Some Characteristics of Sagu (*Canna edulis* Kerr) and Zulu (*Maranta* sp.) Rhizomes

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In this study a comparison between the chemical composition and physical characteristics of sagu (*Canna edulis* Kerr) and zulu (*Maranta* sp.) rhizomes was made. The rheological properties and morphometric characteristics of starches isolated from both modified underground stems were also compared. Sagu rhizomes are bigger than those of zulu. Their external appearance resembles that of yam. The zulu rhizomes yield larger quantities of edible pulps because of the lower percent of peel. The results of the chemical composition analysis show that sagu rhizomes have more total carbohydrate content and less crude proteins, fat, and fiber than zulu rhizomes.

Keywords: *Sagu rhizomes; zulu rhizomes; Canna rhizomes; Maranta rhizomes; starch; SEM observation*

INTRODUCTION

Nonconventional food sources are grown in some countries where traditional crops do not grow due to climatic and agronomic reasons. These nonconventional sources could be the answer to the problem of starvation in many countries in the world. They could also become a useful source of starch not only for food industries but also for other industries. Among these nonconventional plants, we can find maranta and canna. They have good yields of high-quality rhizomes and good agronomic features, such as adaptability. Both of these modified underground stems are good sources of starch (Erdman, 1986; Gallant et al., 1982). In Venezuela, canna and maranta rhizomes are named "sagu" and "zulu", respectively; in other countries they are called arrowroot (Erdman et al., 1984; Erdman, 1986; Montaldo, 1972). In South American countries there is a confusion in the use of the names "sagu" (*Canna edulis* Kerr) and "zulu" (*Maranta* sp.) (Chaparro et al., 1978; Montaldo, 1972). Such imprecision causes problems when it comes to marketing the product, since customers could buy products other than the ones intended. Both crops are cultivated by peasants in the Andes region in small plantations or "conucos". They are used for fresh consumption or for small scale starch extraction. The zulu starch is frequently used by vegetarians, due to its supposedly easier digestion as compared to other starches. Sagu starch probably exhibits a high digestibility too, but it has different functional properties in food formulations. That is why it is so important to differentiate among the two crops. This research aimed to evaluate and compare the external appearances, chemical compositions, and physical characteristics of sagu and zulu rhizomes.

MATERIALS AND METHODS

Sagu (*Canna edulis* Kerr) and Zulu (Maranta sp.) Rhizomes. Sagu and zulu rhizomes were obtained from a local market in the Venezuelan Andes. Starch was isolated from both modified underground stems using the following procedure: The modified plant stems, peeled and sliced, were mixed with water and in a Waring blender. The aqueous slurry was passed through a screen to remove the fibrous material. The sieved slurry was transferred to a container and centrifuged. The supernatant was decanted, and starch was dried at room temperature. Dried starch was transferred into a plastic bag and stored at room temperature.

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Table 1. Physical Attributes of Sagu and Zulu Rhizomes (*n* = 4)

attribute	sagu rhizomes	zulu rhizomes
wt (g)	289.4−831.4	24.9−52.51
length (cm)	14.7−30.6	11.1−18.8
width (cm)	5.5−8.7	2.2−3.2
yield (%)	68.54	87.97
peel fraction (%)	31.46	12.03

Analysis of Physical Attributes, Chemical Composition, and Physical Characteristics of Sagu and Zulu Samples. Sagu and zulu rhizomes were analyzed for their physical attributes: morphology, size, and weight. Morphology was evaluated by describing their color and external appearance. Size was evaluated on a representative sample of stems, by measuring length and width with a vernier. The peeled material (edible portion) was weighed. The yield was calculated from the following equation:

$$\% \text{ yield} = (\text{wt of edible portion/wt of whole modified underground stem}) \times 100$$

The difference between 100 and percent yield represents the peel fraction (percent).

Both types of stems were analyzed for their moisture, crude protein, crude fiber, and ash contents (AACC, 1992) and fatty substances (Schoch, 1964). The total carbohydrate was calculated on dry basis by subtracting the contents of protein, fat, fiber, and ash from 100%. The pH and titratable acidity (Smith, 1967) were also calculated. The data were analyzed for difference by the *t* test (Daniel, 1979).

