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EFFECT OF COWPEA SEED DRYING TEMPERATURE AND WET MILLING ON THE RHEOLOGICAL PROPERTIES OF *MOIN-MOIN* PASTE AND GEL

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ABSTRACT

The effects of cowpea seed drying temperature and wet-milling on the viscosity of moin-moin paste and texture (rheology) of moin-moin gel were studied. The large brown eye Kano white cowpea seeds were soaked in water at 25°C for 5 min, drained and dried at temperatures between 30 and 120°C, decorticated and dry milled into flour. Decorticated cowpea seeds dried at 30°C were soaked in cold water at 25°C for 1.5hr and wet milled into paste. The cowpea flours and paste were reconstituted with water and prepared into moin-moin with and without addition of salt, pepper, tomato paste, onions, vegetable oil and beef flavour. Determination of the moin-moin paste viscosity prior to steaming showed that all the pastes exhibited pseudoplastic flow behaviour. The moin-moin from the wet milled paste had higher viscosity than the samples from flours due to higher swelling of the starch, protein and cell wall materials. The moin-moin pastes containing additional ingredients had higher viscosity than the plain samples due to the additional solid matter. Drying at temperatures between 80 and 120°C increased the viscosity of the plain moin-moin paste but decreased those of samples with added ingredients. Texture studies showed that drying temperature, wet milling and addition of ingredients decreased the hardness of the moin-moin gel at 50% double compression and relaxation.

Key words: *Cowpea, moin-moin, viscosity, and texture*

Introduction

Cowpea seed is a well-known legume consumed in Nigeria and other parts of the world. Its nutritional significance is derived from its high protein content between 21 and 28% (Enwere, 1998). Cowpea seed is unique as food because it can be prepared into different dishes (Dovlo, *et al.* 1976). The immature pods and seeds can be cooked and eaten as vegetable. Extract from the dry mature seed can be used to prepare substrate for *natto*. The mature cowpea seed can be converted into flour or paste used for moin-moin and *akara* preparation and for soup thickening. The cowpea flour has also been used in composite flour with wheat flour for cake and doughnut preparations. Various studies have been conducted on the properties of cowpea flour, paste, *akara*, *moin-moin* and seed (McWatters and Brantley, 1982; McWatters, 1993 and Enwere 1985).

According to Enwere, *et al.* (1998), drying of wetted cowpea seeds at 30°C prior to decortication had no effect on the properties of the protein, starch and seed microstructure. Drying the wetted cowpea seeds at 80°C adversely affected the albumins of the water-soluble protein to a fair degree while drying at 120°C extremely denatured the albumin in the water-soluble proteins and caused the *akara* prepared from the flour to loose its sponginess and become compact. The starch granules also suffered thermal damage as observed under scanning electron microscope examination. Different seed drying temperatures, especially, at elevated temperatures of 100 and 120°C adversely affected the sensory properties of *akara* and *moin-moin*. Viscosity and texture, which are rheological properties, have also been used by various workers to characterise foods (Enwere and Ngoddy, 1986).

The objective of this study, therefore, was to determine the effect of cowpea seed drying temperatures and wet milling on the viscosity and texture of *moin-moin* paste and gel, respectively, using objective rheological instruments.

Materials and Methods

Cowpea seed sample

The large brown eye Kano white variety of cowpea seed (*Vigna unguiculata*) used in this study was purchased from the Nsukka market in December, soon after harvest.

Proximate analysis

The crude protein, moisture, crude fat, crude fibre and ash of the cowpea flour were determined according to AOAC (1984) method. Carbohydrate was determined by difference.

Cowpea flour preparation

The large brown eye Kano white cowpea seeds were prepared into flour according to the method, described by Enwere (1998). The wetted seeds were dried at temperatures of 30, 60, 80, 100 and 120°C prior to flour preparation.

Preparation of wet milled paste

Fresh cowpea paste was prepared immediately before use. In this method, 101.25g of decorticated cowpea seed cotyledons dried at 30°C were soaked in 1 litre of water at 25°C for 1.5 hr. It was drained, weighed and wet-milled into paste by blending for 2 min in an Oster Kitchen Centre blender (Model 965-04F, Oster Corp.}, with addition of more water to increase the sum of absorbed and added water to 300 ml.

