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CONTENTS

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A comparative study of wild yam starch from *Dioscorea schimperiana*

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Starch was extracted from the tubers of *Dioscorea schimperiana* and the following physicochemical properties were determined: viscosity, gelation temperature, solubility, water-binding capacity, grain size and refractive index. Elemental, phosphorus, protein, amylase, oil and ash contents were also determined. The analyses results of the above parameters were compared to those of the starch derived from *Dioscorea dumetorum* which had been the subject of an earlier investigation.

Keywords: ***Dioscorea dumetorum, Dioscorea schimperiana, dioscoreaceae, gelatinization***, retrogradability, International Organization for Standardization (ISO), solubility and starch.

Introduction

The genus *Dioscorea* includes an important group of tropical food yams. Included in the family are some of the following *Dioscoreaceaes*: *schimperiana* (Kunth) (under analysis), *dumetorum (Kunth)*(Nkala, 1992), *cyanesis* and *alata*. This type of plant grows throughout equatorial and tropical Africa and is found in fertile, hilly or well-drained veld areas of Zimbabwe. Starch constitutes about 75 percent of the dry matter content of the tubers (Watt and Breyer-Brandwijk, 1962). Fresh tubers of *Dioscoreaceae* varieties have also been found to contain two classes of metabolites, namely alkaloids and steroids (Watt and Breyer-Brandwijk, 1962; Iwu, 1982). These metabolites are thought to be responsible for the herb-like taste of the tubers, the toxic components mainly being saponins. The yam tubers are generally used for nutritional purposes by rural people (Hegnauer, 1963), but this is only after a preliminary intensive washing to free the tubers of the toxic principles. Failure to do so usually results in a quick knock-down effect in humans, zebras, birds and fish (Khumalo *et al.*, 1992), if consumed. Some of the *Dioscoreaceae* tubers have been used in the treatment of tropical diseases, such as leprosy and tumours (Corley and Tempesta, 1985). They have also been used as phytotherapeutic agents for the treatment of diabetes and as anaesthetics. Disabilities such as infertility have also been minimised by use of the tubers (Watt and Breyer-Brandwijk, 1962) and the

latter have also been recommended in certain preparations for piles and dysentery (Soni *et al.*, 1985).

The main thrust of this investigation is the isolation of starch from the tubers of *D. schimperiana* and to carry out a comparative study of some of its properties with those of starches derived from other members of the family as done by J. C. Favier (Soni *et al.*, 1985).

Materials and Methods

Dioscorea schimperiana was collected along the Great Dyke area near Banket in Zimbabwe, during summer (April 1993) and a voucher specimen No. 921201 is deposited with the National Herbarium and Botanic Garden (Zimbabwe). Fresh tubers of *D. schimperiana* (3.5 kg) were peeled, cut into small pieces and macerated, using a Heavy Duty Juice Extractor, to an off-white slurry (3.3kg). The tubers were soaked, overnight, in a methanol-water solution (1:1) into which sodium metabisulphite had been added to make a 1 percent solution. The suspended starch was sieved using a dish towel and the residue washed with distilled water until the solution was clear. The starch so extracted was allowed to sediment overnight and the supernatant was decanted off. The starch was washed with copious quantities of water (29L) until the decanted water was clear. The starch was then filtered off and air-dried to give an off-white solid (0.1kg; 3 percent) on a fresh weight basis.

Analysis of starch

The physicochemical properties of *D. schimperiana* starch were analysed according to the general protocol of Henkel Inc. Harare (Zimbabwe) (Muzimbaranda, 1993). Parameters such as viscosity, phosphorus and amylose content, water-binding capacity and solubility were determined by Sychawska (Poland). Corn starch (universally used as the 1 percent standard solution) (Muzimbaranda, 1993) was obtained from Henkel Inc. (Zimbabwe).

Physical properties of the starch

The gelatinization of a 7.8 percent starch solution of *D. schimperiana* starch occurred over the temperature range 74 to 84°C with complete gelatinization occurring over 93°C. This was done using a Rheotest-2-rotary viscometer. Characteristics of gelation of the starches of *D. schimperiana* and *D. dumetorum* are shown in Table 1.

Table 1: Characteristics of gelation.

