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YAM PROCESSING TECHNOLOGY

R. H. WALTER (°)

INTRODUCTION

The yam *(Dioscorea spp.)* contains 25-33 % starch (Winton and Winton 1935), the highest concentration of any constituent with the exception of water. Thus this tuber is described as a starchy food.

Rodriguez-Sosa and Gonzalez (1972) and Gooding (1973) have already outlined the technology of "instant yam" production in the Caribbean. They recognize "stickiness" to be a major textural problem with its origin in the starch fraction. Indeed, the nature and properties of all starch are variables that are influenced by factors which are inherent in the processes. Some of these factors are prior yam history, concentration, heating, cooling, amylose-amylopectin ratio, additives and a state of rest. In this presentation, the macro-molecular basis of starch dysfunctionality is reviewed.

PHYSICAL-CHEMICAL PROPERTIES OF (YAM) STARCH

The starch molecule consists of hundreds of glucose units, linked together as branched (amylopectin), and straight (amylose) chains. These chains interact to form a network of partially crystalline structures that appear under the microscope as granules.

The length of the starch molecules endows starch with special properties that are unique for macromolecules, polymers and micelles with diameters in the 1 mμ - 500 mμ range. Of these properties, water-holding capacity, gelatinization viscosity and retrogradation are most important in yam processing. The network structure conveys on starches an ability to absorb many times their weight in water.

Generally, yam-starch granules are uniformly fine-grained. Consequently, they tend to be susceptible to moist heat, and disintegrate upon prolonged cooking (Martin, 1974).

Some yams have a high (34 %) amylose content (Cruz-Cay and Gonzalez, 1974). These starches will be relatively more resistant to heat, because the internal bonding forces generated at the difficultly soluble crystalline sites, where the amylose chains orient almost unidirectionally, impart great stability to the granules.

When moist heat (cooking) is applied to yam starch, the individual polymers become energized, hydrated and swollen. This condition, termed gelatinization (Corn Industries Research Foundation, 1964), occurs over a short temperature range. At the upper limit, the highest degree of swelling is reached, and the granules exhibit the maximum viscosity. Thereafter, further energizing by heat or mechanical agitation disrupts the granule's architecture, releasing starch to the external medium, and, in effect, diluting the concentration. The viscosity decreases to a minimum value which is, itself, subject to internally and externally induced variation.

The same associative forces that impart stability to the unheated granules initiate in the de energized (by cooling, refrigeration or freezing) micelles a

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(°) Cornell University Department of Food Science & Technology NYS Agricultural Experiment Station Geneva, NY 14456.

tendency to revert to the prior state of insolubility (retrogradation), whereby the dispersed polymers re-align themselves and lose water in the process (syneresis). Retrogradation is manifest by scab formation upon cooling, by precipitation in dilute concentration, and by gelation at high concentrations. The strength and rigidity of these gels (Osman, 1967) might permit high-amylose yam flour to be partially substituted for the more tenacioux wheat flour in conventional cooking (Martin, 1974). However, in those food items where the substitution is made, rapid textural changes can be expected (Brennan and Sodah-Ayernor, 1973).

Foods with an acid reaction will "thin out" by heating, as a result of starch hydrolysis (Glicksman, 1969). High concentrations of sugar will impede gelatinization, increase viscosity and decrease gel strength (Osman, 1967). Surfactants have a multiple effect (Osma, 1975), including a retarding influence on retrogradation (Zobel, 1973). Amylopectin exerts a similar retarding influence, due to its branched conformation which hinders the straight-chain realignment of amylose.

CRITICAL STEPS IN YAM PROCESSING

The post-harvest events that culminate in "instant yam" are, as follows :

- * storage
- washing
- peeling
- slicing
- sulfite addition
- * cooking
- * mashing
- chemical additions
- * dehydrating
- milling
- packaging
- * storage

The final flakes or powder should be free-flowing and of uniform texture. These quality criteria will be met, if all operations are designed to preserve the vegetable-cell structure and starch granulation. Otherwise, small particles and free soluble starch will result in undesirable stickiness and accelerated retrogradation (Rodriguez-Sosa and Gonzalez, 1974). In order to assure high product-quality, the processor should take adequate precaution at those critical points (identified by *) where uncontrolled dehydration, the accumulation of extra-cellular starch, a predisposition towards micelle formation, or mechanical action and heat are prone to disintegrate the particle structure. Conversely, rehydration during long storage after packaging will provide the necessary medium in which the starch micelles are able to re-orient themselves and retrograde.

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SUMMARY

Inferior texture and functionality of yam-starch products have primarily a macro-molecular basis. The separation of water of syneresis on stored food suspensions is visually undesirable. Stickiness is attributable to a disrupted granular structure which results in accumulation of extra-cellular starch. The "thinning out" of cooked yam-starch has its origin also in loss of granulation, and in molecular disintegration at high levels of energy input. Jelly collapse, scab formation and syneresis are manifestations of the tendency of the carbohydrate polymers to reassociate into micelles.

Good processing technology should involve an awareness of the critical steps where the control of internal and external variants during manufacturing will affect the outcome.