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CHEMICAL, FUNCTIONAL AND BIOLOGICAL PROPERTIES OF MODIFIED CORN STARCH

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ABSTRACT

Chemical modified corn starch (CMS) such as; starch acetate (SA), starch succinate (SS) and starch phosphate (SP) were prepared, and their chemical, functional properties and biological effects were evaluated. Protein, fat and ash contents of corn starch were decreased by the modification process, except the ash content was increased in SP. Also, the amylose content was decreased in both SA and SP, while it was increased in SS. For functional properties, the obtained results showed that water absorption capacity (WAC) at 25°C and solubility at 90°C were increased in all CMS. Meanwhile, the viscosity was decreased in both SA and SP while, it was increased in SS. Swelling power at 90°C was decreased only in SP . Biological experiment was conducted on normal albino rats after feeding on diet containing 10% of modified starch, the result showed that feeding on both SA and SS decreased the final body weight , while feeding on diet containing SP caused slight increase in final body weight. The experiment on diabetic rats showed a significant decrease in body weight compared with normal rats. Also, feeding on SA significantly decreased serum glucose of healthy and diabetic rats . However , feeding on CMS had no significant differences on lipid fractions, kidney functions and liver functions on healthy rats compared with diabetic rats.

Keywords: starch acetate, starch succinate, starch phosphate, functional properties, biological properties, diabetic rats.

INTRODUCTION

Starch is the most important carbohydrate in all cereals and is a major source of carbohydrates in the human diet. The granules are used in foods because of their good thickening, gelling properties, and an excellent raw material for modifying food texture and consistency (Biliaderis,1991). However, use of native starches in industrial applications is limited because of several drawbacks , including low shear stress resistance, easy thermal decomposition , high retrogradation and syneresis .These shortcomings can be overcome by modifying the starch through chemical , physical or enzymatic methods (Agboola *et al.*, 1991) .

Chemically modified starches (CMS) are resistant to retrogradation , have higher viscosity and are more stable to acid and high temperatures than native starch . (Kishida *et al.*, 2000) . Many studies approach the chemical modification of starch as an alternative way of improving its hygroscopic properties. therefore, they are increasingly used in food industry to improve the physical properties of various food items (Larotonda *et al.*,2005).

However, CMS may also have beneficial nutritional propperties . The puplished results of the joint FAO / WHO (1976) expert committee on food additives showed that modified starches were considered toxicologically safe and may be used in foods without limitation or restrictions .Many investigators have observed a reduced susceptibility to enzymes *in vitro* and *in vivo* compared with the corresponding unmodified starch. therefore, CMS would be expected to exert physiological effects similar to those of dietary fiber. Some of the modified starches seem to be less digestible than the un-modified form (Ebihara *et al.*, 1998) . CMS as resistant starch may reduce the plasma glucose concentration and satiety after ingestion (Raben *et al.*,1994).The effect of modification and processing procedures of starch on human physiology (especially glycemic and insulinemic responses) have also been studied extensively (Bjorck,1996). So, many types of chemically modified starch , such as starches modified by acid hydrolysis , oxidation , etherification , esterification and cross-linking have attracted much attention (Adebowale and Lawal., 2003).

The aim of the present work is to modify corn starch chemically through acetylation, succinylation and phosphorylation processes then, study the effect of these process on the product properties and evaluate their biological effects on normal male albino rats compared with diabetic rats.

MATERIALS AND METHODS

Native starch: Food grade edible corn starch was obtained from the Egyption Starch and Glucose Co.,Turra Factory,Cairo,A.R.E.

Commercial wheat flour: American wheat flour (72% extraction) was obtained from South Cairo Mills Company, Fysal, Giza, Egypt.

Animals: Male albino rats Winster strain weighing 138-143g were obtained from Holding Company of Biological Vaccines and Sera, Public Helwan farm, Cairo, Egypt.

Preparation of starch acetate (SA) and starch succinate (SS) :

Starch acetate and succinate were prepared at laboratory scale as described by Phillips *et al.* (1998) following by the method of Walff *et al.* (1951) with minor modifications .

Prparation of starch phosphate (SP) :

Starch was phosphorylated using the method of Inagaki and Seib (1992).

Determination of degree of substitution (D.S.) of acetylated and succinylated starch :

The acetylation and succinylation level of the modified starch was determined using the titrimetric method of Wurzburg (1964).