Table 1: Recipe for moin-moin preparation

Ingredients	Quantity in moin-moin	
	Plain	With additional ingredients
Cowpea flour	33.75	33.75g
Red pepper (dry)	-	0.1g
Onion (fresh ground)	-	7.0g
Tomato paste	-	7.0g
Meat flavour	-	0.3g
Salt	-	2.0g
Groundnut oil	-	10.0ml
Water (at 70°C)	100.0ml	100.0ml

moin paste and gel preparation

The method described by Enwere *et al.* (1990) was used for *moin-moin* preparation. The recipe is given in Table 1. Two types of *moin-moin* pastes were prepared from the wet- milled cowpea paste and five flour samples obtained from cowpea seeds dried at 30, 60, 80, 100 and 120°C. The first type was, prepared with water and cowpea flour (plain) and the second type was prepared with cowpea flour, and addition of the other ingredients including salt, pepper, tomato paste, onions, beef flavour and vegetable oil. The *moin-moin* paste was dispensed into aluminium container (about 310-ml capacity), with internal diameter of 9.2 cm and depth of 5.2 cm. It was covered with a fitting lid, steamed in a double-decked steamer for 20 min and cooled for 2hr at 4°C prior to texture measurement.

Determination of *moin-moin* paste viscosity

The viscosity of the raw *moin-moin* paste was determined before cooking, using a Brookfield rotational viscometer with a small sample adapter and spindle No 27 (Model HAT, Brookfield Engineering Laboratories Inc., Stoughton, MA, USA). Measurements were taken at speeds of 0.5, 1.0, 2.5, 5.0, 10.0, 20.0, 50.0 and 100 rpm, which correspond to shear rates of 0.17, 0.34, 0.85, 1.7, 3.4, 6.8, 17.0 and 34.0 s^{-1}, as calibrated by the viscometer manufacture.

Measurement of *moin-moin* texture

A combination of the methods of Bourne and Comstock (1981) and Ossai, *et al.* (1987)

described by Enwere, *et al.* (1990) was used for texture measurement. In this study 1 cm^3 (1 x 1 x 1 cm) specimens were cut from the *moin-moin* samples with the aid of a metal grid and a sharp knife. The *moin-moin* cubes were subjected to 50% double compression and relaxation using an Instron Universal Texture Testing Machine (Model 1122, Instron Inc. Canton MA, USA). The Instron was fitted with a compression anvil 5.7-cm diameter and 50 kg load cell. It was operated with a crosshead speed of 10 mm per min. and a chart speed of 100 mm per min. Twelve measurements were made for each sample.

Data analysis

The power-law mathematical equation of Holdsworth (1971) was fitted to the viscosity data after the shear stress was determined using the shear rates ( ) given by the manufacturer and the apparent viscosity values ( ) obtained from measurements in consonance with equations (1) and (2), below:

$$\dot{\gamma} = \eta\dot{\gamma} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where τ = shear stress (Pa. s)

$\tau = \eta\dot{\gamma}$ = Apparent viscosity (Pa. s^{-1})

η = Shear rate (s^{-1})

The Power-law mathematical equation was used to calculate the flow consistency values and flow behaviour indices using the Statistical Analysis System SAS (1985):

$\tau = \eta\dot{\gamma} = b\dot{\gamma}^n$ (Power-law mathematical equation) .... (2)

where

b = flow consistency value

n = flow behaviour index

The texture profile and mechanical properties of the moin-moin gel were obtained from the force-deformation curves (Fig. 3) as follows:

1) Hardness = the highest peak force in the first compression cycle
2) Modulus of elasticity or deformability = the slope of the linear segment of the force-deformation curve during the first compression cycle
3) Cohesiveness = the ratio of the area of second compression cycle to that of the first.

The areas were obtained with the aid of a digitizer attached to an IBM computer. The differences in the mean hardness, cohesiveness, and modulus of elasticity were calculated using analysis of variance and Duncan's Multiple Range Test Procedure.

Results and Discussion

Proximate composition

The large brown eye Kano white cowpea seed used in this study contained 11.11% moisture, 23.38% protein, 1.29% crude fat, 3.1% crude fibre, 3.28% ash and 60.94% total carbohydrate. These values are similar to those reported by Purseglove (1991).

