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Effect of Waxy Maize Starch (Modified, Native) on Physical and Rheological Properties of French Dressing During Storage

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Abstract: Effect of native and two types of modified waxy maize starch (hydroxypropylated distarch phosphate and acetylated distarch adipate) on physical and rheological properties of French dressing were studied. Samples were formulated by adding 1.6-2.2% of each type of starch instead of xanthan and guar which were used as the usual thickeners in control. Emulsion stability and viscosity of samples, formulated by modified starch, were improved compared to native one and between two types of modified starch, acetylated di-starch adipate produced more stable and viscous product. Some interactions were observed between starch and tomato Lycopene, so that color property (L*, a*, b*) of treatments was significantly different from the control. Salad dressings formulated by 2-2.2% of acetylated di-starch adipate showed the best physical and rheological and also sensory properties.

Key words: Salad dressing · Starch · Hydroxypropylated · Acetylated · Native · Physical properties

INTRODUCTION

French dressing is an oil-in-water emulsion containing vegetable oil, whole egg or egg yolk, vinegar, salt, sugar, tomato paste, thickening agents and flavoring agents and spices [1]. Polysaccharides are usually used in dressing formulations as thickening agent and among them starch is more popular because of its low price and additionally wide functional properties which may be provided by various types from different sources [2, 3]. Starch in native form is rarely used because of its tendency to retrogradation, instability in acidic conditions during heating and shearing which may result in synersis. Therefore, different modification methods may be used to improve the stability and functional properties of native starch such as etherification, esterification and introducing cross linkages in polysaccharide chain [2-4]. Each type of modification is supposed to give different properties for special applications.

According to the results reported by Lui, *et al*. [5] acetylation may increase in the clarity, enzymatic digestibility, swelling power and solubility in comparison with native starch.

Arocas, *et al*. [6] studied the freeze/thaw and heat stability of white sauces prepared with two types of modified waxy corn starches (hydroxypropylated distarch phosphate and acetylated distarch adipate) compared to two types of native corn starches (waxy and normal). The results showed that, samples produced with native corn starches, especially the normal one, were more susceptible to synersis and both types of modified starches may improve the viscoelastic properties, freeze/thaw and heat stability of the product.

Kaur, *et al*. [7] investigated on physiochemical, morphological, thermal and rheological properties of different potato cultivars which were hydroxypropylated. They reported that by this type of modification swelling power, solubility of starch increase and the formulated food products behave as a viscoelastic solid with more stability to synersis.

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According to the results obtained by Singh, *et al*. [8] cross linked starches are more stable in acidic media and less likely to break down during cooking and sharing. Acetylation of starch may result in increasing solubility and light transmittance. Hydroxypropylation may increase in light transmittance and motional freedom of starch chains in amorphous regions.

Up to now, some researchers investigated the synergistic effect between modified starch and gums such as xanthan and guar gum [9-11]. But few reports were published, on physical properties of salad dressing in which modified starch is the only ingredient used as the thickener.

In Iran, two types of modified waxy maize starch are usually used in French dressing formulations. Therefore the main objective of this research is to investigate the unique effect of each type of modified ingredient on physical and rheological properties of the final product in comparison to the native one.

MATERIAS AND METHODS

Materials: Three types of Waxy maize starches: native (Amioca; National starch, USA), acetylated di-starch adipate (Cold swell, Instant clearjel-SD; National starch, USA, E1422) and hydroxypropylated distarch phosphate (Cold swell, Ultratex-SR; National starch, USA, E1442) with main properties which are shown in Table 1. xanthan (GRINDSTED® xanthan 200, Danisco, Denmark), guar gum (GRINDSTED® GUAR 250, Danisco, Denmark). All other ingredients used to prepare French dressing samples were supplied from the R&D center of the Behrouznik food industry company (Tehran, Iran).