Determination of phosphorus content in starch phosphate :

Phosphorus in both native corn starch and modified starches were determined by the phospho-molybdenum method which described by King (1932).

Chemical composition of native and modified corn starches:

Native and modified corn starches were determined for moisture, protein, fat, and ash contents according to A.O.A.C. (2000) .

Determination of amylose and amylopectin content of native and modified corn starches :

The method described by McCready and Hassid (1943) was used for the estimation of linear fraction amylose in native and modified starches, and amylopectin was calculated by the difference as in the following equation %Amylopectin = 100- amylose (%).

Water absorption capacity (WAC) :

WAC was measured for native and modified starches by the method described by Medcalf and Gilles (1965).

Solubility and swelling power:

Solubility and swelling power at 90°C were measured for native and modified starches using the methods of Leach *et al.* (1959).

Apparent viscosity:

Viscosity was determined for native and modified starches using the method of Wurzburg (1964).

Biological experiment :

Forty animals of adult male albino rats weighed 138 to 142g were used in present experiment. Animals were fed in the animal house, Crops Technology Department, Food Technology Research Institute (FTRI), Giza, Egypt, under normal conditions and fed on basal diet as shown in Table (1) for one week. After adaptation period, animals were weighed and divided into 8 groups each of 5 rats for one group as follow:

Group 1: Rats fed on basal diet.

Group 3, 4 and 5 : normal rats fed on basal diet containing 10 % of modified starch as shown in Table (1)

Groups 2,6,7 and 8 (diabetic group) : Rats were injected by alloxan solution 150 mg/Kg body weight of recrystallized alloxan *(Buko et al., 1996)* to induce hyperglycemia, then the groups were fed on basal diet for 72 h. where hyperglycemia was developed. To ensure occurrence of diabetes in rats, blood sample was withdrawn after 72 h of alloxan injection and then fed on diets containing modified starch as shown in Table (1) .

Weekly, rats were weighed and blood samples were collected by withdrawing from veva cava eye of both diabetic and normal rats and blood glucose level was determinated. After 5 weeks , animals were decapitated after fasting for 24h, and the blood was collected and centrifuged to obtain the serum which was kept at -18°C until analysis.

Determination of serum glucose :

Serum glucose was determined according to Trinder (1969).

Determination of serum lipid fractions :

Total lipids (T.L) were determined according to Knight *et al.* (1972) , total cholesterol (T.C) was determined according to the method described by Allian *et al.* (1974), triglycerides (T.G) were determined according to the methods of Fossati and Prencipe (1982), HDL-cholesterol (HDL-C) was determined according to Lopez-virella *et al.* (1977) and LDL – cholesterol was calculated for serum samples using the formula of Friedewald *et al.* (1972) LDL-C= T.C-(T.G/5+HDL-C).

Determination of kidney function : Uric acid and Urea in serum were determined according to the methods of Kageyama(1971) and Tabacco *et al.* (1979) serum creatinine was determined according to the method described by Bartels and Bohmer (1971) .

Determination of liver function: Serum transaminase enzymes serum aspartate transaminase (AST) and serum alanine transaminase (ALT) were determined according to the method described by Retiman and Frankel (1957), serum total protein (TP) was determined according to the method described by Gornall *et al.* (1949)

Table (1) :Diet Composition (%)

Components	**G1	*G2	G3 SA	*G6 SA	G4 SS	*G7 SS	G5 SP	*G8 SP
Casein	15	15	15	15	15	15	15	15
Native starch	65	65	55	55	55	55	55	55
Starch acetate (SA)	-	-	10	10	-	-	-	-
Starch succinate (SS)	-	-	-	-	10	10	-	-
Starch phosphate (SP)	-	-	-	-	-	-	10	10
Corn oil	10	10	10	10	10	10	10	10
Cellulose	5	5	5	5	5	5	5	5
Salt mixture	4	4	4	4	4	4	4	4
Vitamin mixture	1	1	1	1	1	1	1	1

* Diabetic rat groups
**G1 fed on basal diet (normal control)
G3,G4and G5 healthy rats fed on modified starches

Statistical analysis:
Statistical analysis was carried out according to Fisher (1970). Least squares differences (LSD) at $P < 0.05$ test were used to compare the significant differences between means of treatment; where a,b,c values are means of five replicates ± SE (Waller and Duncan, 1969).