Rheological Properties of Sagu and Zulu Starches. Pasting properties of the starches were evaluated using the Brabender Viscoamylograph (AACC, 1992; Rasper, 1982). The breakdown, setback, and consistency, expressed in Brabender units, were calculated from the plots (Merca et al., 1981; Mazurs et al., 1957).

Scanning Electron Microscopy. The sagu and zulu starches were sprinkled on adhesive tapes, attached to circular specimen stubs, coated with 200 Å of gold/palladium, examined at 20.0 kV, and photographed in a Hitachi 2400 scanning electron microscope (SEM). The starch granule diameter was

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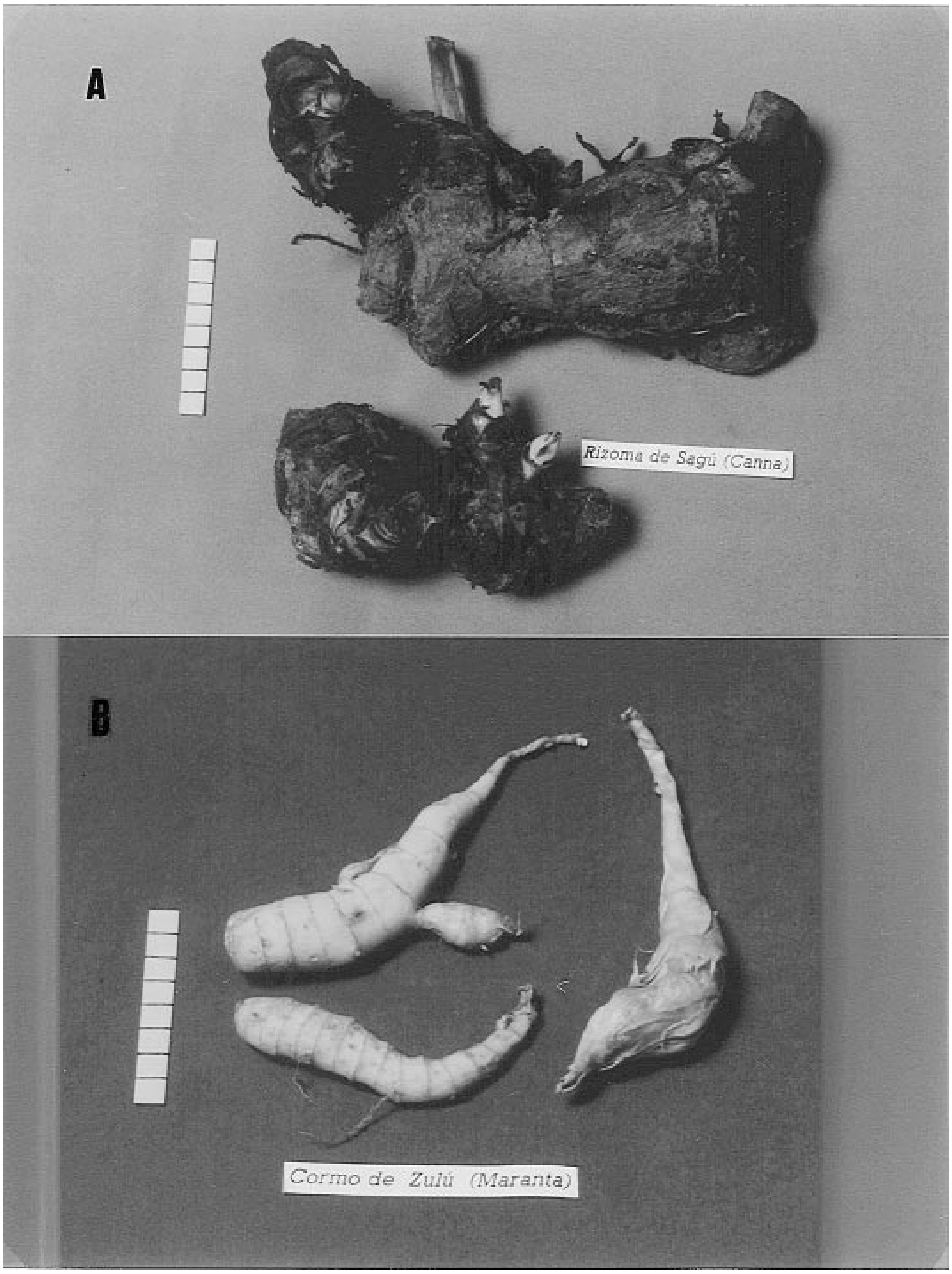

Figure 1. External appearance of sagu (A) and zulu (B) rhizomes.

estimated by averaging the largest dimension of 20 random starch granules from duplicated micrographs for each starch types.

