

Functional properties of unmodified and modified Jack bean (*Canavalia ensiformis*) starches

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ABSTRACT

The native Jack bean (*Canavalia ensiformis*) starch was chemically modified through oxidation and acetylation. Proximate composition analysis revealed higher moisture, protein, fat and ash contents 'native unmodified than modified starches and higher yield in modified starches. Swelling capacity and solubility of all the starches increased with increasing temperature and pH (up to their optimum point); Oil absorption capacity of modified

starches are found to be higher than unmodified starches, but reversed is the case for water absorption capacity. Gel forming capacity indicates the highest LGC for oxidized and lowest LGC for unmodified starches. Acetylated starch was found to have highest alkaline water retention capacity than others starches studied.

Key words: Functional properties, jack bean, starch, acetylation, oxidation

INTRODUCTION

Starch is a carbohydrate polymer made up of an hydroglucose units linked primarily through alpha-1, 4 glucosidic bonds. Diversity stems from a starch's mixture of two types of polymers- amylose and amylopectin. The different characteristics of these molecules play a central role in the versatility of starch in foods. Physical and chemical modifications lead to other differences, which expand the uses of starch. (Carroca, *et al.* 1996).

Starches can be physically modified in a number of ways, including different drying techniques, to provide pearl starches and pregelatinized starches, re-dried starches, agglomerated starches or cold-water-swelling starches. Cold-water-swelling starches, also known as granular starches, have been physically modified to retain granular integrity in a pregelatinised starch (Ronald, 2002). They are not

drum-dried as regular pregelatinized starches. Forms of chemical modification of starch have been practiced commercially for the past years, starting with dextrinization and, later, hydrolysis with acid and / or enzymes. Other forms of chemical modification are oxidation, cross-linking and substitution. Starch-modification techniques allow manufacturers to customize starch properties for any number of applications. Modified starches played a significant role in fat-reduction products, fat replacers in dairy applications, baking applications and meat applications (Kunkpetoon and Wang, 2001).

Legumes contain about 60% carbohydrates in which starch constitutes the major portion (Sathe and Salunkhe, 1981). Jack beans (*Canavalia ensiformis*), a legume nutritive values have been investigated (Bamiro *et al.*; 1994). However, no

information about its physico-chemical properties of its native starch, oxidized starch and acetylated starch. It is the objective of this study therefore, to provide information on the proximate composition, effect of temperature and pH on solubility and swelling properties of jack bean starches.

MATERIALS AND METHODS

Collation of sample and isolation of starch.

Jack bean was obtained at Abeokuta, Nigeria. The seeds were dehulled, sun-dried ($30 \pm 2^\circ\text{C}$) and ground to pass through a 60-mesh sieve (British standard) to obtain fine powder. The starch was isolated from the sample fine powder using the method of Sathe and Salunkhe, (1981)

Acetylation and Oxidation of Starch.

Twenty percent starch slurries (w/v) in distilled water were used for both acetylation and oxidation by following the description of Sathe and Salunkhe, (1981).

Proximate composition

Standard methods of the Association of Official Analytical Chemists (AOAC, 1984) were used for moisture, nitrogen (protein was 6.25%) fat, and ash determinations.

Water and Oil Absorption Capacities

The water and oil absorption characteristics of the unmodified and modified starches were determined as described by Oshodi and Ekperign (1989).

Solubility and Swelling

The solubility swellings of the unmodified and modified starches were determined using Sathe and Salunkhe (1981) method. Effect of pH on solubility and swelling of starches was carried out by preparing 1% (w/v) slurry in distilled water and pH adjusted to the desired value with 0.1 M HCl or 0.1 M NaOH. The slurries were allowed to stand at room temperature for 30 min, centrifuged (2,500rpm) and the solubility (%) and swelling (%) were determined. Effect of temperature on solubility and swelling of starch was similarly studied by preparing 1% (w/v)

starch slurry in distilled water for 30min at the desired temperature (60, 70, 80 and 90°C).

Alkaline water retention capacity.

Jack bean and wheat flour was blended to give 10, 20, 30, 40, and 50% purified starch. 1g of each blend were introduced into a test-tube; 5ml of 0.1MNaHCO_3 was added and mixed for 30 sec in a vari-whirl mixer. The samples were allowed to stand for 25min at room temperature, centrifuged at 2,000rpm for 15min. and drained for 10min. The test tubes with their contents were weighed and the alkaline water retention was calculated.