RESULTS AND DISCUSSIONS

Chemical composition

Chemical composition of native, acetylated, succinylated and phosphorylated corn starch :

Proximate analysis was carried out in order to determinate the purity of the native starch as well as the effect of chemical modification on the composition of the starch. The results are presented on Table (2).

The results showed that the modified starches had the lowest content of fat and protein compared to native starch. The decrease in the contamination, is due to the washing of these component under the conditions used for the modification. Both acetylation and succinylation reduced the ash content due to the capacity of the chemical agent to solubilize minerals during the reaction .In this respect Betancur-Ancona *et al.* (2002) found a similar decrease in ash content when (*Canavalia ensiformis*) starch was modified using succinic anhydride. On the other hand, there was an increase in ash content of starch phosphate due to the formation of phosphate salts during the reaction. These results are agreed with those reported by Ola. S. Ibrahim. (1997).

At the same time amylose content in the acetylated and phosphorylated starches was decreased more than that found in the native starch due to the process of substitution in these modified starch types that affect their degree of binding of iodine which gave lower value of the amylose content . Kasmsuwan and Jane (1994)reported that the cross-linked of maize starch or starch phosphate using phosphorous oxychloride ($POCl_3$) at 25°C at low level of cross-linking , the amylose molecules have been located in bundles between amylopectin clusters. It is randomly interspersed among amylopectin clusters in both amorphous and crystalline regions , so that the iodine blue colour was decreased. However, the presence of some succinyle groups interferes with the reassociation of amylose and amylopectin during the storage of starch molecules subjected to the gelatinization process. This cause the creation of more linear segments, which eases the absorption of higher amounts of iodine ,so the value of amylose content in the succinylated starch was increased which is in consistence with our finding.

Table (2): Chemical composition of native corn starch and chemically modified starches (on dry weight basis).

Samples	Protein %	Ash %	Fat %	Amylose %	Amylopectin %
Native starch	0.54	0.126	0.060	26.00	74.00
Starch acetate (D.S.= 0.0910)	0.42	0.116	0.030	25.80	74.20
Starch Succinate (D.S.= 0.0263)	0.41	0.096	0.033	27.90	72.10
Starch phosphate (D.S= 0.0028)	0.36	0.165	0.031	24.60	75.40

Functional properties :

Results in Table (3) represent the functional properties of native and chemical modified starches.It could be observed that, the chemical modification increased the water absorption capacity (WAC) of the native starch . The higher increase in WAC was observed in succinylated starch (95%) followed by acetylated starch (74%) and phosphorylated starch (71%) . This results are in good agreement with that obtained by Betancur-Ancona *et al.* (2002) and Nabeshima and Grossmann (2001). Waliszewski *et al.* (2003) showed that chemical modification improved starch water binding capacity because the hydrophilic groups were incorporated.

The chemically modified starches were more soluble than that of native starch . The low solubility value of native starch could be attributed to the increase of binding forces within starch molecules and resistance towards solubility . Under the same condition , there was an increase in solubility of modified starches, this increase may be due to hydrophilic groups or residual activity in starch (Aiyleye *et al.*,1993).

The swelling power was decreased at 90°C of starch phosphate compared to native starch which may due to two different possible interpretations, losing granular integrity , resulting in mixture of soluble starch and granules fragments, or larger granules could be preferentially broken down , leaving apopulation of smaller intact granules . These results agreed with Ola. S. Ibrahim. (1997).

However, succinylation and acetylation consideraly increased granule swelling power. This observation is in agreement with the report of Betancur-Ancona *et al.* (2002) and Adebowale and Lawal (2003) .

Also, results in Table (3) indicated that the value of apparent viscosity was decreased by acetylation or phosphorylation treatment. However succinlated starch had higer apparent viscosity. This results differs than that of Ola. S. Ibrahim. (1997) who reported that phosphorylation caused an increase in viscosity, but agreed with Betancur-Ancona *et al.* (2002) who reported that succinylation increased apparent viscosity. Derivatisation of starch with an ionic substituent group such as succinate, at low degree of substitution (DS) converted it into a polyelectrolyte. Starch acquires typical properties of a polyelectrolyte such as increased water solubility and increased solution viscosity (Bhandari and Singhal, 2002).

Table (3): Functional properties of native and chemically modified starches.

Samples	Water absorption capacity (g)A	Apparent viscosity (CP)B	Solubility (%)C	Swelling power (g water/g starch)D
Native starch	1.20	13	6.20	9.80
Starch acetate	1.78	10	8.40	9.90
Starch succinate	2.03	20	8.6	10.10
Starch phosphate	1.73	10	7.09	6.04

A. Measured at 25°C
B. Measured of 0.2 % starch suspension in Brookfield viscometer,spindle no.2 , 25°C and 100 rpm.
C. and D. Measured at 90°C.

