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Morphological Characteristics and Crystalline Structures of Granules of Some Wild Yam Species (Dioscorea) from Côte D'ivoire Forest Zone

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Abstract: Starches extracted from tubers of (07) species of wild yam (*Dioscorea*) have been studied with regard to the morphology and to the crystalline structure of their granules. The results revealed shapes and variable starch granule sizes and characteritics for every starch. These starches are constitued of granules with triangular, ovo triangular, ellipsoidal and polyhedric shape. Globaly the distribution of the granule size varies from 0.8 to 90 μm. It is for starch granules of every uniform and asymmetric specie. The starch of *D. dumetorum* that has some small granules (Ø = 3μm) has a crystalline structure of A type and the other studied starches that have some thick granules (Ø = 25μm) have a crystalline structure of B type.

Key words: Wild yam, granule, starch, morphology, crystalline structure

INTRODUCTION

The tubers of many tropical plants constitute an important potential starches reserve. To use these starches, it is important to know better their characteristics and properties.

Among these tropical tubers, there is the yam (*Dioscorea* sp.) whose properties start to be known (Duprat *et al*., 1980; Trèche, 1989; Amani *et al*., 2004). The interest to know much the properties of these wild yam species could be registered in this dynamic of research. Several researchers completed works referring to the properties yams in particular their starches. Thus Delpeuch *et al*. (1978), Trèche (1989), Farhat *et al*. (1999) and Amani (2002), respectively studied the properties of starches of yams cultivated in Ghana, in Cameroun, in Nigeria and in Ivory Coast. Our investigation survey comes to complete those carried out on the yams of Ivory Coast in former work (Amani, 2002, 2004). It could constitute a data source on the morphological and crystalline properties from the starches of some spontaneous yam species (*Dioscorea*) of the Ivory Coast forest zone.

MATERIALS AND METHODS

Starch samples studied were extracted from the tubers of seven (07) wild yam species (*Dioscorea*): *D. praehensilis*, *D. hirtiflora*, *D. minutiflora*, *D. bulbifera*, *D. togoensis* and *D. dumetorum* (Hamon *et al*., 1995) collected in July and August 2002 in the area of Memni at 80 km from Abidjan in southern forest zone of Ivory Coast.

The starch was extracted according to an adaptation of the method described by Delpeuch *et al*. (1978): 2-3 kg of wild yam tuber was washed and peeled, cut out pulp was plunged in the sulphited water (0.01%) then crushed with the popeller crusher (IK-Varke-Germany). The paste obtained was included in distilled water and then dispersed in a NaCl 4% solution to separate proteins from the starch. After new series of washing with distilled water, alternating with decantations, the starch suspension was then dried at 40°C with the ventilated drying oven P. Selecta (Barcelona-Spain). The dried product was moderately crushed with the hammer mill (Fristsch pulverizet type 201-Germany) and was filtered (250 μm). The shape of the starch granules was observed under the sweeping electron microscope (Cambridge Stereoscan 120) under tensions of 10 and 20 Kv. The size of the starch granules in suspension in lugol (0.2g Iodine in 2% KI solution) was observed and measured under the photonic microscope (CETI-Belgium) equipped with an eyepiece on micrometric scale and an objective micrometer. The distribution of the average diameter of the granules was given on a total of 500 granules (Rasper,1971).

X-ray diffraction study of the starch granules: The samples are preserved above a solution saturated with

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CuSO4 (50-55% of relative humidity) at the ambient temperature during two weeks. The analyses are carried out in the field 2θ ranging between 10° and 80° with a step of measurement of 0.04° and a time of integration of 6 sec by using the diffractometer (Bruker D8 Advance-U.K) equipped with a copper tube working to 40 Kv and 50 mA producing a radiation CuKá to wavelength λ = 0.154nm.

RESULTS

The results of the topographic analysis of the starches presented in Fig. 1, respectively show the granules of the starches extracted from the yam (*Dioscorea*) species: *D. minutiflora* with ellipsoidal form (Fig. 1a); *D. hirtiflora* with ovo triangular form (Fig. 1b), *D. praehensilis* with ovo triangular form (Fig. 1c), *D. bulbifera* tuber with triangular form (Fig. 1d): *D. burkilliana* with ovo triangular form (Fig. 1e); *D. bulbifera* bulbill with triangular form (Fig. 1f) and *D. dumetorum* with polyhedric form (Fig. 1g).

