# A Comparative Study of the Syneresis of Yam Starches and Other Modified Starches

Amani N. G.[1*], Tetchi F. A.[1], Dufour D. [2] and Kamenan A.[1]

[1] UFR/STA, Université Abobo-Adjamé, 02 BP 801 Abidjan, COTE D'IVOIRE
[2] CIRAD-AMIS, 73 Rue J.F. Bréton, 34398 Montpellier, France.
*Corresponding author

**Abstract**

**The syneresis of starch gels from 19 yam cultivars (belonging to 4 *Dioscorea* species and complex of species) and 5 modified starches were studied during refrigeration (4°C) and freezing (-20°C).**

**Syneresis of starch gels evolved on refrigeration at the onset from zero and remained constant between 20% to 60% after 8 weeks of storage for all the yam species. The cultivars *Daminangba* (*Dioscorea alata*) and *Assawa* (*Dioscorea cayenensis*) were the most refrigeration-resistant. During freezing, syneresis of yam gels evolved from zero and remained constant in the 56 - 70% interval for the *D. alata*, 35 - 70% for the *D. cayenensis-rotundata* complex, and 37 - 55% for *D. dumetorum* and *D. esculenta*. The *Kpokpokpo* (*D. cayenensis-rotundata*) was the most freeze-resistant cultivar. The resistance during refrigeration of *Daminangba* and *Assawa*, as well as the freeze resistance of *Kpokpokpo* were in all cases less than those of *Amioca* and *Colflo* 67, the best modified commercial starches. Treatment of yam gels with appropriate doses of hydrophilic ingredients might be necessary to reduce their syneresis to acceptable levels.**

**Keys words**: Syneresis, Refrigeration, Freezing, Stability, Yam starch.

## Introduction

More than 600 species of yams are recorded in the *Dioscorea* genus (Coursey, 1967). Some of them are found in the temperate regions while the majority are in the inter-tropical humid zone. In West and Central Africa, the 5 most cultivated species and/or complex species are the *D. alata*, *D. bulbifera*, *D. dumetorum* (Pax), *D. esculenta* (Lour), and the complex *D. cayenensis* Lamk - *D. rotundata* Poir. The major component of yam is starch which represents about 80% of dry tuber weight (Degras, 1986).

Starch is a plant polysaccharide whose gel forms a hydro-colloid mostly used in food and non food industries. In the food domain, it constitutes an essential tool for increasing the added-value and acceptability during preparation of several foods as textural agents (thickening, stabilising, gelifying). With respect to water content, temperature and the presence of other ingredients, the starch solution could behave as a viscous liquid or as a gel. Its behaviour during cooking and its aptitude towards some transformations allow for the starch to be used in frozen, refrigerated and thawed food formulations. Meanwhile, when starch gels or starchy foods are frozen and then thawed, or even when subjected to thermal fluctuations - situations that are obvious during processing, storage or distribution - certain changes in quality could occur. Amongst these is syneresis, a spontaneous separation of liquid from the gel suspension following contraction of the gel (Lapedes, 1978). Syneresis is equally defined as the partial expulsion of the soluble phase from the gel.

The objective of this study is to evaluate the syneresis of starch gels from yam in Côte d'Ivoire and other modified starches, in a bid to ascertain their suitability as ingredients in refrigerated, frozen and deep-frozen foods.