Flow behaviour of *moin-moin* pastes

Flow behaviour properties of the *moin-moin* pastes determined and reported in this study include apparent viscosity, shear stress, flow behaviour index (n) and flow consistency value (b).

Apparent viscosity

The trends of the apparent viscosity of *moin-moin* pastes at different shear rates are shown in Figure 1. It was observed that the viscosity of the *moin-moin* pastes decreased as shear rate increased. Onweluzo, *et al.* (1994), also observed this trend in their rheological study of flours from lesser-known legumes. The plain *moin-moin* pastes had low viscosity because the protein was not denatured and starch was not gelatinised so could not swell and cause thickening with resultant effect on viscosity. In addition, the larger flour particles partly sedimented out of the paste when left to stand. This increased viscosity at the level of the spindle. The rate of sedimentation increased as drying temperature increased. Consequently, the viscosity of the plain moin-moin paste increased as cowpea seed drying temperature increased.

The plain *moin-moin* paste prepared from the wet-milled cowpea had much higher viscosity at

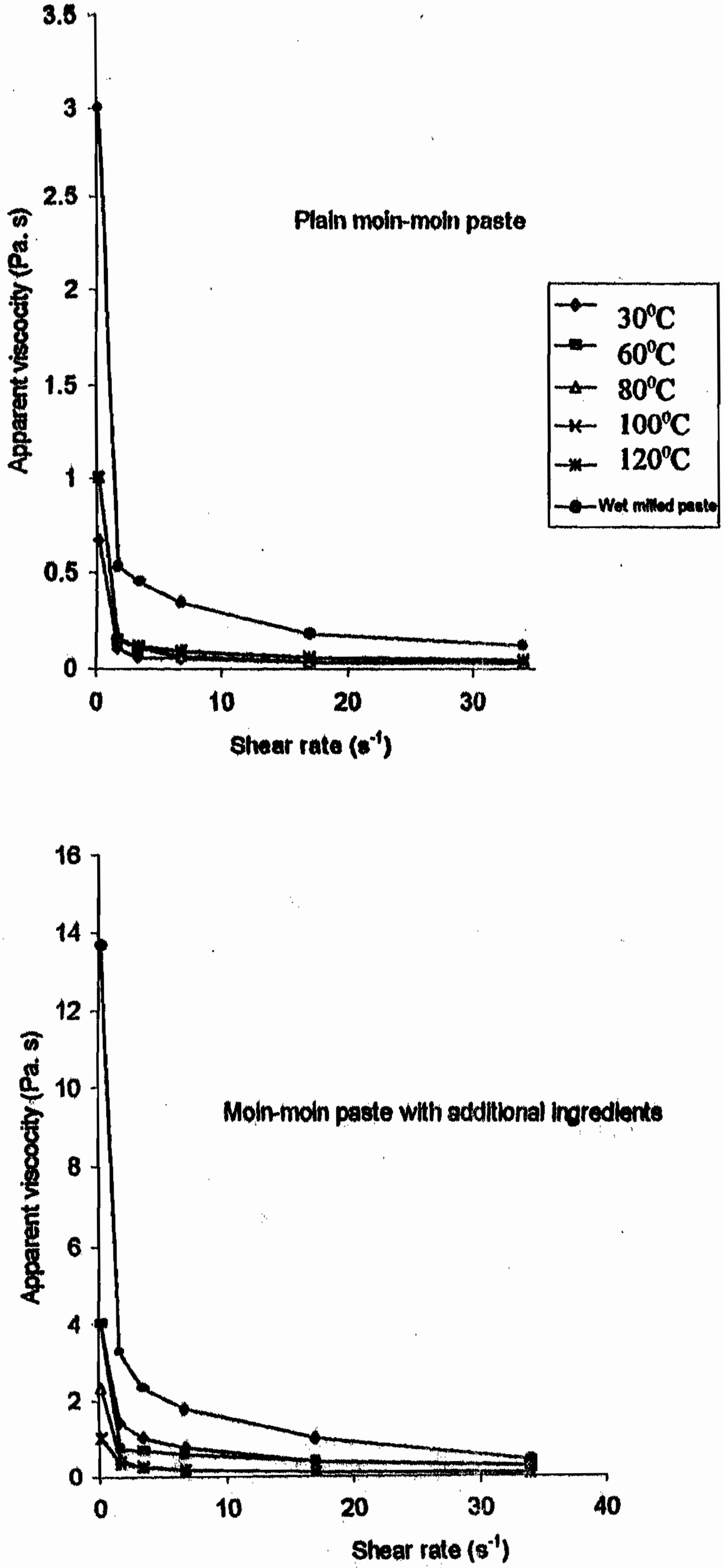

Fig. 1 Apparent viscocity at different shear rates of moin-moin pastes prepared with cowpea flour or wet-milled with or without additional ingredients

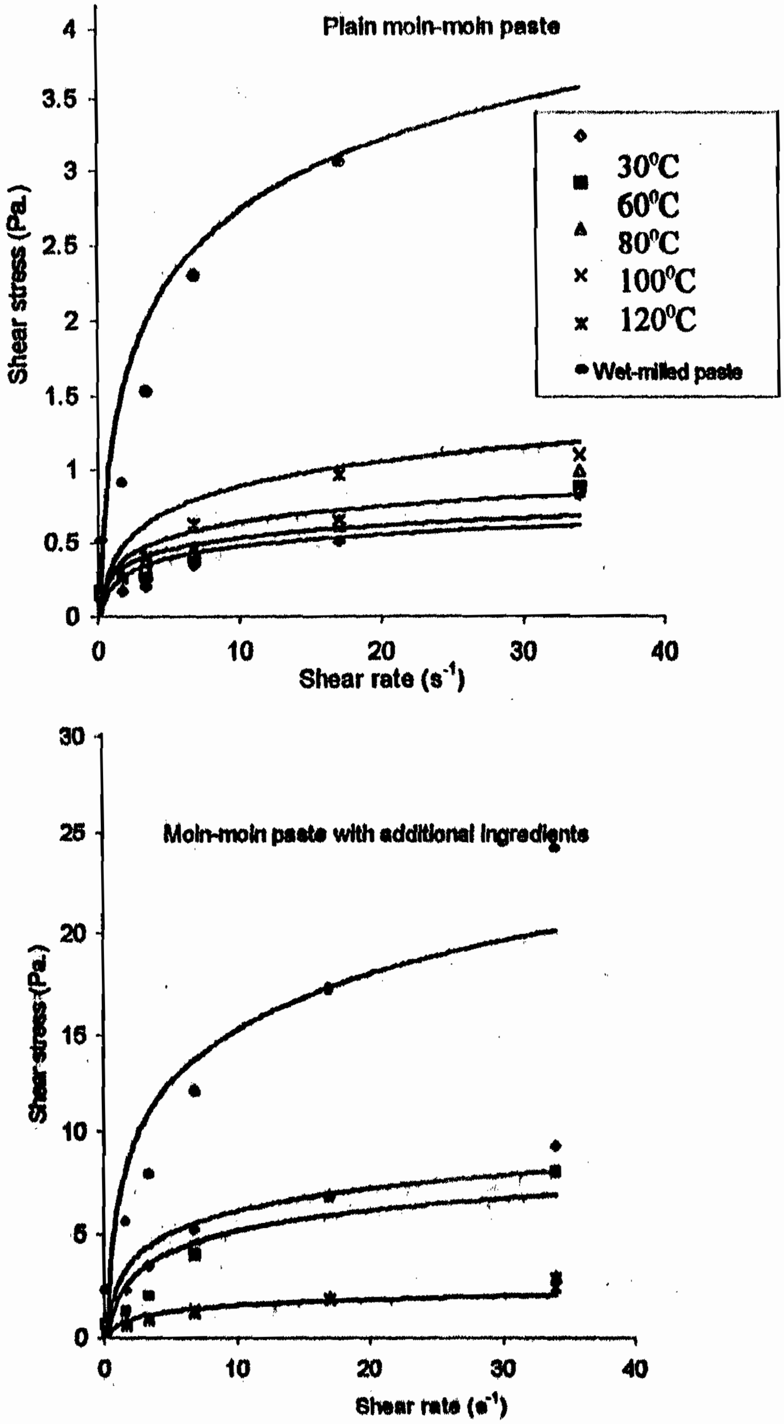

Fig. 2 Apparent viscocity at different shear rates of moin-moin pastes prepared with cowpea flour or wet-milled with or without additional ingredients