Biological effects of chemically modified starches (CMS):

Effect on rat body weight :

Data in Table (4) represent the gain in body weight (g) in normal groups. It could be stated that, succinylated and acetylated starches significantly reduced the gain in body weight, while phosphorylated starch slightly decreased gain in body weight compared with normal control. The decrement of body weight gain may be due to the satiety ratings which are higher after meals with CMS than native starch (G1) . These ratings are higher in WAC and viscosity and thus influencing the emptying and digestion of other compounds in the gut digestal (Raben *et al.*,1997 and Ebihara *et al.*,1998) . These results are in agreement with Til *et al.* (1986) who reported that feeding on hydroxypropyl distarch phosphate and starch acetate caused slightly lower body weights. Also, feeding on five chemically modified starches (acetylated distarch phosphate, acetylated diamylopectin phosphate, starch acetate, hydroxypropyl distarch glycerol and phosphated distarch phosphate reduced body weights except that of the phosphated distarch phosphate (deGroot *et al.*,1974).

Table (5) represent gain in body weight in diabetic rats . It could be stated that, there was a significant decrease in body weight gain of diabetic rats compared to normal control and this due to break down of protein to obtain energy (Meyer *et al.*, 1998). These results are in agreement with

Yadav *et al.* (2004) who found that the body weight of alloxan-treated rats (diabetic rats) was significantly decreased after 21 days of diabetes compared to normal control.

Table (4) : Initial body weight, final body weight and gain in body weight (g) of normal control and rats groups fed on 10% chemical modified starches.

Groups	Initial body weight (g)	Final body weight (g)	Gain in body weight (g)
G1	138.2 ± 7.06	185.4± 8.02	+47.00[a]
G3	140.6 ± 4.83	136.4± 4.76	- 4.20[c]
G4	142.2 ± 5.88	134.2± 4.28	- 8.00[c]
G5	139.2 ± 7.20	145.4± 7.01	+ 6.20[b]
L.S.D. at 5%			8.756

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Table (5): Initial body weight, final body weight and gain in body weight (g) of normal control and diabetic rats groups fed on 10% chemical modified starches.

Groups	Initial body weight (g)	Final body weight (g)	gain in Body weight (g)
G1	138.2 ± 7.06	185.4 ± 8.02	+47.2[a]
G2	143.0 ± 5.47	107.6 ± 4.34	-35.4[b]
G6	140.4 ± 6.93	116.2 ± 6.11	-24.2[b]
G7	142.4 ± 6.46	108.4 ± 5.48	-34.0[b]
G8	139.0 ± 7.77	111.0 ± 6.42	-28.0[b]
L.S.D. at 5%			12.251

The column values followed by the same letters are not significant different.
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Effect on serum blood glucose:

Tables (6 and 7) represents the effect of chemically modified starches on blood glucose in normal and diabetic rats. The data revealed that starch acetate significantly decreased blood glucose level of group 3 and group 7. These results agree with Raben *et al.* (1997) who found that chemical modification of potato starch (acetylation or β – cyclodextrin) improved the stateing, glycemic index and insulinemic properties of the meal. The glycemic index and insulinemic index of foods have been found to correlate with hunger and satiety after a meal. Thus foods with low indexes were more satiating than foods with high indexes (Holt *et al* ., 1992). Also , CMS are resistant to small intestinal amylosis, thus there capacity to lower the glycemic response may be more predictable than the other types of resistant starches (Brid and Topping., 2002). Acetylated , propionylated or butyrylated starches raise large bowel of short chain fatty acids (SCFAs) when fed to rats and these reduced plasma glucose levels. (Ferguson and Jones .,2000 and Annison *et al.*, 2003).