## Materials and Methods

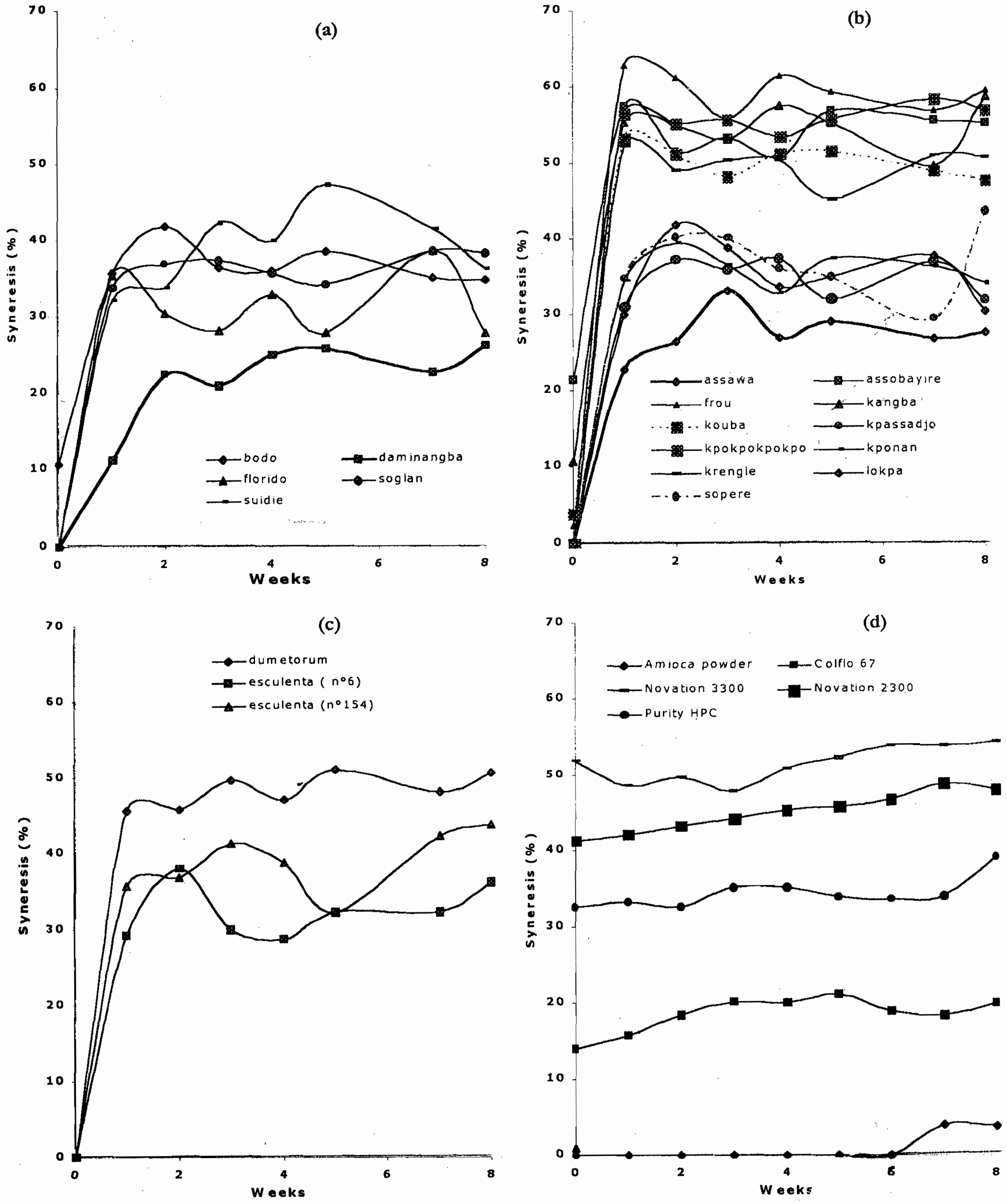
### Raw materials

The study was conducted on 19 cultivars belonging to 4 yam species and complex of species of the *Dioscorea* genus (**Table 1**). For the purpose of comparison, three

**Table 1.** Different yam cultivars studied

| Species | Cultivars | |
|---|---|---|
| *Dioscorea alata* | - Bodo<br>- Daminangba<br>- Florido | - Soglan<br>- Suidié |
| *Dioscorea cayenensis-rotundata* | - Assawa<br>- Assobayirè<br>- Frou<br>- Kangba<br>- Kouba<br>- Kpassadjo | - Kpokpokpo<br>- Kponan<br>- Krenglè<br>- Lokpa<br>- Sopèrè |
| *Dioscorea dumetorum* | - Dumetorun | |
| *Dioscorea esculenta* | - Esculenta 6 | - Esculenta 154 |

**Fig. 1.** Evolution of the syneresis of starch gels during refrigeration at 4°C: (a) *D. alata* (b) *D. cayenensis-rotundata* complex (c)- *D. esculenta* and *D. dumetorum* and (d) Modified commercial starches.



classes of commercial starches (from the National Starch and Chemicals Co, England) were also involved. These were the waxy maize starch (*Amioca powder*), chemically- modified starches (*Colflo 67* and *Purity HPC*), and physically-modified starches (*Novation 2300* and *Novation 3300*).