The average diameters of the various starch granules (Table 1) are respectively 3 µm (*D. dumetorum*), 25 µm (*D. hirtiflora*), 31 µm (*D. bulbifera* bulbill), 32 µm (*D. bulbifera* tuber), 34 µm (*D. praehensilis*), 40 µm (*D. minutiflora*) and 44 µm (*D. burkilliana*). The starch of

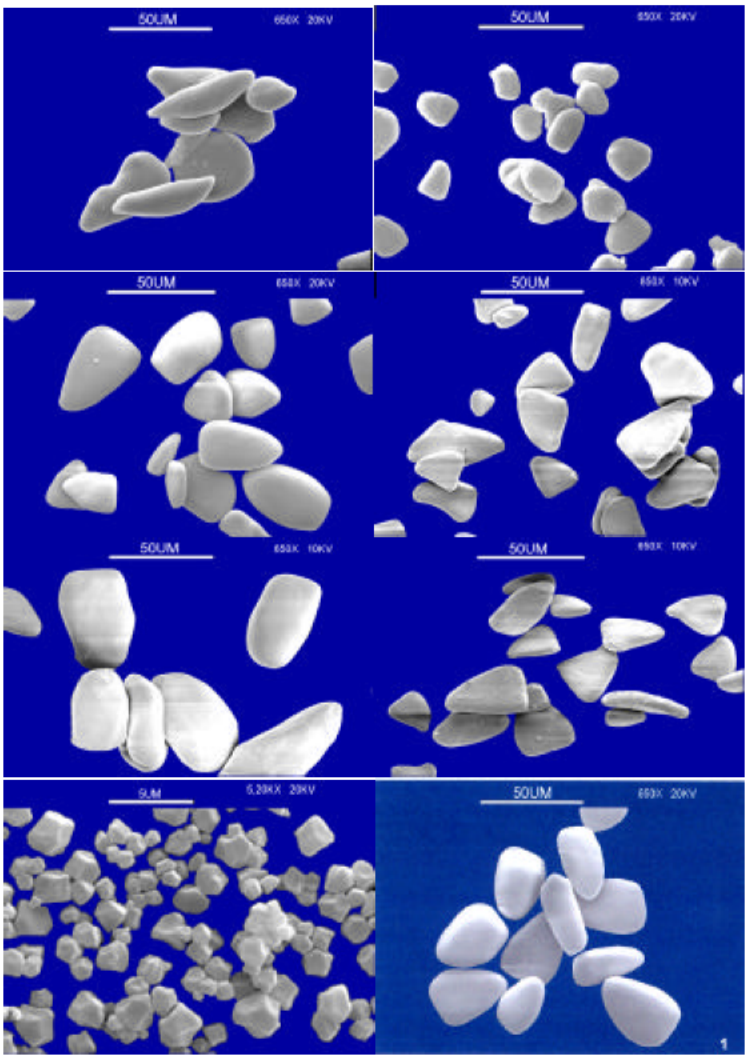

Fig. 1: Morphology of wild yam starch granules , a) D. Minutiflora, b) D. Hirtiflora, c) D. Praehensilis d) D. Bulbifera (tuber), e) D. Burkilliana, f) D. Bulbifera (bulbill), g) D. Dumetorum, h) D. Togoensis