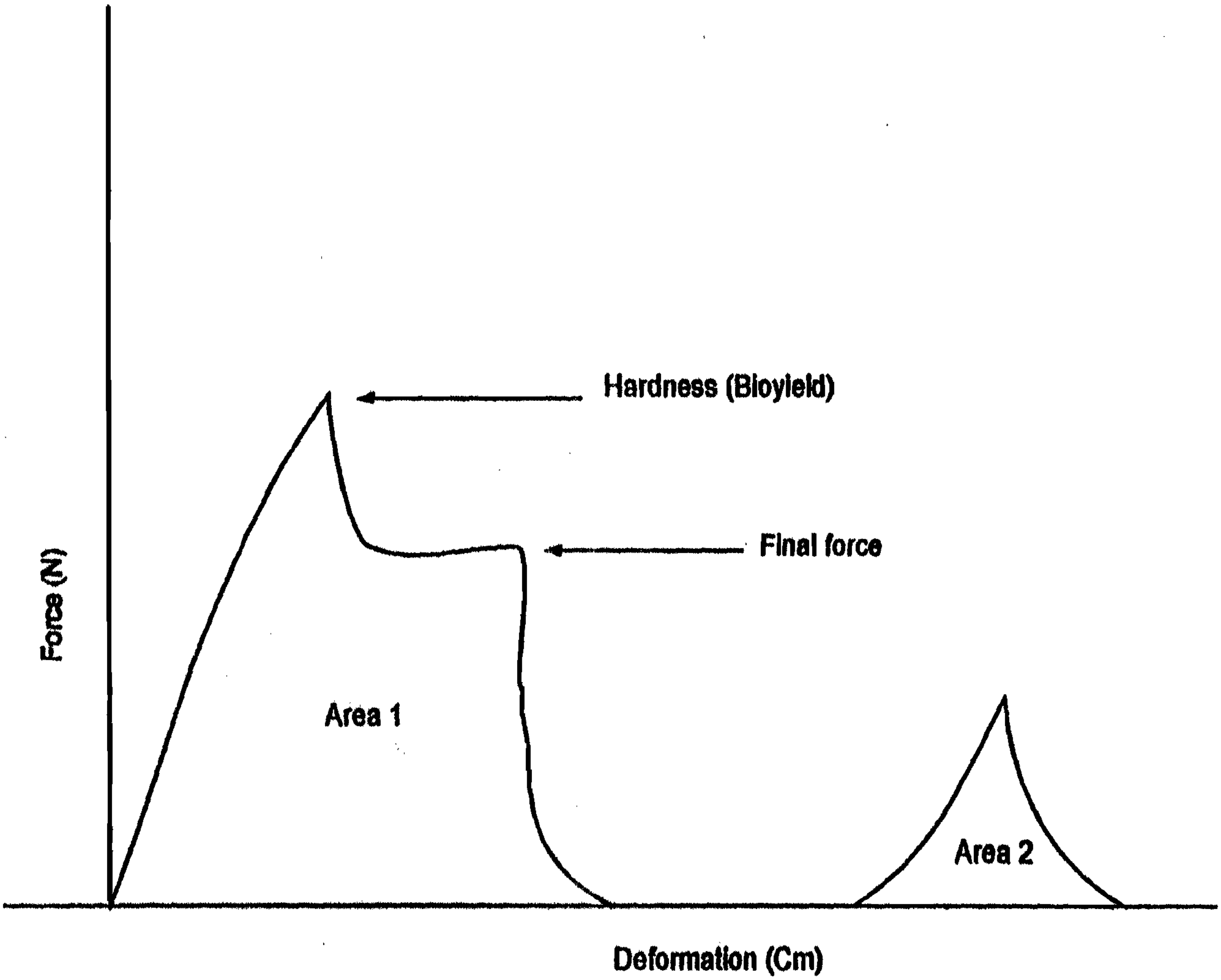

Fig. 3 A typical force-deformation curve at 50% compression level of *moin-moin* samples using a compression anvil fitted to the Instron Universal Texture Testing machine.

all shear rates than the *moin-moin* pastes prepared from flour with and without additional ingredients. Soaking and wet-milling increased swelling of the cowpea components (protein, starch and cell wall materials), reduced mass density of the proteins and increased thickening and viscosity of the paste.