Gelation

The least gelation concentrations of the unmodified and modified Jack bean starches were determined according to the methods of Coffman and Garcia (1977)

RESULTS AND DISCUSSION

The chemical composition of unmodified, oxidizes and acetylated Jack bean starches are shown in Table 1. Table 2 shows that modification of Jack bean starch reduces water absorption capacity. Gelation properties of native and modified jack bean starches are shown in Table 3. Effect of modification on the gelation of Jack bean starches was given in Table.4. . Effect of temperature on solubility, pH on solubility, temperature on swelling, and pH on swelling of Jack bean starches are shown in Figs. 1,2,3 and 4 respectively.

Unmodified Jack bean starches have more moisture, protein, fat and ash contents than modified starches. However, acetylating and oxidation reaction does not induce important changes in the derivatives composition produced according to the treatments obtained compared with the native starch (Table 1). Acetylated Jack bean starch had higher water absorption capacity than oxidized starch. Oxidized and acetylated Jack bean starches had the higher oil absorption (4.51, 4.19% respectively) than native starch (3.8%). This shows that oxidation and

acetylating can be used to improve oil absorption capacity of jack bean starch.

Acetylating and oxidation increased the solubility (Fig. 1) and swelling power of the granules (Fig.3). The highest solubility and swelling capacity in all cases were observed at 90°C. This shows that penetrating power of water into the granules of the starches studies can be increased at high temperature. This trend has been observed for *Canavalia ensiformis* by Ancona, et al (1997) and bambara groundnut by Lawal et al (2004).

The highest solubility and swelling capacities of acetylated sample starch may be due to the introduction of hydrophilic substituting groups that allow the retention of water molecules because of their ability to form hydrogen bonds. This ensures high retention of water that enters the granule, increasing the swelling capacity. This is a useful property in the manufacture of some confectionary products. The effect of pH on solubility and swelling capacity of Jack bean starches is presented in Fig. 2 and 4 respectively. In both cases, modified starches recorded higher solubility and swelling capacity at various pH. Maximum solubility was obtained at pH 6, 10, and 10 for unmodified, oxidized and acetylated starches respectively. While that of swelling capacity are at pH 8, 8 and 10 for

unmodified, oxidized and acetylated starches respectively.

Figs. 1, 2, 3 and 4 however, show that maximum solubility and swelling capacity could be obtained at 90°C and pH 6-8 for unmodified; 90°C and pH 8-10 for oxidized; and 90°C and pH 10 for acetylated jack bean starches.

Using the least gelation concentration (LGC) as an index of gelation, the result obtained in this study indicates the highest LGC for oxidized starch and lowest LGC for unmodified starch. In all the samples studied, increasing concentration facilitated gelation properties. This may be due to the enhancement of interaction occurred among the binding forces as the concentration increased. The introduction of carbonyl and carboxyl groups probably caused intermolecular repulsions that limited interaction of oxidized starch molecules, which led to reduction in gelation properties. (Lawal, et.al, 2004).

Considering the values of alkaline water retention capacity of unmodified and modified starches (Table 4) shows that acetylated starch have highest alkaline water retention capacity. This may be due the fact that the protein components of wheat flour cannot realize their full potentials in the presence of acetyl group.