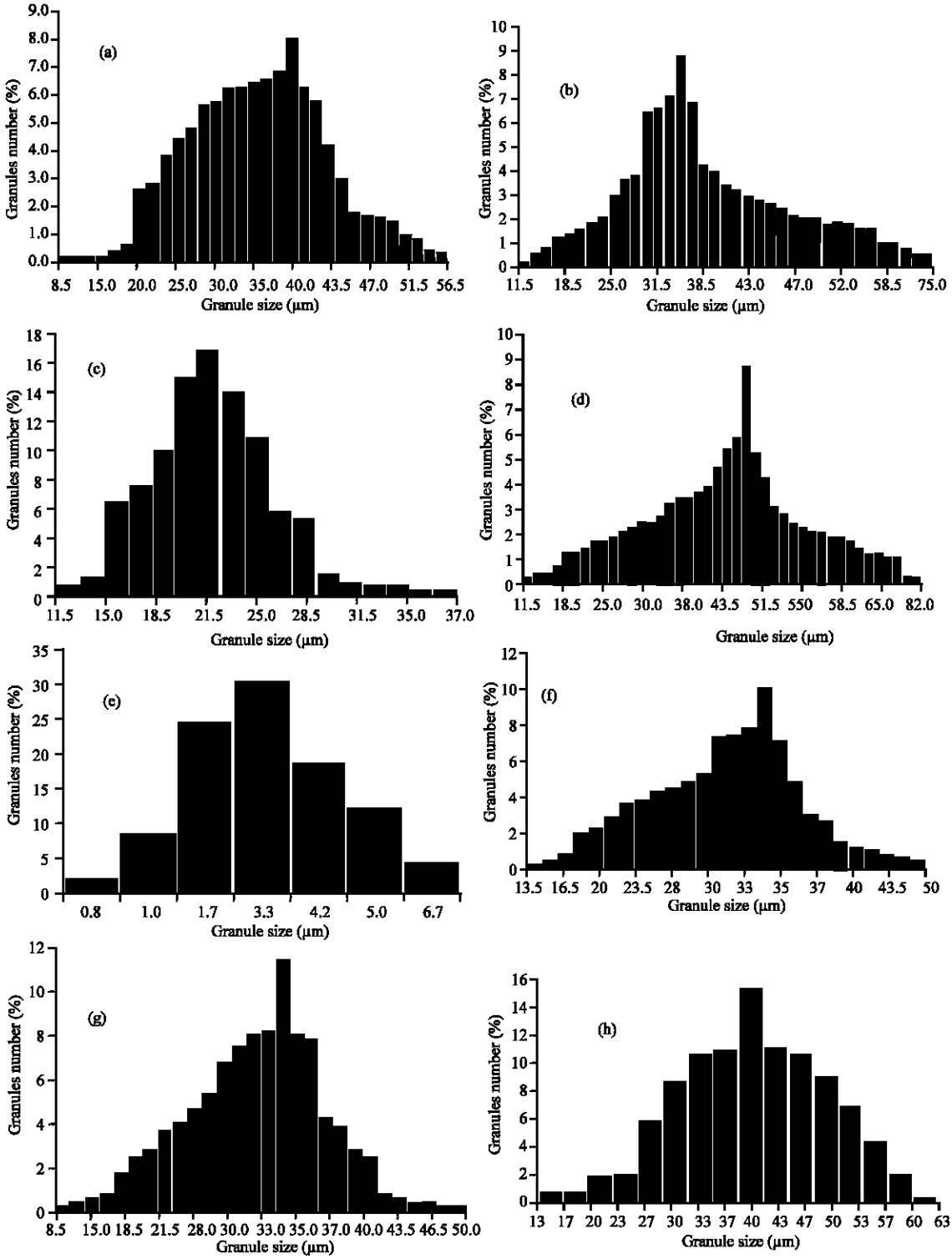

Fig. 2: Size frequence distribution of wild yam granules starch , a) *D. praehensils*, b) *D. minutiflora*, c) *D. hirtiflora*, d) *D. burkilliana*, e) *D. dumetorum*, f) *D. bulbifera* (bulbille), g) *D. bulbifera tubercule* , h) *D. togoensis*

D. dumtorum has small diameter granules and the starch of *D. burkilliana* has large diameter granules. The starches granules size distribution were determinated by taking the size which is the average