When pepper, tomato paste, onion puree, salt, beef flavour and vegetable oil were added to all the *moin-moin* pastes, viscosity increased substantially due to increased solid content or dry matter. The viscosity of the *moin-moin* pastes containing additional ingredients generally showed a reverse trend when compared with plain *moin-moin pastes*. It decreased as drying temperature increased because there was little sedimentation of particles around the spindle. The particles were more homogeneously distributed inside the paste such that the effect of thickening by additional ingredient mainly controlled the trend of viscosity. The tomato paste, dry pepper and onion puree, which were thick also, acted as viscosity enhancers, which prevented substantial particle sedimentation.

Shear stress- shear rate relationships

The shear stress-shear rate relationships of the *moin-moin* pastes are shown in Figure 2. Onweluzo, *et al*. (1994), also observed this relationship in their viscosity study of flours from lesser-known tropical legumes. For all the *moin-moin* pastes, the shear stress increased as the shear rate also increased. The shear stress of the plain *moin-moin* pastes generally increased as the cowpea seed drying temperature increased. When ingredients were added, the trend was reversed. The shear stress values for the *moin-moin* prepared from the wet-milled cowpea paste was higher for the plain samples and the products containing all ingredients due to the of swelling of the cowpea seed particles during soaking, greater thickening and more particle-particle interaction.

Power-law parameters

The power-law parameters are the flow behaviour index (n) and the flow consistency value (b) given in Table 2. The flow behaviour index of all the *moin-moin* samples were less than one and greater than zero, depicting a pseudoplastic flow behaviour (Holdsworth (1971) and Uzoma and Ahiligwo (1995). The flow behaviour index of the plain *moin-moin* prepared with flour obtained from cowpeas dried at 120°C had higher value than the other samples prepared from flours but the differences were not significant. The plain *moin-moin* prepared from the wet milled cowpea paste had significantly higher flow behaviour index than samples from the flour. When other ingredients were added, the flow behaviour indices of all the moin-moin prepared from cowpea flour increased to almost

Table 2: Power-law parameters (flow behaviour index (n) and flow consistency value (b) of moin-moin pastes.

Sample	Flow behaviours index (n) of moin-moin pastes		Flow consistency value (b) of moin-moin pastes	
	Plain	With additional ingredients	Plain	With additional ingredients
Dried at 30°C	0.3392[b]	0.5131[a]	0.1864[c]	0.5810
60°C	0.2982[b]	0.5080[a]	0.2410[bc]	0.7666
80°C	0.3037[b]	0.5132[a]	0.2817[b]	0.6510
100°C	0.3118[b]	0.5129[a]	0.2707[b]	0.4768
120°C	0.4400[a]	0.5151[a]	0.2655[b]	0.4234
Wet-milled paste	0.4343[a]	0.3983[b]	0.8822[a]	4.6110

Values in the same column not followed by the same letter a significant at $p \leq 0.05$.

Table 3: Texture profile parameters of moin-moin gel samples at 50% double compression and relaxation

Type of sample	Treatment	Hardness N	Cohesiveness	Elastic modulus N/cm
Plain	30°C	6.8147^{a}	0.2775^{a}	2.3341^{a}
	60°C	6.2236^{ab}	0.2226^{b}	2.5083^{a}
	80°C	5.8664^{b}	0.1902^{b}	2.4833^{a}
	100°C	5.0358^{b}	0.2269^{b}	2.3167^{a}
	120°C	5.3563^{b}	0.2362^{b}	2.3917^{a}
	Wet-milled paste	7.1286^{a}	0.2618^{a}	2.5830^{a}
With additional ingredients	30°C	4.2118^{a}	0.25607^{a}	0.6417^{a}
	60°C	3.9436^{ab}	0.2523^{a}	0.6500^{a}
	80°C	3.7016^{b}	0.2293^{b}	0.6083^{a}
	100°C	3.0934^{c}	0.2134^{c}	0.5667^{b}
	120°C	2.9495^{c}	0.2171^{c}	0.5333^{c}
	Wet-milled paste	4.1006^{a}	0.2661^{a}	0.6333^{a}

Values in the same column not followed by the same letter are significant at $p \leq 0.05$.

the same level. However, addition of other ingredients decreased the flow behaviour index of the *moin-moin* samples prepared from the wet-milled cowpea paste, even to a value lower than that of moin-moin pastes prepared from cowpea flour.