RESULTS AND DISCUSSION

Table 1 shows the physical features of the sagu and zulu modified underground stems. Weight varied in the 289−831 g range for sagu rhizomes and in the 25−53 g range for zulu rhizomes. The yield was lower in sagu rhizomes than in zulu, because the zulu rhizomes have a thin layer of peel coating the edible portion. The length and width of sagu rhizomes used in this research were larger than those reported in the literature (Chaparro et al., 1978) and larger than those of the zulu. They ranged between 14.7 and 30.6 cm and between 5.5 and 8.7 cm, respectively. The color of zulu rhizomes was yellowish, while sagu was darker, similar to yam. The external appearance of the sagu rhizomes shows an aspect segmented with transversa line, forming small internodes (Figure 1). From the bases of these internodes, scaly leaves grow out and partially cover the rhizome. However, zulu rhizomes have a smooth peel and have few scaly leaves covering it (Figure 1).

Table 2 summarizes the chemical composition and some physical properties of the sagu and zulu rhizomes. The moisture content of the sagu rhizomes was 68.28% and of the zulu, 79.88%. Similar results for sagu rhizomes were reported in other studies (Chaparro et al., 1978). Protein, fiber, and fat contents were higher ($p < 0.05$) in zulu than in sagu rhizomes. The results of the three components of sagu rhizomes mentioned above were higher than the results presented in the literature (Chaparro et al., 1978). These results suggest that sagu rhizomes have a higher starch content than

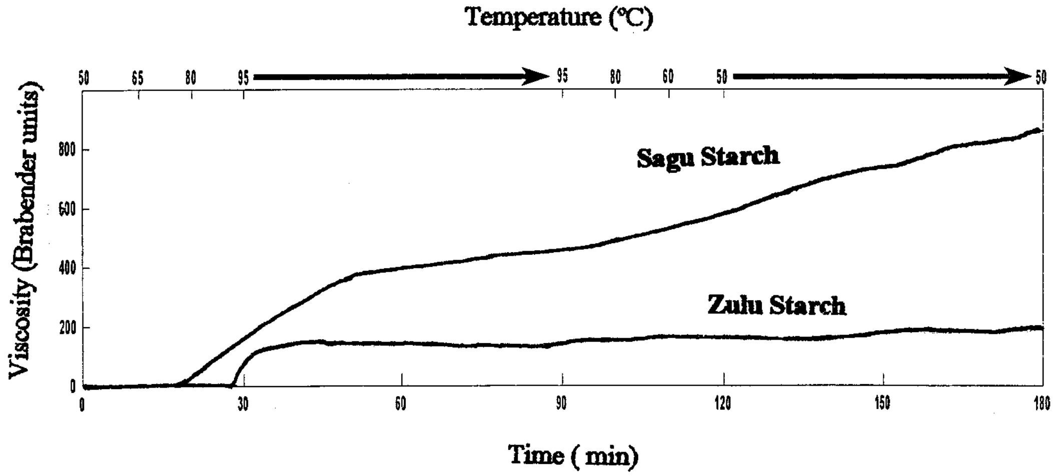

Figure 2. Brabender pasting curves for zulu and sagu starches.

Table 2. Composition (Percent Dry Basis except Moisture) and Some Physical Characteristic of Sagu and Zulu Rhizomes

parameter	sagu rhizomes	zulu rhizomes
moisture	68.28 ± 0.33	79.88 ± 0.62
crude protein[a]	1.22 ± 0.09	5.46 ± 0.51
crude fat	2.00 ± 0.09	5.96 ± 0.1
ash	1.29 ± 0.02	2.84 ± 0.12
crude fiber	1.70 ± 0.03	7.49 ± 0.18
total carbohydrates	93.79	78.25
pH	6.8 ± 0.1	6.9 ± 0.1
acidity (mequiv/g)	0.0648 (±2.6 × 10^{-4})	0.0531 (±1.4 × 10^{-4})

[a] N × 6.25.