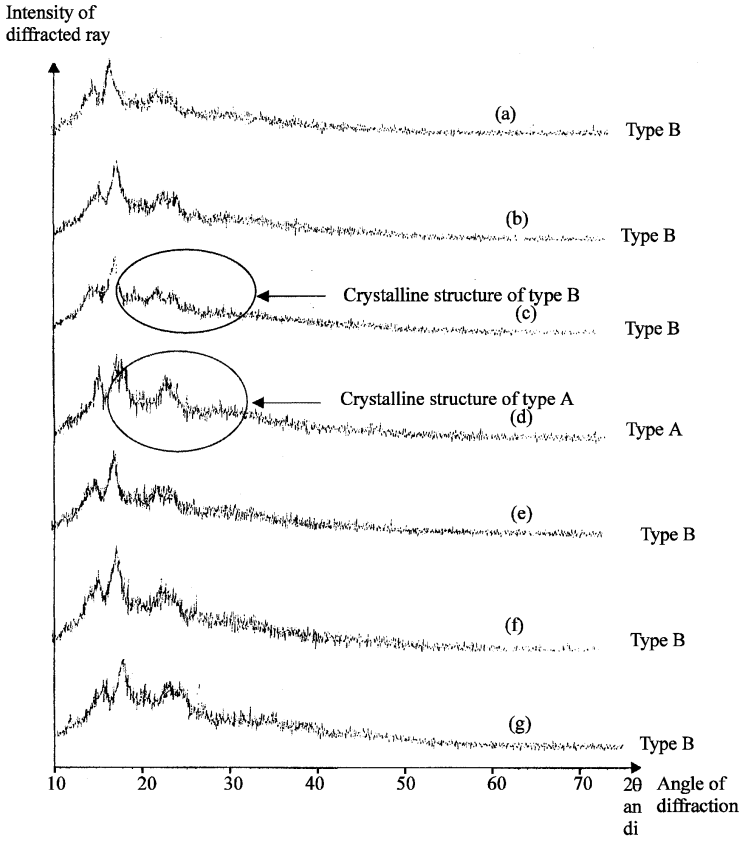

Fig. 3: X-ray diffraction spectra of wild yam starches granules: a) *D. praehensilis*, b) *D. hirtiflora*, c) D. *burkilliana*, d) *D. dumetorum*, e) *D. bulbifera* (bulbill), f) *D. bulbifera* (tuber), g) *D. togoensis*

Table 1 : Physical characteristics of wild yam starches granules

Samples	Granules form	Interva distribution of size (µm)	Mode (µm)	Average diameter (µm)	Crystalline structure
D. Prachensilis	Ovo triangulaire	8.5-56.5	40	34	B
D. hirtiflora	Ovo triangulaire	11.6-37.0	21.5	25	B
D. burkilliana	Ovo triangulaire	12.0-90.0	50	44	B
D. bulbifera tubercule	Triangulaire	8.5-52.0	33.5	32	B
D. bulbifera bulbille	Triangulaire	13.5-52.0	33.5	31	B
D. dumetorum	Polyedrique	0.83-6.70	3.3	3	A
D. mimutiflora	Ellipsoidale	11.5-75.0	35	40	-
D. togoensis	-	-	-	-	B

between the lengths of the long axis and the short axis of the granule (Rasper,1971).

The intervals of starches granules size distribution are respectively from:

11.50 to 75µm (*D. minutiflora*), 11.60 to 37µm (*D. hirtiflora*), 8.50 to 56.50 µm (*D. praehensilis*),

8.50 to 52µm (*D. bulbifera* tuber), 13.5 to 52µm (*D. bulbifera* bulbill), 0.83 to 6,70 µm (*D. dumetorum*), 12 to 90µm (*D. burkilliana*) (Fig. 2). The starch of *D. burkilliana* has the greatest interval of distribution and that of *D. dumetorum* has the small interval of distribution.

The modes of the distributions are, respectively 3.3 µm (*D. dumetorum*), 21.50 µm (*D. hirtiflora*), 33.5µm (*D. bulbifera* tuber), 33.5 µm (*D. bulbifera* bulbill), 35.0 µm (*D. minutiflora*) 40.0 µm (*D. praehensilis*), 50.0 µm (*D. burkilliana*).The starch of *D. burkilliana* has the largest mode and that of *D. dumetorum* has the smallest mode.