Parameters	*D. schimperiana*	*D. dumetorum*
Gelation temperature (°C)	81	79
Maximum viscosity (mPas)	207	173
Temperature at maximum velocity (°C)	93	86
Stabilisation after 20 min at 96°C (Mpas)	150	72

The viscosities were taken using Contraves and Brookfield viscometers. Brabender and Contraves viscographs are shown in Figures 1 and 2 below. The viscosities after a 20 minute stabilisation at 96°C for *D. schimperiana* and *D. dumetorum* starches are 200 mPa and 75 mPa (Nkala and Sibanda, 1994) respectively. A higher viscosity shows that the granules are fully swollen and a lower viscosity indicates that the granules are only moderately swollen. Ideally, *D. schimperiana* starch would be preferred in uses such as glues and adhesives, and in some food applications, because it is stable and does not easily retrograde

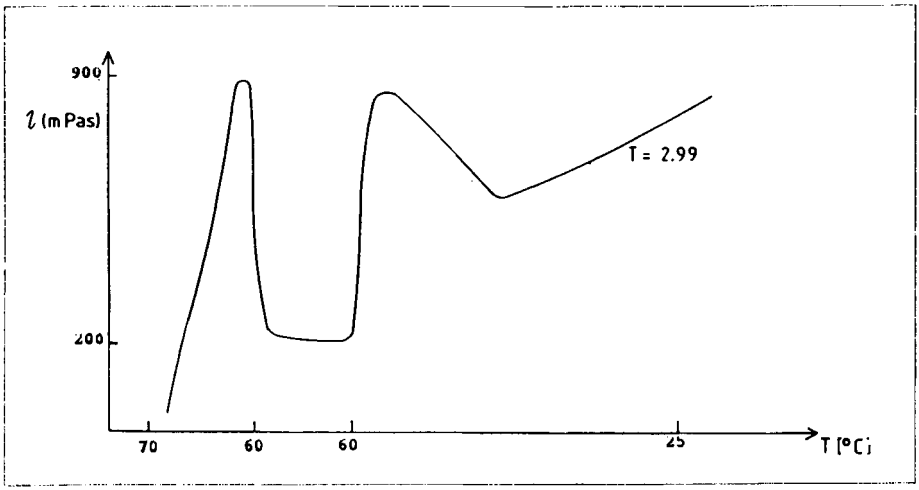

Figure 1: Bradender viscograph of *D.schimperiana* starch.

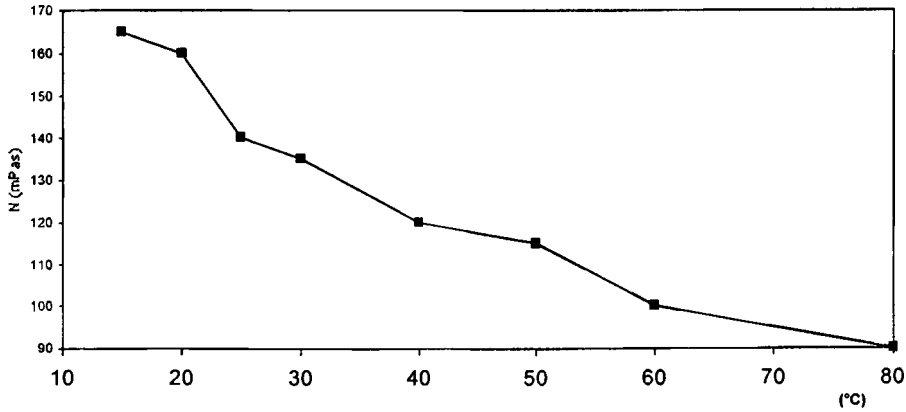

Figure 2: Contraves viscosities of *D. Schimperiana* starch.

Other parameters

A summary of the results of a comparison of some of the properties of the starches of *D. schimperiana* and *D. dumetorum* is shown in Table 2 below.

Values in parentheses are those specified by the International Organisation for Standardization (ISO) (Nkala, 1994; ISO 3947, 1977; ISO 3188, 1978; ISO 3593, 1981).

Table 2 : Selected properties of starches from *D. schimperiana* and *D. dumetorum* (comparative basis).

Parameters	*D. schimperiana*	*D. dumetorum*
Moisture content (%)	14.3 (14.2) (ISO 3947, 1997)	12.35
Amylose content (%)	24.5	14.8
Lipid content (%)	0.44 (≤ 0.7) (ISO 3947, 1977)	3.96
Protein content (%)	0.40 (≤0.7) (ISO 3947, 1977)	1.73
Phosphorus content (%)	19	28.8
Ash content (%)	0.90 (≤ 0.2) (ISO 3188, 1978)	0.16
Absorption of I_2 λ_{max} (nm)	500	595
pH	5.52 (5–6) (ISO 3593, 1981)	5.25

Thus, *D. schimperiana* would seem to be more suitable source of starch for both domestic and industrial purposes than *D.dumetorum*.