### Starch extraction

Starch was extracted using a modified version of the method of Banks and Greenwood (1975). Tubers were peeled, sliced and steeped in 0.1% sodium bisulphate solution. The slices were ground in a Warring blender (Moulinex) and the paste recovered in 4% sodium chloride solution and then sieved successively through 500 µm, 250 µm and 100 µm sieves. The starches were alternatively decanted and washed at least 4 times. The deposit obtained was spread on an aluminium foil and oven-dried at 45°C for 48hrs. The dry product was ground, quantified and then stored.

### Preparation of starch gels and measurement of syneresis

The gels (4% w/w) were prepared by dissolving each starch in distilled water and heating for 15 min, accompanied by agitation. About 10 g gel portions were cooled to room temperature and then centrifuged at 2660 *g* at 20°C for 30 min. At this point, initial syneresis was evaluated (week 0), and the remainder of gels either refrigerated at 4°C or frozen at -20°C for a period of 8 weeks. Every week, two test portions of each storage group were retrieved. The frozen gels were thawed at 50°C for about 90 min while the refrigerated portions were thawed at room temperature for about 60 min. All the tubes were then centrifuged as previously described.

Syneresis was determined as the percentage ratio of the mass of separated liquid to that of the initial gel portion (Schoch, 1968).

## Results and Discussion

### Effect of refrigeration on syneresis of starch gels

**Figure 1** represents the evolution in syneresis behaviour of the yam starch and modified starch gels during storage at 4°C.

The syneresis of gels of yam cultivars was virtually zero at the onset except for *Bodo* at 10% (**Fig. 1a**), and *Kangba* and *Assawa* (**Fig. 1b**) respectively at 10% and 21%. This syneresis increased considerably during the first week of storage and then levelled off in the 20 - 45% interval for *D. alata*, 25 - 60% for *D. cayenensis-rotundata*, and 30 - 50% for *D. dumetorum* and *D. esculenta*. Specifically for *D. cayenensis-rotundata* complex of species two groups of cultivars could be identified (**Fig. 1b**); a first with a syneresis stabilised at 25 - 40% (cv. *Assawa*, *Lokpa*, *Kpassadjo*, *Kponan* and *Sopèrè*) and a second at 50 - 60% (cv. *Kouba*, *Krenglè*, *Assobayirè*, *Kpokpokpo*, *Kangba* and *Frou*). As for modified starches (**Fig. 1d**), syneresis was constant throughout the period of storage. These were at about 0%, for the waxy maize starch (*Amioca*), 52% and 41% for the physically-modified starches (*Novation 2300* and *Novation 3300*) and 17% and 33% for the chemically-modified starches( *Colflo* 67, and *Purity HPC* ).

Syneresis is a phenomenon that expresses gel retrogradation and involves reorganisation of amylose and amylopectin molecules. This reorganisation is at the onset not effective in yam starches and as such accounts for their low syneresis. This syneresis increases considerably thereafter (on continued storage) which is characteristic of the effective amylose reorganisation. The rate of gel retrogradation is known to be partially correlated with its amylose content (Dufour *et al.*, 1996), and this should account for the poor retrogradation of modified waxy maize (*Colflo* 67 and *Purity HPC*) which have a zero amylose content.

The relative low syneresis of cv. *Daminangba* (**Fig. 1a**) and cv. *Assawa* (**Fig. 1b**) indicate that amongst the yam cultivars, these were the most resistant to refrigeration. They were however less resistant than the modified *Colflo* 67 and *Amioca* starches.

### Effect of freezing and thawing on syneresis of starch gels

Figure 2 presents the evolution in syneresis of yam starch and modified starch gels following freezing and thawing.

Syneresis increases considerably and stabilises from the second week at the 55 - 70% interval for the *D. alata* (**Fig. 2a**), 35 - 70% for *D. cayenensis-rotundata* (**Fig. 2b**) and 37 - 55% for *D. dumetorum* and *D. esculenta* (**Fig. 2c**). The modified starches showed stable syneresis from the onset (**Fig. 2d**) and throughout 8 weeks of storage.