French Dressing Preparation: The French dssressing samples used in this study were formulated by fresh whole egg, vinegar (11% (w/v)), soybean oil, salt, mustard powder, sugar, tomato paste, red pepper, citric acid, garlic powder, Sodium Benzoate and Potassium Sorbate which were 10, 8, 38, 2, 0.4, 6, 5, 0.08, 0.1, 0.04, 0.063, 0.012%, respectively. 1.6-2.2% of each type of modified starch was used in treatments while control prepared with xanthan and guar gums instead of starch (Table 2). First of all, watery phase was made by mixing tomato paste and spices in water then the mixture pasteurized in 90°C for 10 minutes. (If the starch was pregelatinized, it was added to powder materials otherwise it was mixed with watery phase and gelatinized.). At the second stage, watery phase, powder materials and whole egg mixed homogeneously by a pilot turbo mixer (MHM-60K-I-high-speed vane disk stirrer, Arkan felez, Iran). Finally oil was added very slowly, while stirring at 6000 RPM for 6 min. The prepared emulsions were stored in glass sealed jars (200 ml), left for 1 week, 1-3 months at room temperature till analyzed.

Chemical Tests: pH of the samples was measured at 25°C using a Cyber Scan 500 pH meter. Fat percentage was determined according to the Mistry and Hassan method [12] and acidity analyzed according to the method of AOAC [13].

Table 1: Physical properties of starches [23]

Type of Starch	Apparent viscosity[1] (Pa.s)	WHC (gr/gr)	Swelling Power (gr/gr)
Instant clearjel- SD	1.515 ± 0.162^a	22.26 ± 1.011^a	9.16 ± 0.32^a
Ultratex- SR	0.514 ± 0.007^b	24.287 ± 1.783^a	8.22 ± 0.28^a
Amioco	1.04 ± 0.742^c	8.167 ± 1.35^b	4.6 ± 0.52^b

[1]Viscosity of 4.75% starch solutions were analyzed in 3.67(1/s) constant shear rate.

Table 2: Sample formulations

Samples	Type of the starch	Percentage (%)
FS01(control)	-	-
FS02	Ultratex- SR	1.6
FS03	Ultratex- SR	1.8
FS04	Ultratex- SR	2
FS05	Ultratex- SR	2.2
FS06	Instant clearjel- SD	1.6
FS07	Instant clearjel- SD	1.8
FS08	Instant clearjel- SD	2
FS09	Instant clearjel- SD	2.2
FS10	Amioca	1.6
FS11	Amioca	1.8
FS12	Amioca	2
FS13	Amioca	2.2

Physical Tests

Emulsion Stability: Emulsion stability of French dressing samples was analyzed, according to the method of maskan and Gugus with some modifications [14]. 10 g of each sample was heated in graduated tubes, in water bath at 80°C for 30 min and then centrifuged at 3000 RPM (Sigma 101, SIGMA Laborzentrifugen GmbH, Germany) for 15 min [15]. The emulsion stability was calculated as (the height of the emulsified layer/ the height of the whole layer of the centrifuge tube) ×100% [15]. All tests were performed in triplicate, after 1week, 1 and 3 months storage of samples at 4°C.

Apparent Viscosity: Apparent viscosity of samples was analyzed by Brookfield Viscometer DV-II programmable at the empirical reliable condition: spindle number 3, 100 RPM T%> 80% during 20 minutes.

Color Measurement: The color parameters L* (lightness), a* (redness), b* (yellowness) were analyzed by using a HunterLab Color Flex® 45/0 spectrophotometer [16].

Sensory Analysis: A 9-point hedonic scale (1=the lowest, 9=the highest) was used to evaluate the sensory characteristics, including appearance, color, odor, viscosity, texture, taste and overall acceptability by 30 trained panelists [17]. All samples were coded with three-digit random numbers. Water was provided to cleanse the palate between testing of two samples [18].

Statistical Analysis: One-way analysis of variance (ANOVA) and Tukey's test ($P \leq 0.05$) were used to analyze the results obtained from all of the tests.

RESULTS AND DISCUSSION

Chemical Properties: The results of chemical tests have been shown in Table 3. According to the results, There is no significant difference between all the samples and control in pH, acidity and fat percentage. pH of samples was between 3.83-3.84, acidity was between 0.82-0.83 and fat percentage was 37-40. So, replacing gums like xanthan and guar with different modified starches did not effect on chemical properties of French dressing.

