PHYSICO-CHEMICAL CHARACTERISTICS OF MODIFIED STARCH AND ITS USES IN FOODS

By

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B.Sc. Agric. Sc. (Food Technology), Cairo University, 1981

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ABSTRACT

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In the present study, the effect of pregelatinization, acid-thinning and dextrinization methods on physico-chemical and rheological properties of corn, potato and common bean starches were investigated. Native and modified starches were used for substitution wheat flour at 5, 10 and 15% in noodle preparation and its quality properties were determined. In addition, salad dressing was produced by replacing 5% of fat with native and modified starches.

Data showed that moisture content of analyzed samples ranged from 9.70 to 14.45%, these obtained values were less than 20% and were acceptable. Water and oil binding capacity increased after pregelatinization, which may be attributed to the fact that hydrophilic tendency of starch increases after heat-moisture treatment (HMT). Generally, significant differences in swelling power were observed between native and modified corn starches at 50, 70 and 90^{o}C. The decrease in maximum viscosity of modified corn starch was observed for pregelatinized starch (940 B.U) followed by (1050 B.U) for acid-thinned starch in comparison to 1080 B.U for native corn starch.

It could be indicated that native and modified potato starches had a significant effect on weight and volume increase, in addition to cooking loss of noodles prepared with substitution of wheat flour by 5, 10 and 15% levels of native and modified potato starches. Generally, the all noodle samples containing 5, 10 and 15% of native and pregelatinized corn starches were acceptable in comparison to the control ones. Taste panel members showed preference for noodles containing 100% wheat made from wheat flour (control), 5, 10, and 15% of native and pregelatinized potato starches and 5% of acid-thinned potato starch.

Data also showed that fat content in salad dressing containing 5 % of dextrinized potato starch was relatively lower (73.99%) in comparison to 75.99 % for control salad dressing, without significant difference in fat content could be detected between the samples containing native, pregelatinized, acid-thinned and dextrinized potato starches. The protein content of control salad dressing and the samples containing acid-thinned and dextrinized common bean starches was slight higher than of those containing native and pregelatinized common bean starch. No significant differences in appearance, color, flavor, consistency and acceptability of salad dressing samples containing native, pregelatinized and acid-thinned corn starches could be detected by the panel and exhibited the higher appearance, consistency, acceptability and total score in comparison to those of the control sample and that containing dextrinized corn starch.

It could be concluded that 5 and 10% of native corn starch and 10, 15% of pregelatinized corn starch can used in partially replacement of wheat flour which used in manufacturing of noodles without negative effects on their cooking quality and sensory characteristics. On the other hand, the control salad dressing and all salad dressing samples containing 5% of native and modified corn or potato, common bean starches were acceptable, except that containing dextrinized starch.

Key Words: Modified corn starch, modified potato starch, modified common bean starch, physico-chemical properties, noodles, salad dressing

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1. INTRODUCTION

Starch is one of the most abundant carbohydrates in nature and present in many food plants. Traditional staple foods such as cereals, roots and tubers are the main source of dietary starch. Starch is one of the main energy sources in our diet. The word starch is derived from the Middle English sterchen, meaning to stiffen, which is appropriate since it can be used as a thickening agent when dissolved in water and heated.

Starch is an important ingredient for the food industries, whereas starches with specific properties are necessary to impart functionality desirable attributes to foods. Native starches provide viscous, cohesive and sticky pastes when they are heated and gels when these pastes cool off (**Adebowale *et al.*, 2005**). In general, native starch presents low shear stress resistance and thermal decomposition, in addition to high retrogradation and syneresis. Native corn starch can be modified to obtain pastes with specific attributes that can resist extreme food processing requirements like heat, stirring and low pH conditions.

Starch modification may be done by physical or chemical methods. Physical modification is made using heat and moisture (pregelatinization); while chemical treatments involve the introduction of functional groups into the starch molecule using reactions of derivatization (etherification, esterification and crosslinking) or decomposition (acid or enzymatic hydrolysis and oxidation) (**Wurzburg, 1986 and Singh *et al.*, 2007**). Knowledge about physical and chemical modification effects on starch granules structure is necessary to understand their functional properties and allow developing starches with desired properties enhancing their uses, especially in food industry. Modification treatment, reaction conditions and starch source are critical factors that govern the pasting behavior of starch pastes (**Reddy & Seib, 1999; Gonzalez & Perez, 2002 and Singh *et al.*, 2004b**).