Discussion

The characteristics of gelation indicate that starch from *D. schimperiana* completely gelatinizes at a temperature above 93°C as compared to a temperature of 86°C for *D. dumetorum*. This is an indication that the associative forces in *D. schimperiana* starch are stronger than those in *D. dumetorum* starch, thus requiring prolonged heating for the disruption of the starch matrix. These results show that the starch from *D. schimperiana* has a higher gel strength than that of *D. dumetorum*. The protein content was determined by the Kjeldahl method and that of the *D. schimperiana* starch was found to lie within the internationally accepted range (≤0.7 percent) whereas that of *D. dumetorum* was 1.73 percent. The advantage of low protein content is that it reduces the retrogradability of the starch.

D. schimperiana starch has a lipid content of 0.44 percent (≤ 0.7 percent) whereas that of *D. dumetorum* is 3.96 percent. A low lipid content is ideal for commercial purposes (ISO 3947, 1977) in the sense that it prevents the starch from turning rancid on storage.

The ash content of *D. schimperiana* starch was found to be 0.9 percent, a value which is far higher than that of *D. dumetorum* (0.16 percent) and even higher than the internationally accepted value of 0.2 percent. This could have been due to incomplete combustion and also to the conversion of various metals into their oxides.

The amylose content of *D. schimperiana* starch is 24.5 percent whereas that of *D. dumetorum* is 14.8 percent. The difference is also confirmed by the differences in iodine absorption. Inspite of its other favourable properties, a high amylose content in *D. schimperiana* starch might promote retrogradation, particularly on long storage.

Grain size was analysed using the screen Deck Grab sample method at Henkel Chemicals Inc. Results are tabulated in Table 3 (a) below. A microscope analysis was also taken [Table 3(b)] and photomicrographs of the starch granules are also shown as Figure 3.

Table 3(a): Screen analysis for grain size distribution.

Sieve	Micron	percentMass
+70	+212	0.86
+100	+150	0.22
+120	+125	0.25
+170	+90	0.62
+200	+75	0.42
+240	+63	0.90
Receiver	240	97

Table 3(b): Grain size analysis by a microscope.

Micron	percentMass
>31m	16.49
21.9 – 30.9 mm	4.26
13.9 – 21.8 mm	19.15
<13.9 mm	60.10

The inference from these results is that the starch granules are made up of very small grains and 97 percent of them are below 63 μm. When passed through the 150mm sieve; 0.22 percent of the sample was obtained. It was observed that most

