275	249	277	224	263	269
503	289	321	320	310	346	260	305	304

Table 3. Concentration and η_{sp}/C .

Concentration (gdL ⁻¹)	Raw starch η_{sp}/C	A η_{sp}/C	B η_{sp}/C	C η_{sp}/C	D η_{sp}/C	E η_{sp}/C	F η_{sp}/C	G η_{sp}/C	H η_{sp}/C
0.625	0.370	0.490	0.395	0.330	0.435	0.3824	0.370	0.422	0.462
1.1	0.618	0.497	0.565	0.406	0.414	0.520	0.490	0.489	0.550
1.5	0.752	0.553	0.531	0.525	0.503	0.542	0.514	0.609	0.547
1.8	1.011	0.558	0.659	0.715	0.595	0.724	0.479	0.659	0.687
2.1	1.516	0.668	0.794	0.791	0.751	0.894	0.553	1.092	0.728

Table 4. Showing variation of intrinsic viscosity and swelling power with respect to amount of ginger.

Quantity of ginger (g)	Swelling power	Intrinsic viscosity
1	9.4	0.39
5	10.2	0.40
10	10.6	0.22
20	12.5	0.22
30	13.9	0.20
40	14.2	0.25
50	14.3	0.30
60	14.3	0.38

Table 5. Paint properties assessments.

Paint sample	Opacity	Adhesion	Thixiotr-Opic flow	Mild dew resistant	Drying time (min)
HEC	Excellent	Good	Good	Resisted mildew	3.0
Cassava starch	Poor	Good	Poor	Too bad	3.5
Modified starch (1 g)	Poor	Good	Poor	Fairly poor	3.5
Modified starch (5 g)	Poor	Good	Poor	Fairly poor	3.5
Modified starch (10 g)	Good	Good	Fair	Fairly poor	4.25
Modified starch (20 g)	Good	Good	Fair	Fairly poor	4.25
Modified starch (30 g)	Good	Good	Fair	Fairly poor	4.25
Modified starch (40 g)	Good	Good	Fair	Fairly poor	4.25
Modified starch (50 g)	Weak	Good	Poor	Fairly poor	4
Modified starch (60 g)	Weak	Good	Poor	Fairly poor	4

can compete favorably as commercial thickener. The flow properties, opacity and drying times of the samples with 10, 20, 30 and 40 g, respectively, were okay after five days.

Conclusion

Cassava starch modified by the active components of ginger can be used as thickener in emulsion paint formulation. The different concentrations of active component of ginger used gave rise to modified starch with different flow property in paint. The results show that there is a range within which active component of ginger is needed in the modification of starch for it to be suitable as thickener in the formulation of emulsion paint. In the presence of mildew resistant additive, cassava starch modified by the active component of ginger can be used as thickener in the formulation of emulsion paint.

REFERENCES

- AOAC (1980). Official Methods of Analysis[®] 13th edn, Association of Official Analytical Chemists.
- Agboola SO, Akingbala JO, Oguntimehin GB (1990). Production of low substituted cassava starch acetates and citrates. *Starch* 43 (1): 13-15.
- Benesi IR (2005). Characterisation of Malawian cassava germplasm for diversity, starch extraction and its native and modified properties. PhD Thesis, Department of Plant Sciences, University of the Free State, South Africa. pp. 74-123.
- Bertolini AC, Mestres C, Colonna P, and raffi J (2001) Free radical formation in UV- and gamm- irradiated cassava starch, *Carbohydr. Polym.* 44, 269-271.
- Daramola B, Osanyinlusi SA(2006). Investigation on modification of cassava starch using active components of ginger roots (*Zingiber officinale* Roscoe). *Afr. J. Biotechnol.* 5 (10):917-920.
- Fiedorowicz M, Tomasik P, Lii CY (2001). Degradation of starch by polarised light. *Carbohydr. Polym.* 45: 79–87.
- Gunaratne A, Hoover R (2002). Effect of heat-moisture treatment on the structure and physicochemical properties of tuber and root starches. *Carbohydr. Polym.* 49:425–437.
- Liang Y, Zhang BS, Yang LS, Gao DW (2004). Chemical reaction activity of tapioca starch with non-crystallized granule state. *Journal of Zhengzhou Institute of Technology (China)*. 25:9–13.
- Nakazawa Y, Wang YJ (2003). Acid hydrolysis of native and annealed starches and branch-structure of their Naegeli dextrans. *Carbohydr. Res.* 338:2871–2882.
- Van der Watt, Godman McCormick, Gok Schultz(1989). in *Encyclopedia of polymer Science and Engineering*. 17: 730
- Wang YJ, Wang LF (2003). Physicochemical properties of common and waxy corn starches oxidized by diVerent levels of sodium hypochlorite. *Carbohydr. Polym.* 52:207–217.
- Zhang T, Oates CG (1999). Relationship between -amylase degradation and physico-chemical properties of sweet potato starches. *Food Chem.* 65:157–163.