Physical Characteristics

Emulsion Stability: Effect of different types/amount of starch on the emulsion stability of salad dressing samples has been shown in Table 4. According to the results, emulsion stability of samples formulated with modified types of starches were higher compared to the native one (Amioca). After one week, there was no significant difference between samples containing the same amount of each type of modified starch (i.e [FS02, FS06]). But, longer period time of storage may cause instability specially in samples with lower amounts of starch (i.e [1.6, 1.8%] after 1 and 3 months respectively). So, samples which have lower stability compared to control during storage, were eliminated for further experiments from the sample group. Between the two types of modified starches, the acetylated di-starch adipate produced more stable products which may be observed after 1 month storage. So that, FS09 containing 2.2% of this acetylated type of starch was the most stable emulsion which showed significantly higher stability than FS05 with the same amount of hydroxypropylated one. From the physical aspects, both types of modified starches have the same water holding capacity (Table 1).

Table 3: Chemical properties of French dressing samples

Samples	pH	Acidity	% Fat
FS01(control)	3.84±0.005[a]	0.82±0.005[a]	37.167±0.289[a]
FS02	3.83±0.005[a]	0.82±0.005[a]	38.5±0.5[a]
FS03	3.84±0.005[a]	0.82±0.005[a]	39.33±0.289[a]
FS04	3.84±0.005[a]	0.82±0.005[a]	39±0[a]
FS05	3.84±0.005[a]	0.83±0.005[a]	38.33±0.577[a]
FS06	3.84±0.005[a]	0.83±0[a]	38.83±0.289[a]
FS07	3.83±0.005[a]	0.82±0.005[a]	39±0.5[a]
FS08	3.84±0.005[a]	0.82±0.005[a]	39.167±0.289[a]
FS09	3.83±0.005[a]	0.83±0.005[a]	39.167±0.289[a]
FS10	3.83±0.005[a]	0.83±0.11[a]	38.667±0.577[a]
FS11	3.84±0.01[a]	0.82±0.005[a]	38.33±0.746[a]
FS12	3.84±0.01[a]	0.83±0.005[a]	38.667±0.289[a]
FS13	3.83±0.005[a]	0.83±0.01[a]	38.667±0.577[a]

Table 4: Physical properties of French dressing samples during storage

	Physical properties					
	Emulsion stability			Viscosity		
Samples	1 wk[(1)]	1 mth	3 mths	1 wk	1mth	3 mths
FS01(control)	97.83±0.28^{fg}	97.8±0.28^{cd}	96.8±0.28^{a}	789±28.9^{cd}	765.6±14.6^{a}	706.67±20^{a}
FS02	94.83±0.28^{c}	-	-	718.7±14.8^{b}	-	-
FS03	97.16±0.28^{ef}	95.66±0.2^{a}	-	836.7±48.3^{d}	699±8.54^{b}	-
FS04	98.5±0.5^{gh}	96±0.2^{bc}	-	910.3±5.5^{e}	892±8.08^{c}	-
FS05	99.16±0.28^{h}	97.3±0.28^{bd}	96.3±0.28^{a}	987.3±11^{f}	957.6±5.51^{d}	905.6±13.5^{b}
FS06	96.16±0.28^{de}	-	-	825±26.9^{cd}	-	-
FS07	97.33±0.28^{f}	96. 3±0.28^{a}	-	961±28.6^{ef}	897.6±15^{c}	-
FS08	98±0^{fg}	98±0.2^{c}	97±0.2^{b}	998±2^{f}	901±23^{c}	866±15^{b}
FS09	99.33±0^{h}	98.33±0.28^{c}	98.16±0.2^{b}	979±16.5^{f}	900±10.15^{c}	870.1±11.2^{b}
FS10	95.3±0.57^{cd}	-	-	627.7±18.4^{a}	-	-
FS11	95.3±0.57^{cd}	-	-	632±13.5^{a}	-	-
FS12	93.3±0.57^{b}	-	-	713.7±10.1^{b}	-	-
FS13	92±0^{a}	-	-	767±15^{bc}	-	-

[1]Emulsion stability and viscosity of samples were analyzed after 1 week,1 and 3 months storage at 4°C