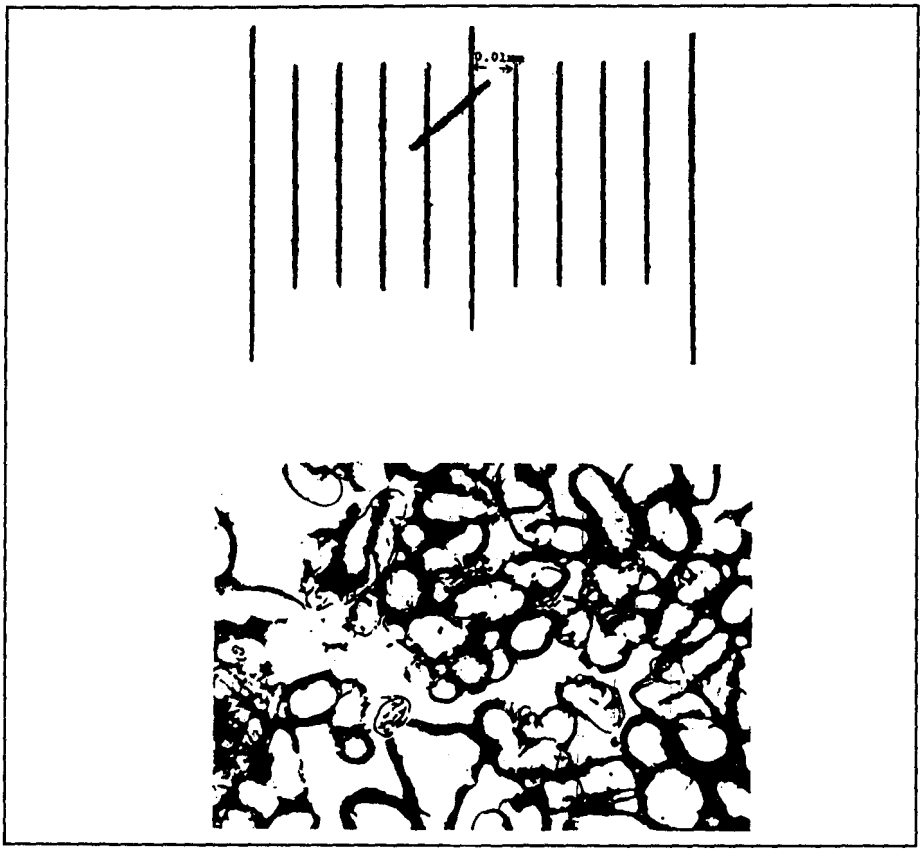

Figure 3: Photomicrograph of starch granule (with scale).

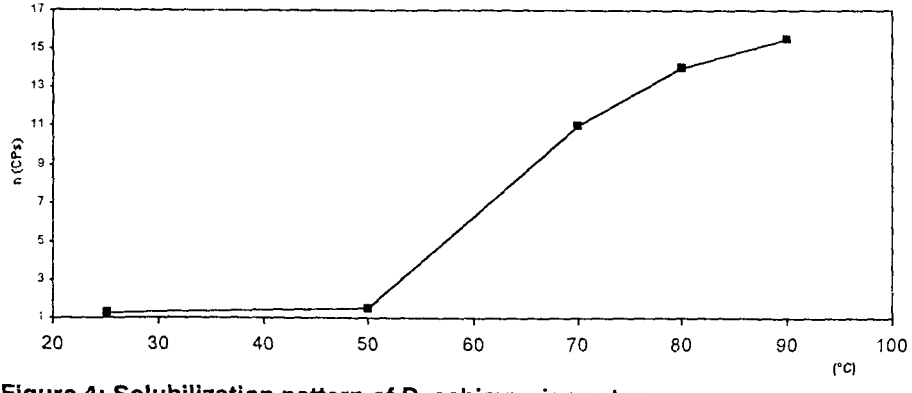

Figure 4: Solubilization pattern of D. schimperiana star.

of the matter was fibrous implying that the amount of starch retained could lie within the International requirements of 0.1 percent (ISO 1666, 1973) retainment.

Solubility and water-binding capacity

The solubility and water-binding capacity of *D. schimperiana* starch are shown in Figures. 3 and 4 below. The water-binding capacity of the starch was found to be 88 percent. This is an average value which is attributed to the strong association of starch polymers in the granules. A high water binding capacity (above 100 percent) indicates a loose association of the polymers.

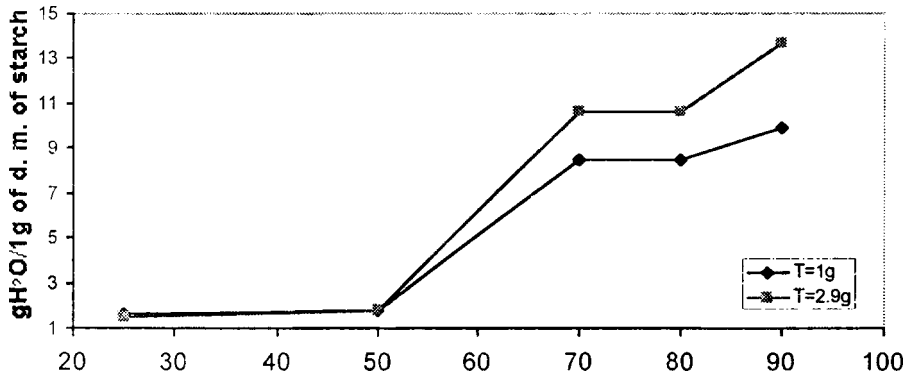

Figure 5: Water-binding capacity of *D. schimperiana* starch.

The solubility of the starch was quite low (1.4 percent to 15.5 percent). It was observed from the curve that solubility value increased with temperature. Solubility is a measure of the extent of the association of hydrogen bonding within the molecules and the compactness of the granules.

Conclusion

From the results discussed above, it is evident that the properties of *D. schimperiana* and *D. dumetorum* starches do not vary widely although most of the parameters of *D. schimperiana* starch lie within the internationally accepted values. The difference could be due to the variation in seasonal changes to which the tubers of *D. schimperiana* and *D. dumetorum* were subjected (Nkala, 1992). Structure and composition vary according to the size of the granules and we would therefore expect more pronounced properties in the starch found in the wet season *(D. schimperiana)* than that found in the dry season *(D. dumetorum)* (Nkala, 1992).

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