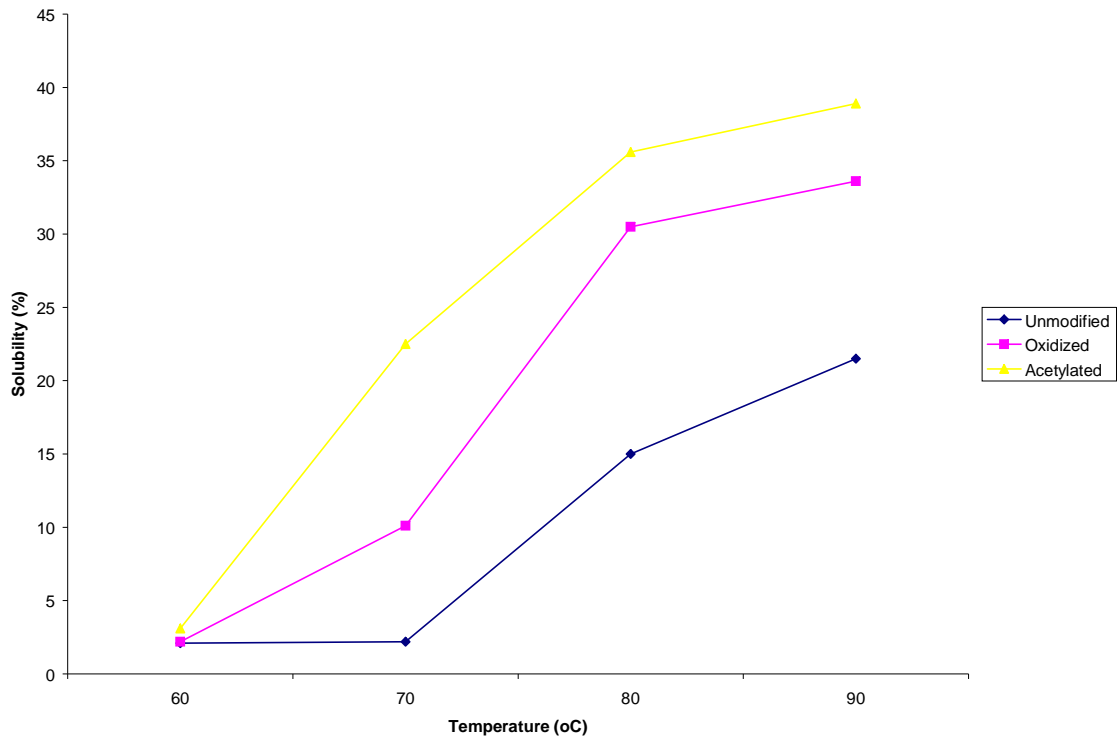


Fig 1. Effect of temperature on solubility of Jack bean starches.