A "spongy" texture is generated following prolonged freezing and thawing of starch gels, characteristic of the maximum reorganisation of amylose and amylopectin molecules (Pingault, 1995; Dufour *et al.*, 1996; Zheng and Sosulski, 1998). This structure was not attained by the different plant species after the same duration of freezing. Amongst the yam cultivars, cv. *Kpokpokpo* (**Fig. 2b**) and cv. *Esculenta* 6 (**Fig. 2c**) were the most resistant to freezing whereas *D. alata* (**Fig. 2a**), *Kangba* and *Frou* (**Fig. 2b**) were the least resistant. On the whole, our results are much lower than those of Pingault (1995) who obtained about 60% syneresis for frozen yam starches centrifuged at 7900*g*. It is worth noting that the difference in syneresis could arise from differences in centrifugal force (Eliasson and Kim, 1992).

On the whole, syneresis of yam gels was greater during freezing than during refrigeration (**Figure 3**), indicating clearly the effect of the former on the molecular reorganisation of amylose and amylopectin. This phenomenon is translated as a maximum release of water from the gel.

## Conclusion

Syneresis differed between the different yam species (non species-specific) and their cultivars. In terms of cold resistance, cv. *Daminangba* (*D. alata*) and *Assawa* (*D. cayenensis-*

**Fig. 2.** Evolution of the syneresis of starch gels during freezing at 20°C: (a) *D. alata* (b) *D. cayenensis-rotundata* complex (c) *D. esculenta* and *D. dumetorum* and (d) Modified commercial starches