Spectra of diffraction X-ray of the yams are presented in Fig. 3. The scale of swept values 2θ extends from 10° to 80°. In this field the spectra which correspond to the starches of *D. praehensilis*, *hirtiflora*, *burkilliana*, *bulbifera* (tuber and bulbill) present peaks at 2θ values of 15°; 17°; 22°; 24° and the

spectrum corresponding to the starch of *D. dumetorum* presents peaks at 2θ values of 15°; 17°; 17,1°; 23,3° (Fig. 3).

DISCUSSION

The shapes of the granules of studied starches are characteristic for each type of starch (Fig. 1). The examination of the forms with the similarities of dimensions (Table 1) makes us to classify the studied starches in four types. We have thus granules with ovo triangular form in the starches extracted from *Dioscorea praehensilis, hirtflora, burkilliana*; granules with triangular form in the starches extracted from *D. bulbifera* (tuber and bulbill); granules with ellipsoidal form in the starch extracted from *D. minutiflora* and the granules with polyhedric form in the starch extracted from *D. dumetorum*. These different starches have granules like the starches granules extracted from other yam species studied by Coursey (1967), Rasper (1969), Szylt *et al.* (1978), Delpeuch *et al.* (1978) and Duprat *et al.* (1980). In particular starches extracted from the cultivated yams *D. alata* and *D. dumetorum* which have, respectively granules with ovo triangular and polyhedric form.

The observation of starches under the sweeping electron microscope shows heterogeneous dimensions of granules for the same species, dimensions and variable forms from one specie to another. According to Degras the morphological characters of the starch granules depend on several factors of a genetic nature (origin of the plant) and ecological agro (period of pulling up of the tubers).

The average diameter of the starch granules varies from 3 μm (*D. dumetorum*) to 44μm (*D. burkilliana*). The starches granule sizes are in the whole like those referring to various starches of yam studied by Amani (2002) whose average diameters is between 3.4 and 21 μm. The starches of the wild yams seem to have more coarse granules (⌀ = 25 - 44μm) except the granules of the starch extracted from *D. dumetorum* which have a small average diameter (Ø = 3.0 μm).

The size of the starch granules is a factor to be considered in the determination and substantially the interpretation of the physicochemical properties of starches (Deang and Del Rosario, 1999).

The spectrum of a crystalline structure of type A presents three characteristic peaks at 2θ values of 15°; 17°; 18.1° having appreciably the same height and 2 peaks with 2θ values of 9° and 12°. Whereas the spectrum of a crystalline structure of type B presents 2 characteristic peaks at 2θ values of 5.5° and 17°, then 3 peaks with 2θ values of 15°; 22° and 24° (Delpeuch *et al.*, 1978). By comparing these characteristics of the identified spectra with the crystalline structures of types A and B with those of the spectra of studied wild yams starches, we could deduce that the crystalline structure of the starches extracted from yams *Dioscorea praehensilis*, *burkilliana*, *hirtiflora*, *togoensis* and *bulbifera* (tuber and bulbill), whose spectra present peaks at 2θ values of 15°; 17°; 22° and 24° would be identified to a crystalline structure of type B (Fig. 3). And the crystalline structure of the starches extracted from yam *D. dumetorum* whose spectrum presents peaks at 2θ values of 12°; 15°; 17°; 18,1° would be identified to a crystalline structure of type A (Fig. 3).

The starches with coarse granules (Ø = 25-44 μm) have a crystalline structure of type B and the starch with small granules (Ø = 3 μm) has a crystalline structure of type A (Table 1). This result is in agreement with this one done by Delpeuch *et al.* (1978) referring to the starches extracted from the tropical food plants. The spectrum of the type A was always allotted to the starches extracted from cereals and the spectrum of the type B allotted to the starches extracted from the tubers and roots according to Duprat *et al.* (1980) but it will be noticed here that the starch extracted from *D. dumetorum* is an exception because its crystalline structure is of type A like the cereal starches.

CONCLUSION

The starches are characterised by a morphological diversity of the granule from one specie to another. Except the starch of *D. dumetorum* which has a crystalline structure of type A similar to that one of the cereal starches. The other studied starches have a crystalline structure of type B like the majority of the roots. Obtaining new data in the investigation of starches properties could allow a significant projection on knowledge of the wild yam (*Dioscorea* sp.) tubers species and contribute to their popularization.

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