Of all the plain *moin-moin* pastes, the 80°C samples had the highest flow consistency (b) value. This decreased toward 30 and 120°C. This trend was similar when other ingredients were added. However, the *moin-moin* pastes prepared from wet milled cowpea with other ingredients had higher flow consistency value than for corresponding plain samples. The moin-moin prepared from the wet milled cowpea paste had about four times the flow consistency values of samples prepared with cowpea flours for the plain sample and when other ingredients were added. *Moin-moin* pastes obeyed the power law equations just like other liquid foods, for example, 13% and 16% soymilk (Son and Sing, 1998).

Typical flow behaviour of *moin-moin* pastes

From the flow behaviour data obtained, it has been shown that as the shear rate of all the moin-moin pastes were increased, the shear stress increased, but the viscosity decreased. In addition, the flow behaviour indices (n) of all the *moin-moin* pastes were greater than zero and less than 1.0, irrespective of the cowpea seed drying temperature or type of milling. According to Holdsworth (1971), this is typical of pseudoplastic flow behaviour. This was used in the study of rheological properties of gums by Uzomah and Ahiligwo (1995) and Son and Sing (1998)).

Many studies have shown that the flow behaviour of liquid foods can be used to characterise them and to determine the effect of processing on their components. Consequently, the change in the viscosity of liquid foods especially those containing protein and starch have been used to determine the effect of various treatments on their components (Evans and Haisman, 1979, and Lee and Rha, 1977).

Texture profile and mechanical properties of *moin-moin* gel

A typical force-deformation curve of steamed *moin-moin* gel samples is shown in Figure 3 and the texture profile parameters and mechanical properties are given in Table 3. The hardness and cohesiveness of both the plain *moin-moin* samples and those containing additional ingredients decreased from 30 to 120°C. These decreases probably resulted from the alterations of the protein and starch because of the effect of heat during drying (Enwere, *et al*, 1998). There were differences between the elastic modulus of the *moin-moin* samples prepared from the different flours but they were not significant, showing that the rate of deformation of the plain moin-moin samples were similar.

The hardness of the plain *moin-moin* samples prepared from wet-milled cowpeas was higher than those prepared from cowpea flour, although they were significant only for 80 to 120°C samples. The cohesiveness of the moin-moin prepared with wet milled paste was similar to the 30°C sample but significantly higher than the 60 to 120°C moin-moin samples.

When other ingredients were added to the *moin-moin* samples, the values for the hardness and elastic modulus, generally decreased but cohesiveness remained almost at the same level. This is the reverse of the observation in the viscosity of the raw paste, where addition of ingredients increased viscosity.

According to Ossai *et al.* (1987), the oil added to the *moin-moin* is primarily responsible for reduced hardness. When other ingredients were added to the moin-moin, there seemed to be a general trend where the gel hardness, cohesiveness and elastic modulus decreased with increase in cowpea seed drying temperature. The effect was significant from 80°C for hardness and cohesiveness and elastic modulus from 100°C. Despite the differences in the rheological characteristics of the *moin-moin* paste prepared from wet-milled paste and flours from 30 to 80°C pre-treatment, they were observed in earlier study to have desirable sensory properties. They were also very acceptable to taste panellists (Enwere, 1985).

Conclusion

This study has shown that drying wetted cowpea seeds at temperatures above 80°C adversely affected some rheological properties of the resulting flour. The *moin-moin* pastes and gels prepared from the 100 and 120°C drying operations were generally different from those between 30 and 80°C samples although in some cases, significant differences occurred at 80°C. Wet-milled cowpea seed produced *moin-moin* paste that was thicker than those from flours and the corresponding *moin-moin* gels were harder than those gels prepared from flours. The cowpea seeds to be used for flour intended for *moin-moin* preparation should, therefore, not be dried at temperatures above 80°C since some adverse effects began to occur from the higher temperature.

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