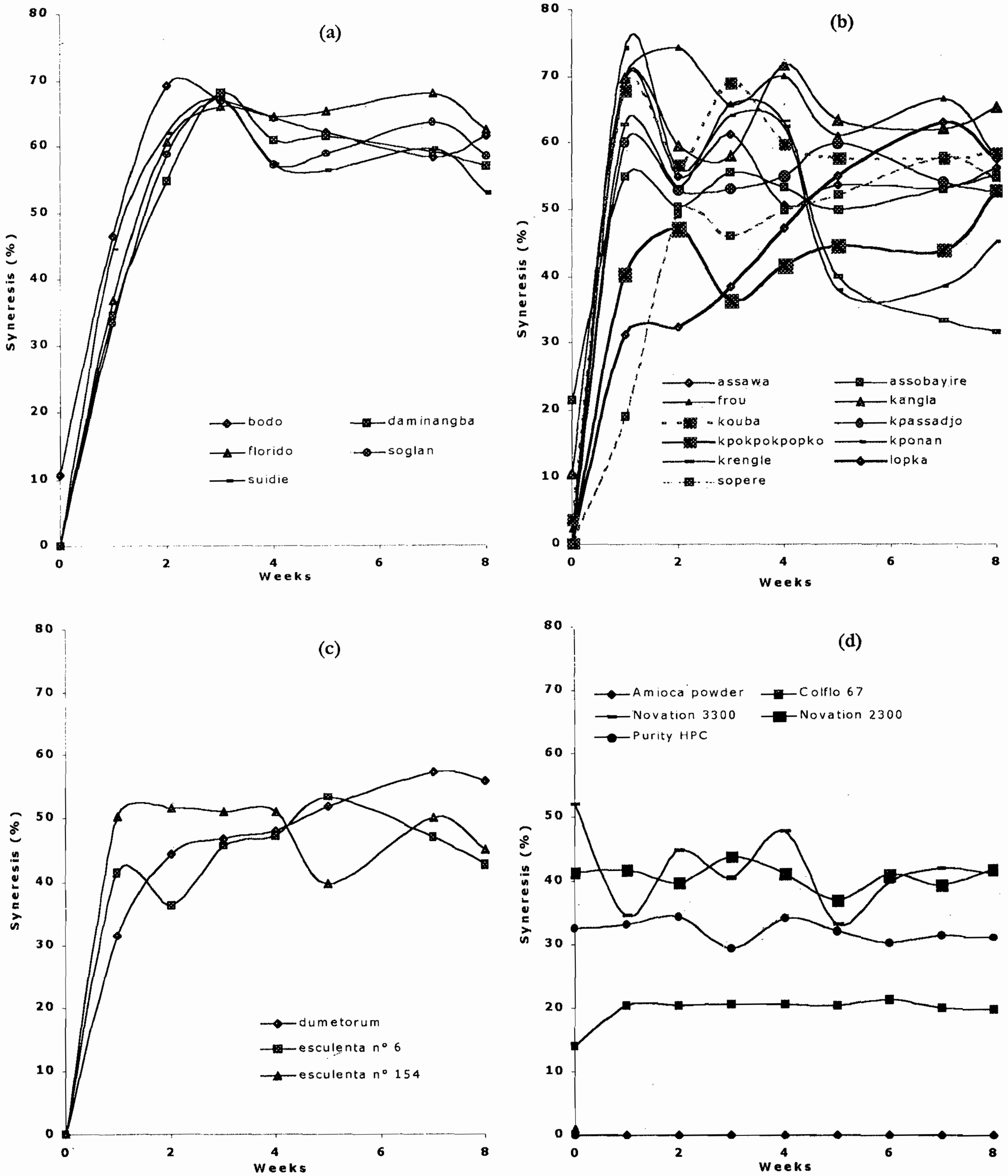
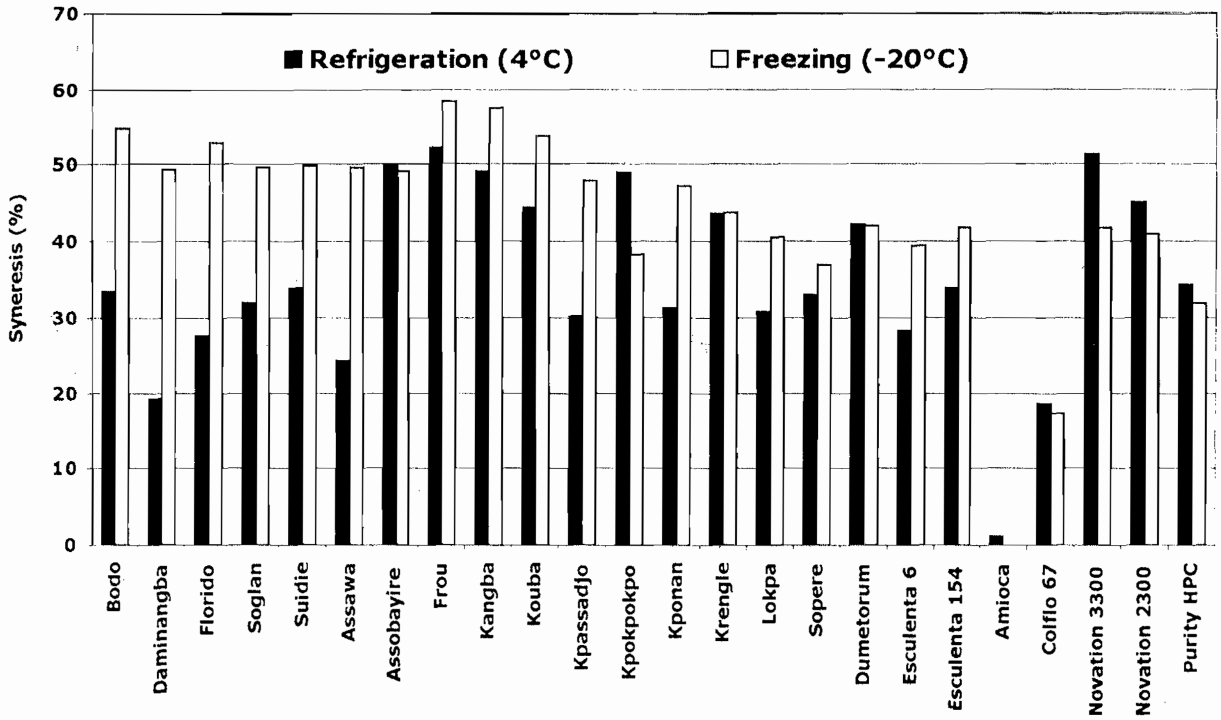


**Fig. 3.** Comparative effect of refrigeration and freezing on the syneresis of yam and modified starch gels.




*rotundata*) were the most freeze-resistant and cv. Kpokpokpo (*D. cayenensis-rotundata*) and cv. *Esculenta* 6 (*D. esculenta*) were the most refrigeration-resistant. On the other hand, *D. cayenensis-rotundata* cultivars (*Assobayirè*, *Frou*, *Kangba* and *Kpokpokpo*) were the least freeze-resistant while those of *D. alata* (cv. *Bodo* and *Florido*) and *D. cayenensis-rotundata* (cv. *Frou* and *Kangba*) were the least refrigeration-resistant.

Yam starch gels were less resistant to cold storage than *Colflo* 67 and *Amioca powder* which are the best commercial starches. Additional treatment of yam gels with appropriate doses of hydrophilic ingredients might be necessary to reduce their syneresis.

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