Table 3. Rheological Properties of Starches Isolated from Sagu and Zulu Rhizomes

rheological properties[a] (UB)	sagu starch	zulu starch
gelatinization temp range (°C)	68−90	75−90
peak viscosity[a] (P)	300	150
final viscosity, 95 °C[a] (H)	460	150
cooled to 50 °C[a] (C)	660	170
breakdown[a] ($P - H$)	−160	0
setback[a] ($C - P$)	360	20
consistency[a] ($C - H$)	200	20

[a] Values are reported in Brabender units. $n = 2$.

their zulu counterparts. The total carbohydrate content was 15.54% higher in sagu than in zulu rhizomes. The pH was close to neutrality, and acidity was low in both stems.

The rheological properties of the starches isolated from sagu and zulu modified underground stems are summarized in Table 3. The gelatinization temperature range was higher in sagu starch than in zulu. The agreement between the data of gelatinization temperature range measured by amylographology in this study for sagu starch and those observed in the same starch using thermal analysis technique by differential scanning calorimetry (Wooton et al., 1979) is relatively good. The overall viscosity was higher in the sagu starch at the same concentration. The breakdown result of the zulu starch shows a plateau on the Brabender pasting curve and was lower when compared to *Maranta arundinacea* (Ciacco et al., 1977; Erdman, 1986). On the other hand, the negative breakdown data show that the viscosity of the sagu starch increases during the gelatinization process. Neither starch has a viscosity peak (Figure 2). Setback and consistency were lower in zulu starch. The absence of the viscosity peak and the high-temperature stability of the zulu starch make it an ideal ingredient for instant soup mixes. The high viscosity level developed by sagu starch should make it a suitable thickener for sauces and dressings.

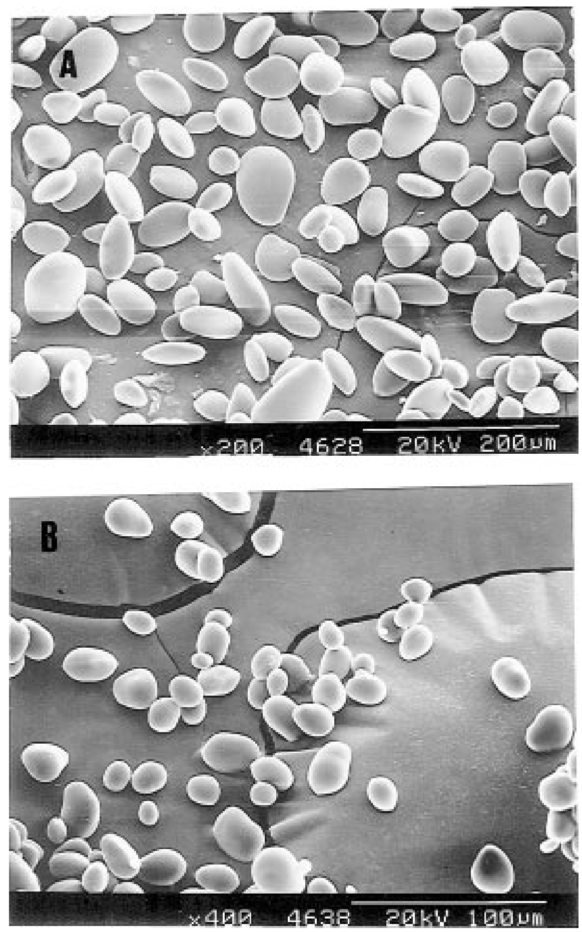

Figure 3. Scanning electron micrographs of sagu (A) and zulu (B) starches.

Scanning electron photomicrographs of zulu and sagu starches are presented in Figure 3. Zulu starch showed small rounded and large kidney-shaped granules. They were approximately twice as small as the sagu starch granules. Sagu starch showed small rounded granules and large lenticular.

CONCLUSION

It is evident that both modified underground stems present inherent differences in composition and rheological characteristics; this makes them different in their functional properties. These differences must be considered when these modified underground stems are processed or marketed, especially when it is known that they are often misnamed in South American countries.

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Received for review September 9, 1996. Accepted March 11, 1997.[⊗]

JF960680I

[⊗] Abstract published in *Advance ACS Abstracts*, May 1, 1997.