Noodles are widely consumed throughout the world and it is a fast growing sector of the noodle industry. The world instant noodle market is projected to reach 158.7 billion packs by the year 2010 (**Anonymous, 2008**). This is because noodles are convenient, easy to cook, low cost and have a relatively long shelf-life. It has been estimated that at least twelve percent of global wheat production is used for processing Asian noodle products (**FAO, 2005 and Hou, 2001**). Market research has typically indicated that consumption of noodles continues to expand rapidly in various countries in Europe, South America, the Middle East as well as, Asia. Of the many types of noodles, instant noodle is the fastest growing sector of these products. The unique processing, involving steaming and deep frying, gives instant noodles a distinctive flavor and texture (**Rho *et al.* 1986**). The texture of the noodle is expressed as rubbery, firm, or smooth (**Kubomura, 1998**).

Instant noodles should have a porous spongy structure as well as pregelatinized starch through the steaming process (**Wu *et al.* 1998**). During the frying process, many tiny holes are created as water is quickly dehydrated and replaced by oil on the surface of the noodles, serving as channel for water during cooking (**Hou, 2001**). Frying and steaming processes can enable quick serving compared with other types of noodles, and the processes are important in governing the quality of instant noodles (**Kim, 1996**).

Salad dressing is oil in water emulsion whereas oil, is the discontinuous phase and water is the continuous phase. According to Food and Drug Administration (FDA), Salad dressing is defined as a semisolid emulsified food with the same, ingredient and optional ingredients as mayonnaise with the exception of cooked starch paste. There are two types of salad dressing; pour-able and spoon-able dressing which vary in flavor, chemical and physical properties (especially viscosity). The example of spoon-able salad dressing is mayonnaise and the pour-able one is salad cream **Babajide and Olatunde (2010).**

Therefore, the purpose of the present study was to investigate the following main points:

1- Isolation of corn, potato and common bean starches and applied chemical and physical modifications of the obtained starches.
2- Studying the effect of starch modification methods on the chemical, physical and rheological quality of isolated corn, potato and common bean starches.
3- Feasibility of production of noodles by substitution of wheat flour with different levels of modified corn, potato and common bean starches.
4- Investigating the physical properties and sensory attributes of salad dressing produced by adding selected modified starches.

Table (1): Proximate composition of corn grain, potato tubers and common beans (% on dry weight basis).

Samples	Moisture	Crude protein (N x 6.25)	Lipids	Ash	Crude fiber	Nitrogen free extract (NFE)*
Corn	12.20 ± 0.20^{b}	10.14 ± 0.30^{b}	4.82 ± 0.10^{a}	2.28 ± 0.10^{b}	2.73 ± 0.30^{b}	80.03 ± 0.80^{b}
Potato	79.30 ± 0.10^{a}	10.14 ± 0.05^{b}	0.48 ± 0.05^{c}	4.35 ± 0.10^{a}	2.42 ± 0.15^{b}	82.61 ± 0.25^{a}
Common beans	9.60 ± 0.10^{c}	22.35 ± 0.20^{a}	1.77 ± 0.15^{b}	4.31 ± 0.20^{a}	3.76 ± 0.10^{a}	67.81 ± 0.45^{c}

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). NFE* calculated by difference.

Table (2): Proximate composition of native and modified corn starches (% on dry weight basis).

Starch samples	Moisture	Crude protein (N x 6.25)	Lipids	Ash	Nitrogen free extract (NFE)*
Native corn starch	11.40 ± 0.14^{c}	0.73 ± 0.01^{a}	0.58 ± 0.01^{a}	0.78 ± 0.02^{b}	97.91 ± 0.91^{c}
Modified corn starch					
Pregelatinized	11.65 ± 0.07^{b}	0.58 ± 0.01^{b}	0.29 ± 0.01^{d}	0.79 ± 0.03^{b}	98.33 ± 0.11^{a}
Acid-thinned	13.70 ± 0.10^{a}	0.42 ± 0.01^{d}	0.54 ± 0.01^{b}	0.70 ± 0.01^{c}	98.33 ± 0.03^{a}
Dextrinized	9.70 ± 0.14^{d}	0.54 ± 0.01^{c}	0.47 ± 0.01^{c}	0.90 ± 0.01^{a}	98.09 ± 0.13^{b}

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). NFE* calculated by difference.