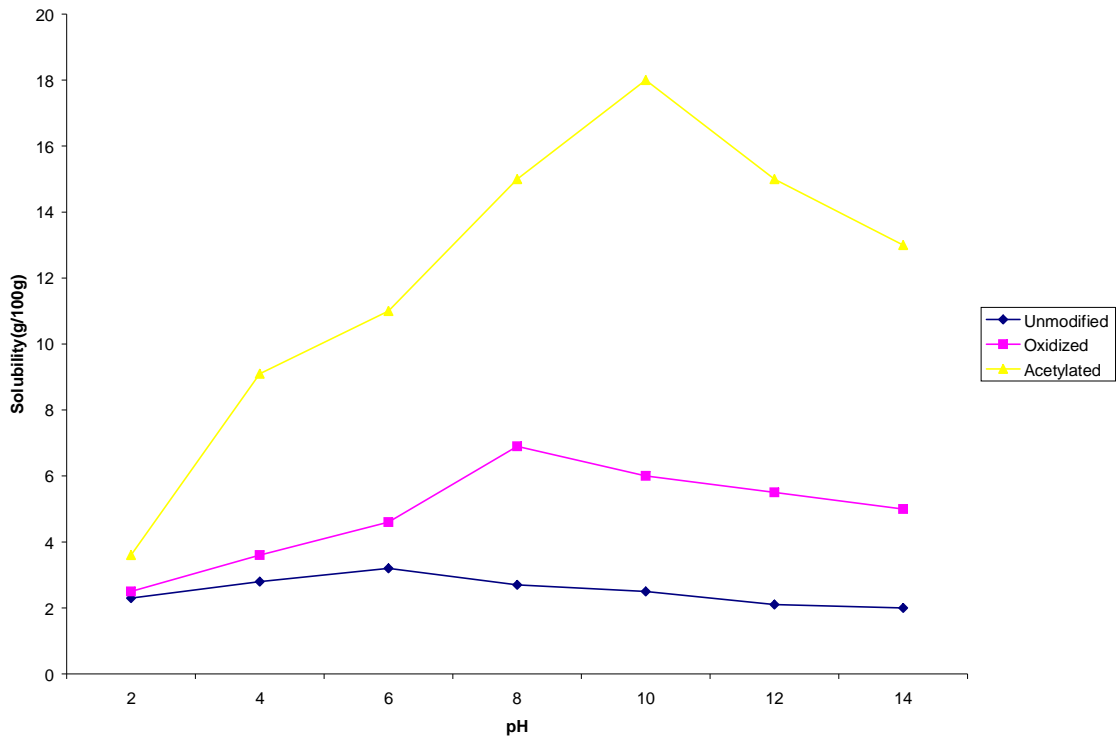


Fig 2. Effect of pH on solubility of Jack bean starches

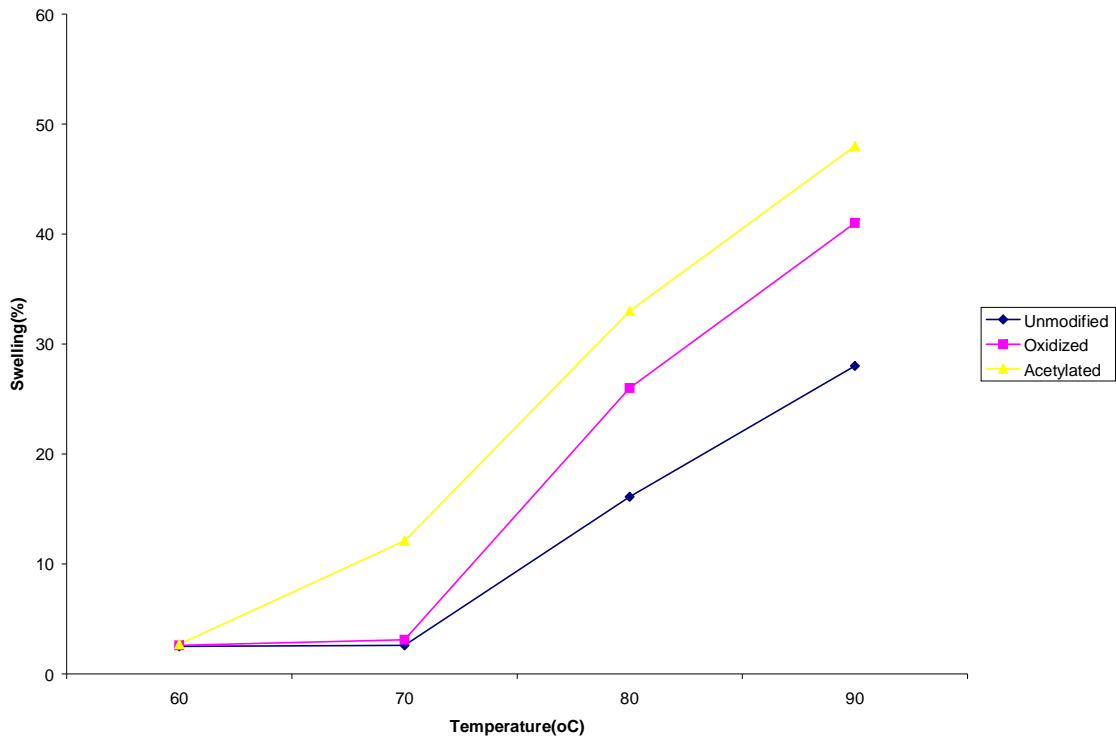


Fig 3.Effect of temperature on swelling of Jack bean starches

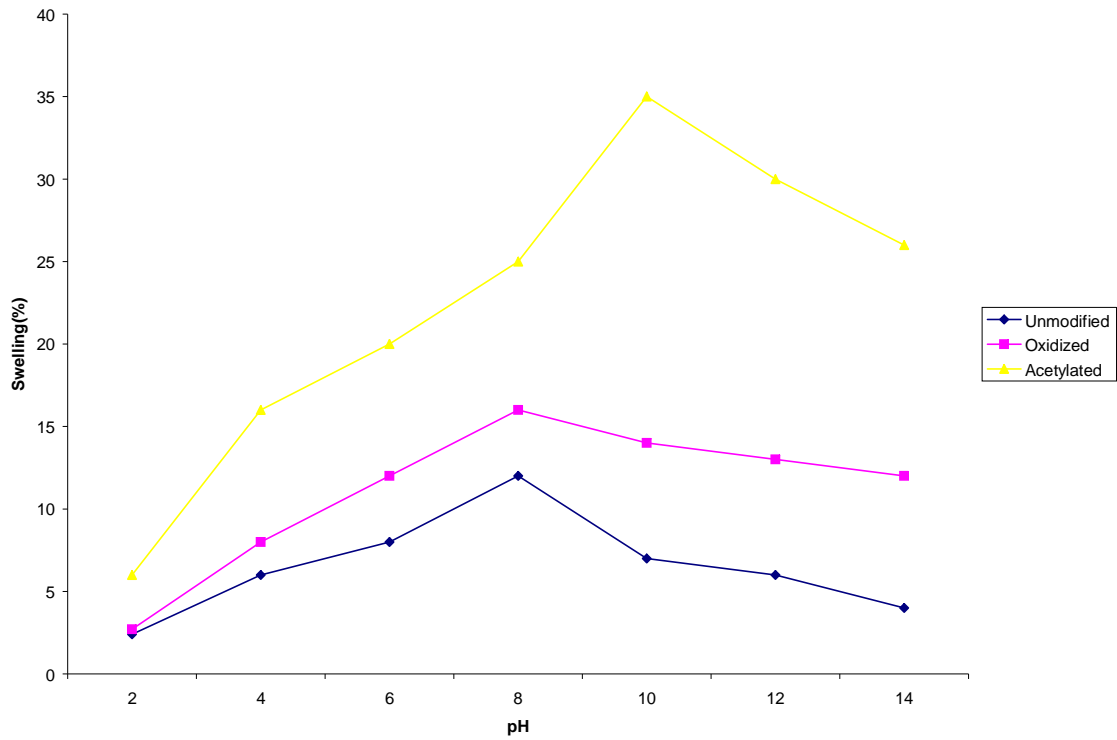


Fig 4. Effect of pH on swelling of Jack bean starches

Table 1. Proximate composition of Jack bean starches.

Parameter (%)	Unmodified	Oxidized	Acetylated
Yield	37.20±1.12	87.34±2.01	81.28±2.31
Moisture	10.31±0.34	2.89±0.10	4.50±0.51
Protein	0.92±0.06	0.47±0.08	0.73±0.05
Fat	0.36±0.01	-	-
Ash	0.10±0.01	-	-

All values are shown as means ± SD

Table 2. Water and oil absorption capacities of Jack bean starches

	Unmodified	Oxidized	Acetylated
Water absorption capacity (%)	3.11±0.22	1.75±0.11	2.81±0.01
Oil absorption capacity (%)	3.80±0.31	4.51±0.21	4.19±0.32

All values are shown as means ± SD

Table 3. Alkaline water retention capacity (AWRC) of unmodified, oxidized and acetylated Jack bean starches.

Starch and Wheat flour blend		AWRC (g/g)		