Table 5: Color parameters of the chosen samples

Samples	L*	a*	b*	E?
FS01(control)	76.44±0.215^{a}	9.04±0.055^{a}	20.28±0.14^{a}	-
FS05	67.143±0.755^{b}	19.77±0.1^{b}	32.62±0.35^{b}	18.81±0.71^{a}
FS08	69.23±0.496^{c}	12.84±0.84^{c}	27.24±0.18^{c}	10.72±0.3^{b}
FS09	69.807±0.58^{c}	13.37±0.83^{c}	27.61±0.23^{c}	10.82±0.09^{b}

Onofre *et al*. [19] investigated the properties of hydroxypropylated starches and concluded that presence of hydroxylpropyl groups may increase the WHC of starch with more fluid like matrices. It may be supposed that this structure has more tendency to synersis because of more mobility of water and results in lower emulsion stability.

Viscosity Measurements: According to Table 4, apparent viscosity, FS08 had the highest and FS11 the lowest viscosity among samples. As it may be predicted, samples formulated with acetylated modified starch showed higher viscosities than others ([FS02, FS05], [FS06, FS09], [FS10, FS13]), after 1 weak, 1 and 3 months storage. Using more amounts of this type of modified starch (up to 2%), produced more viscous emulsions whereas higher percentages (2.2%) of it showed no significant difference. So, it seems that the highest viscosity may be achieved by 2% of acetylated di-starch adipate.

Color Measurement: According to the results of the emulsion stability test, only 3 samples (FS05, FS08, FS09) along with control, remained for color evaluation test. In Table 5, color parameters of the chosen samples are reported. As it may be observed, all of the samples have lower L*, higher a* and b* in comparison to control. Therefore, starch may affect the color intensity of products. It seems that Lycopene as the main colorful constituent of salad dressing could be preserved much better in the presence of starch. Rami *et al*. [20], investigated tomato pastes properties which were preserved by some additives such as starch and showed that starch may increase the oxidative resistance of lycopene. This protective effect is related to the water binding property of carbohydrates including starch [21]. As it has been proved, water binding capacity of corn starch (90-91%), is almost same as Xanthan (90%) and higher than guar gum (65%) [8, 22]. Therefore, replacing gums with modified/preglatinized maize starch may improve the redness of salad dressing samples. Additionally this higher water absorption property could result in higher lightness (L*) specially in products formulated with acetylated di-starch adipate (FS08, FS09).

Sensory Evaluation: Sensory evaluation of 3 samples containing modified starches and control is shown in Fig 1.7 sensory parameters including taste, color, odor, texture, appearance, overall acceptability showed significant differences with the control ($p \geq 0.05$) except viscosity. So far, higher viscosity for samples containing modified starch, confirmed by panelists as it has been shown in viscometric tests.

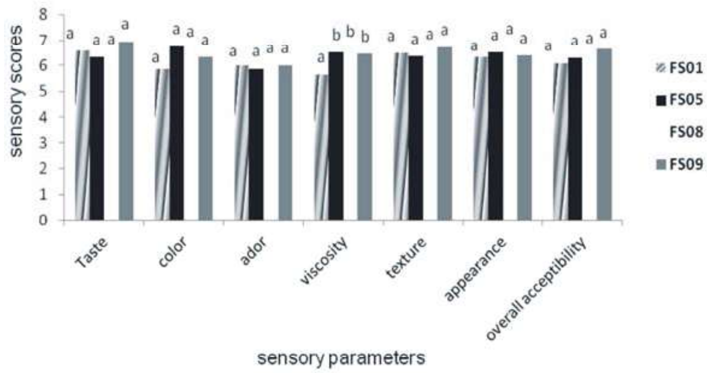

Fig. 1: Sensory evaluation of French dressing samples

CONCLUSION

It may be concluded that, using pregelatinized/ modified waxy maize starch in 2-2.2% in salad dressing formulations may improve the color intensity and rheological properties of the product. One of the main problems with products such as salad dressing is related to viscosity reduction during storage. In this research, both types of modified starch provided desirable viscosity in product up to 1 month which was decreased during longer periods of storage. Recently a new type of modified starch named Octenyl succinic anhydride (OSA) has been introduced in food industry and it may be suggested to study the effect of this new hydrocolloid in order to prevent the viscosity changes vs time at cold temperatures compared with other type of modified starches.

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