Table (3): Proximate composition of native and modified potato starches (% on dry weight basis).

Starch samples	Moisture	Crude protein (N x 6.25)	Lipids	Ash	Nitrogen free extract (NFE)*
Native potato starch	14.05 ± 0.07[b]	0.55 ± 0.01[a]	0.18 ± 0.01[a]	0.22 ± 0.00[b]	99.91 ± 0.05[d]
Modified potato starch					
Pregelatinized	14.05 ± 0.07[b]	0.42 ± 0.01[b]	0.11 ± 0.01[d]	0.20 ± 0.01[c]	99.27 ± 0.27[b]
Acid-thinned	14.45 ± 0.10[a]	0.33 ± 0.01[d]	0.14 ± 0.01[c]	0.20 ± 0.01[c]	99.33 ± 0.06[a]
Dextrinized	13.70 ± 0.14[c]	0.35 ± 0.01[c]	0.16 ± 0.01[b]	0.30 ± 0.01[a]	99.20 ± 0.16[c]

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). NFE* calculated by difference.

Table (4): Proximate composition of native and modified common bean starches (% on dry weight basis).

Starch samples	Moisture	Crude protein (N x 6.25)	Lipids	Ash	Nitrogen free extract (NFE)*
Native common bean starch	12.40 ± 0.07^{a}	1.01 ± 0.01^{a}	0.67 ± 0.01^{a}	0.07 ± 0.00^{b}	98.25 ± 0.05^{d}
Modified common bean starch					
Pregelatinized	11.65 ± 0.07^{b}	0.86 ± 0.01^{b}	0.42 ± 0.01^{d}	0.06 ± 0.01^{c}	98.66 ± 0.06^{c}
Acid-thinned	11.70 ± 0.01^{b}	0.52 ± 0.01^{d}	0.54 ± 0.01^{b}	0.06 ± 0.01^{c}	98.89 ± 0.01^{a}
Dextrinized	11.70 ± 0.14^{b}	0.65 ± 0.01^{c}	0.48 ± 0.01^{c}	0.14 ± 0.01^{a}	98.73 ± 0.15^{b}

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). NFE* calculated by difference.

Table (5): Physical properties of native and modified corn starches.

Starch samples	Bulk density (g/cm^3)	WBC (g/g)	OBC (g/g)	pH
Native corn starch	0.766 ± 0.009^c	1.20 ± 0.02^b	1.60 ± 0.21^c	5.47 ± 0.01^c
Modified corn starch				
Pregelatinized	0.790 ± 0.006^b	1.49 ± 0.01^a	2.35 ± 0.07^a	5.43 ± 0.01^d
Acid-thinned	0.770 ± 0.003^c	1.22 ± 0.04^b	1.98 ± 0.21^b	6.72 ± 0.01^b
Dextrinized	0.850 ± 0.008^a	1.18 ± 0.08^b	2.21 ± 0.14^a	6.73 ± 0.00^a

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). WBC: water binding capacity, OBC: oil binding capacity.

Table (6): Physical properties of native and modified potato starches.

Starch samples	Bulk density (g/cm^3)	WBC (g/g)	OBC (g/g)	pH
Native potato starch	0.866 ± 0.001^{d}	1.42 ± 0.06^{b}	1.98 ± 0.21^{a}	6.48 ± 0.01^{d}
Modified potato starch				
Pregelatinized	0.877 ± 0.004^{c}	1.53 ± 0.04^{a}	1.84 ± 0.00^{a}	6.63 ± 0.01^{c}
Acid-thinned	0.889 ± 0.003^{b}	1.36 ± 0.01^{c}	1.93 ± 0.14^{a}	7.08 ± 0.01^{a}
Dextrinized	0.904 ± 0.004^{a}	1.37 ± 0.01^{c}	$1. 52 \pm 0.07^{b}$	6.97 ± 0.01^{b}

Data are the mean ± SD; n = 3, Values followed by the same letters in the same column are not significantly different ($p \leq 0.05$). WBC: water binding capacity, OBC: oil binding capacity.