Table (6): Blood glucose level (mg/dl) in normal rats fed on diets containing 10% chemical modified starches

Groups	Zero time	1week	2weeks	3weeks	4weeks	5weeks
G1	94.42[a] ±7.06	96.14[a] ±6.67	97.17[a] ±5.81	95.64[a] ±4.75	94.8[a] ±5.61	95.92[a] ±3.81
G3	97.21[a] ±6.82	96.71[a] ±5.87	94.41[a] ±5.47	90.4[a] ±4.98	84.99[a] ±3.76	79.26[b] ±3.49
G4	91.03[a] ±5.61	90.43[a] ±4.87	89.72[a] ±5.44	87.8[a] ±4.33	88.6[a] ±4.8	90.17[ab] ±4.14
G5	98.01[a] ±7.37	96.79[a] ± 5.49	93.86[a] ±6.19	95.2[a] ±6.53	97.4[a] ±5.73	96.73[a] ±5.34
L.S.D. at 5%	20.243	16.775	17.210	15.645	15.110	12.7538

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Table (7): Blood glucose level (mg/dl) in diabetic rats fed on diets containing 10% chemical modified starches

Groups	Zero time	1week	2weeks	3weeks	4weeks	5weeks
G1	94.42[b] ±7.06	96.14[b] ±6.67	97.17[b] ±5.81	95.64[b] ±4.75	94.8[c] ±5.61	95.92[c] ±3.81
G2	273.4[a] ±12.08	271.2[a] ±10.88	267.7[a] ±9.82	265.9[a] ±8.54	264.8[a] ±8.21	262.46[a] ±7.31
G6	265.6[a] ±9.56	262.8[a] ±8.56	256.4[a] ±8.37	245.5[a] ±7.75	228.6[b] ±7.47	212.6[b] ±6.58
G7	270.4[a] ±11.108	269.8[a] ±9.77	265.6[a] ±9.29	262.5[a] ±10.07	259.2[a] ±10.10	257.2[a] ±9.47
G8	259.9[a] ±9.016	257.6[a] ±9.24	254.62[a] ±8.69	250.8[a] ±9.14	248.4[ab] ±7.10	245.8[a] ±7.47
L.S.D. at 5%	29.266	26.947	25.132	24.266	23.125	21.149

The column values followed by the same letters are not significant different.
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Effect on serum lipid fractions:

Tables (8 and 9) represents the level of total lipids (T.L), total cholesterol (T.C), triglycerides (T.G), high density lipoprotein - cholesterol (HDL-C) and low density lipoprotein - cholesterol (LDL-C) in normal and diabetic rats. It could be observed that in normal group (G3,G4, G5) their were no significant differences in lipid fractions compared to normal control (G 1) .In contrast, the levels of T.C , T.G , T.L and LDL-C were higher in diabetic groups . These results are in the line with those of Anderson *et al.* (1973) who found that Pitman-Moore miniature pigs fed on formulated diets containing 5.4% unmodified starch and 5.6% phosphated distarch phosphate had non significant difference in cholesterol and triglycerides levels .Also, Raben *et al.* (1997) reported that, serum triacylglycerol concentrations were not significantly different in the fasted state and after meal ingestion of rats fed on chemical modified potato starch (acetylation β – cyclodextrin) . Our results are disagreed with those found by Ebihara *et al.* (1998) who showed that two different types of CMS (hydroxypropyl starch and hydroxypropyl distarch phosphate) decreased the plasma cholesterol level of rats but their was no effect on T.G level.

Table (8): Triglycerides, total cholesterol, HDL- cholesterol, LDL-cholesterol and total lipids, levels (mg/dl) in normal rats fed on diets containing 10% chemical modified starches.

Groups	Triglycerides	Total cholesterol	HDL-cholesterol	LDL-cholesterol	Total lipids
G1	112.6[a] ± 3.97	95.2[a] ± 7.74	49.02[a] ± 3.29	23.660[a]± 10.41	326.0[a]± 13.89
G3	109.6[a] ± 5.76	88.0[a] ± 8.07	47.87[a] ± 2.80	18.212[a]± 6.74	321.2[a]± 13.01
G4	105.8[a] ± 4.30	92.0[a] ± 6.77	50.02[a] ± 2.95	20.816[a]± 4.78	330.6[a]± 10.99
G5	116.2[a] ± 4.61	87.4[a] ± 7.44	45.22[a] ± 1.94	18.940[a]± 6.57	318.6[a]± 9.87
L.S.D. at 5%	14.12	22.5647	8.336	22.234	36.1247

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Table (9): Triglycerides, total cholesterol, HDL- cholesterol, LDL-cholesterol and total lipids, levels (mg/dl) in diabetic rats fed on diets containing 10% chemical modified starches.