Starch (%)	Wheat flour (%)	Unmodified	Oxidized	Acetylated
100	0	2.26±0.01	2.32±0.02	3.51±0.03
90	10	1.91±0.02	2.26±0.01	3.22±0.01
80	20	1.64±0.01	2.10±0.02	2.74±0.04
70	30	1.46±0.01	2.37±0.03	2.15±0.02
60	40	1.40±0.03	1.96±0.01	2.04±0.01
50	50	1.30±0.02	1.86±0.03	1.96±0.01

All values are shown as means ± SD

Table 4. Effect of modification on the gelation of Jack bean starches.

Concentration (% w/v)	Unmodified gelation remark	Oxidized gelation remark	Acetylated gelation remark
2	- Liquid	- Liquid	- Liquid
4	- Viscous	- viscous	- Liquid
6	+ Gel (LCE)	- Viscous	- Viscous
8	+ Gel	+ Gel (LCE)	- Viscous
10	+ Firm Gel	+ Gel	- Viscous
12	+ Firm Gel	+ Firm Gel	+ Gel (LCE)
14	+ Solid Gel	+ Firm Gel	+ Gel
16	+ Solid Gel	+ Solid Gel	+ Firm Gel

(-) = no gelation, (+) = gelation, and LCE = Least concentration endpoint, which is the lowest starch concentration at which gel remained in the inverted tube.

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