Groups	Triglycerides	Total cholesterol	HDL-cholesterol	LDL-cholesterol	Total lipids
G1	112.6[c]± 3.97	95.2[c] ± 7.74	49.020[a] ± 3.29	23.66[c]± 10.41	326.0[b] ±13.89
G2	217.2[a] ± 10.93	178.4[a] ± 4.22	33.082[b]± 1.41	101.87[a]± 4.03	516.0[a] ±17.05
G6	185.6[b] ± 8.87	149.0[b] ± 9.93	40.092[b]± 1.64	71.79[b]± 8.66	412.2[a] ±12.55
G7	210.0[ab]± 9.86	172.0[a] ± 6.01	36.574[b]± 2.39	93.42[ab]± 8.50	507.8[a] ±14.91
G8	202.4[ab]± 8.72	169 [ab] ± 6.80	35.796[b]± 1.78	92.72[ab]± 6.97	499.6[a] ±17.56
L.S.D. at 5%	25.9707	21.224	6.5292	23.622	47.00315

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Effect on kidney function:

The results of kidney function, i.e., urea, uric acid and creatinine were reported in Tables (10 and 11). The data showed that there were no significant differences on serum blood urea , uric acid and creatinine between normal group(G3, G4 and G5) and normal control (G1). However, data in Table (11) showed that there are significant increments in serum urea ,uric acid and creatinine in case of diabetic groups compared with normal control.

These results are in agreement with Anderson *et al* .(1973) who found no significant differences on biochemical analysis of blood (urea nitrogen, alkaline phosphatase and total protein) of pig fed on diets containing 5.6% phosphated distarch phosphate. In this respect, Cervenka and Kay (1963) reported that no adverse effects were observed on blood chemistry such as, urine parameters and liver functions in rats groups after given gelatine capsules containing 50, 250 and1250 mg modified starch/kg b.wt. This results differs from the results of Til *et al.*(1986) who found slight urinary changes in rats fed on hydroxypropyl distarch phosphate and starch acetate.

Table (10): Urea, uric acid, and creatinine levels (mg/dl) in normal rats fed on diet containing 10% chemical modified starches.

Groups	Urea	Uric acid	Creatinine
G1	$25.00^{a} \pm 2.91$	$3.76^{a} \pm .341$	$0.802^{a} \pm .081$
G3	$22.40^{a} \pm 2.60$	$3.36^{a} \pm .266$	$0.768^{a} \pm .09$
G4	$20.56^{a} \pm 2.07$	$3.59^{a} \pm .281$	$0.726^{a} \pm .074$
G5	$27.00^{a} \pm 3.20$	$3.28^{a} \pm .402$	$0.702^{a} \pm ..078$
L.S.D. at 5%	8.1930	0.2421	0.9825

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Table (11): Urea, uric acid, and creatinine levels (mg/dl) in diabetic rats fed on diet containing 10% chemical modified starches

Groups	Urea	Uric acid	Creatinine
G1	$25.0^{b} \pm 2.91$	$3.76^{c} \pm .341$	$0.802^{b} \pm .081$
G2	$54.0^{a} \pm 4.89$	$8.56^{a} \pm .423$	$1.76^{a} \pm .121$
G6	$42.4^{a} \pm 3.77$	$6.86^{b} \pm .577$	$1.42^{a} \pm .185$
G7	$50.4^{a} \pm 3.97$	$7.64^{ab} \pm .465$	$1.56^{a} \pm .131$
G8	$47.8^{a} \pm 3.70$	$8.03^{ab} \pm .528$	$1.62^{a} \pm .156$
L.S.D. at 5%	11.5206	1.3983	0.4101

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Effect on liver functions:

Tables (12 and 13) represents the amount of total protein (TP), the activities of serum aspartate amino transaminase (AST)and serum alanine amino transaminase (ALT).The data showed that there was no significant change in normal groups compard to normal control in serum TP. However, a significant decrease of serum total protein in rats from 7.12 g/dl in normal control to 5.34 g/dl in diabetic control. In this study, the decrease in serum protein may be due to the effect of alloxan on RNA and protein synthesis. Also, the data show that AST and ALT activities were significantly increased in serum after injecting with alloxan (150mg/Kg body weight), while there was no significant different in AST and ALT values between rats fed chemical modified starches and normal control. These results agreed with Anderson *et al* .(1973) and Cervenka and Kay (1963).

Table (12): Total protein (g/dl), activities of ALT, AST (IU/l) in normal rats fed on diets containing 10% chemical modified starches.

Groups	TP	ALT	AST
G1	7.12^{a}±0.227	23.20^{a}±1.854	33.8^{a}±2.417
G4	7.08^{a}±0.0149	22.10^{a}±2.216	36.2^{a}±2.922
G5	6.80^{a}±0.330	19.76^{a}±1.636	29.8^{a}±4.271
G6	7.08^{a}±0.159	25.16^{a}±1.745	32.6^{a}±4.045
L.S.D. at 5%	0.68349	5.06237	10.4908

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Table (13): Total protein (g/dl) , activities of ALT, AST (IU/l) in diabetic rats fed on diets containing 10% chemical modified starches.

Groups	TP	ALT	AST
G1	7.12^{a}± 0.227	23.2^{c}±.1.854	33.8^{b}±2.417
G2	5.34^{bc}±0.150	50^{a}±2.829	59^{a}±.4.159
G6	6.014^{b}±0.185	38.6^{b}±.3.572	46.4^{ab}±.5.420
G7	5.46^{bc}±0.276	46.8^{ab}±.3.184	57.2^{a}±.4.397
G8	5.26^{c}±0.242	48.2^{ab}±.3.929	54.2^{a}±.4.694
L.S.D. at 5%	0.6502	9.3081	12.6527

The column values followed by the same letters are not significant different.
The column values followed by different letters are significant different.

Conclusion

Chemical and functional properties of native and chemical modified starches (CMS) were investigated. All chemical modification process reduced fat, protein and ash content except phosphorylation process increased ash content. Water absorption capacity and solubility were increased with chemical modification process, the succinylated starch gave a higher value. Acetylation and phosphorylation reduced apparent viscosity, while succinylation process gave a higher value . These properties give pastes and gels a better thickening capacity, clarity and stability at low temperatures.

The biological effects demonstrated that the succinylated and acetylated starches reduced the final body weight, while phosphorylated starches caused slight increase in final body weight. Also, acetylated starches reduced serum glucose in healthy and diabetic rats. In general the CMS had no affect on serum lipid fractions ,kidney and liver functions in healthy rats but improved serum lipid fractions, kidney and liver functions in diabetic rats in case of using starch acetate .

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الخواص الكيماوية والوظيفية والبيولوجية لنشا الذرة المحور

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تم اجراء عمليات تحوير كيميائية لنشا الذرة و ذلك بتحضير ثلاث مشتقات منه و هم خلات النشا و فوسفات النشا و سكسينات النشا و تم تقييم الخواص الكيماوية و الوظيفية و التأثيرات البيولوجية لهم وقد وجد ان محتواهم من البروتين و الدهون والرماد يقل بعمليات التحوير فيما عدا محتوي الرماد يزداد في حالة فوسفات النشا.ايضا حدث انخفاض قي محتوي الاميلوز في كلا من خلات و فوسفات النشا بينما زاد محتواه في سكسينات النشا.

اظهرت نتائج الخواص الوظيفية حدوث زيادة في القدرة علي امتصاص الماء عند ٢٥°م و خاصية الذوبان في الماء عند ٩٠°م في جميع انواع النشا المحور و ايضا حدث انخفاض للزوجة في كلا من خلات و فوسفات النشا بينما زادت في سكسينات النشا كما حدث انخفاض في قوة الانتفاخ عند ٩٠°م في حالة فوسفات النشا فقط.

ولتقييم المشتقات الناتجة تم اجراء تجربة بيولوجية علي ذكور الفئران البيضاء بعد تغذيتها علي وجبة محتوية علي١٠% من النشا المحور و اظهرت النتائج ان التغذية علي كلا من سكسينات و خلات النشا احدثت انخفاض في وزن الجسم بينما التغذية علي وجبة محتوية علي فوسفات النشا اظهرت زيادة طفيفة في وزن الجسم بينما حدث انخفاض ملحوظ في وزن الجسم للفئران المريضة بالسكر مقارنة بالفئران الطبيعية و ايضا وجد ان التغذية علي خلات النشا ادت لحدوث انخفاض معنوي لمستوي جلكوز الدم للفئران الطبيعية والمريضة بالسكر بينما التغذية علي مشتقات النشا لم يحدث اختلافات معنوية علي مكونات دهون الدم ، وظائف الكلي والكبد في الفئران الطبيعية مقارنة بالفئران المريضة بالسكر.

ولذلك نوصي بادخال هذه المشتقات في منتجات المخابز لما لها من فائدة تصنيعية و علاجية هامة.