STARCH AND DRY MATTER CONTENT OF NETTED GEM IN RELATION TO FRENCH FRY TEXTURE[1]

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ABSTRACT

Studies were made on the relation of French-fry texture to solids content and to starch granule size in stored Netted Gem potatoes. Texture as evaluated both by a sensory panel and by an objective method was positively correlated with the percentages of starch granules in the 31 — 44 and 22 — 31 micron ranges. The usual positive correlations of texture with starch content, dry matter content, and specific gravity were in evidence. In limited trials, greater starch viscosiy and swelling power were associated with poorer texture. Heating time required to reach maximum viscosity was also related to texture, the longer heating times being associated with better texture.

RESUMEN

Se han hecho estudios de la correlación entre la papa frita a la francesa y el contenido en sólidos y el tamaño de los gránulos de almidón en papas Netted Gem almacenadas. La textura, evaluada tanto por un grupo de expertos como por un método objetivo, fué positivamente correlacionada con los porcentajes de gránulos de almidón entre los tamaños de 31 — 44 y 22 — 31 micras. Eran evidentes la usuales correlaciones positivas de la textura con el contenido en almidón, materia seca y con la gravedad específica. En ensayos limitados la mayor viscosidad del almidón y la tendencia a la hinchazón fueron asociadas con la textura más deficiente. El tiempo de calentamiento requerido para alcanzar una viscosidad máxima también estaba correlacionado con al textura, estando asociado el tiempo mayor de calientamiento can la mejor textura.

INTRODUCTION

The subject of the relation of tuber composition to the texture of boiled, baked and French-fried potatoes has received a great deal of attention. In general, it has been found that mealiness is positively correlated with high dry matter and starch contents (Barrios, Newsom and Miller 2, Le Tourneau and Zaehringer 9, Talburt and Smith 17, Unrau 18) and high specific gravity (Shanna, Isleib and Dexter 14). Mealiness has also been reported as positively associated with the size of starch granules (Barrios, Newsom and Miller 3, Briant, Personius and Cassel 4). Complicating factors in considering the whole question are the variable relationship between specific gravity and solids content (Porter and Rose 12) and the variation of these in different zones within the tuber (Shanna, Isleib and Dexter 13). Mealiness has also been reported as being associated with the viscosity of a gelatinized suspension of itssue (Unrau and Nylund 19).

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The present study concerns evidence of relationships between French-fry texture and dry matter and starch granule size. It touches also on starch viscosity and on compositional changes in storage.

Materials and Methods

The potatoes used in this study were all of the Netted Gem (Russet Burbank) variety. Nine lots were obtained, two from Alberta, one from Manitoba, one from Ontario and five from New Brunswick. All were shipped to Ottawa in October, 1967, where they were conditioned at 65 F for 14 days, then stored at 39 F and 81 to 85 per cent relative humidity. Weighed 60-80 lb bags were re-weighed at 14-day intervals during the storage period. Before use in experiments (5 examinations at two month intervals) tubers of uniform size were selected and re-conditioned at 68 F for 10 days.

Analyses

Specific gravity was determined by weighing a lot of about 10 lbs of whole tubers in a wide-mesh plastic bag on a solution balance, then re-weighing the lot suspended in water by a fine wire attached accurately below the centre of the bottom bearing of one pan. Specific gravity was read from a Young calculator (Young et al 22).

In order to achieve as much uniformity as possible in the tests, steps were taken to confine them to material near the center of the tubers, where poorest French-fry texture and lowest dry matter are found. For analytical purposes the tuber was trimmed lengthwise to a rectangular shape with edges at least 3 inches long. A one-inch long transverse central section was cut and diced to ¼-inch cubes. Starch samples were prepared quantitatively frm such material and separated into 5 fractions (Johnston et al 5). Dry matter was determined by drying at 105 C for 40 hr.

Processing

Tubers were abrasion peeled, cut into rectangular blocks as above, then cut into ⅜-inch French-fries longitutinally in an Urschel slicer. The strips were rinsed with cold water, water-blanched at 180 F for 8 minutes, then cooled rapidly below 110 F by a blast of air at room temperature. They were then fried in shortening for one minute at 360 to 365 F, placed on trays, and frozen overnight in a —10 F room. Strips of 4 $\pm$ ¼ inch were selected and fried for 2 minutes at 362 to 365 F immediately before testing.

Texture Evaluation by Sensory Panel

The texture evaluation was carried out by a panel consisting of three members. The scale used was: very good – 9, good – 7, fair – 5 ,poor – 3, very poor – 1. Fries having very good texture were dry and stiff, and had a crystalline or granular internal texture. Fries of fair texture were firm but had little, if any, crystallinity. Poor texture represented a soggy external appearance and jelly-like interior.

Objective Texture Measurement

The instrument used was developed by Voisey and MacDonald (20).

It consists of a variable probe penetrometer mounted above a strain-gauge platform. Using a standardized procedure a ⅝-inch long section from the middle of the fry was punctured centrally at one end and the response was recorded. The resistance to the probe was calculated and designated H/D_t (Kenkars 6).

Viscosity and Swelling Power

Viscosity was determined with a Brabender Amylograph which had been modified by replacing the standard dynamometer with a transducer incorporating a strain gauge (Voisey and Nunes 21). This allowed the use of 5-g instead of the usual 25-g samples. Results were expressed as centimetergrams (cmg).

Swelling power was measured at 75 and 85 C by the method described by Schoch (15). This is the weight of sediment produced by one gram of starch.

Results and Discussion

Analytical data from the initial and final samplings are given in Table 1, to indicate the type of material used and the storage changes.

The most striking difference to be noted by simple inspection of the data is the higher solids content of the Western samples, and this is usually the case from year to year. It should be kept in mind that because of the sampling method used these values are somewhat lower than those for whole tubers.

Table 1 fails to sugggest any patterns in the size distribution of the starch granules or in the changes in these during storage. Similarly, the weight losses of the whole tubers seem to be random. Furthermore, when the starch content is calculated as percentage of dry matter, there seems to be no consistent pattern.

To guard against the possibility of differences in the data from examination to examination, all calculations were originally carried out treating each examination as a separate entity. Calculation of the correlation coefficients revealed the usual high values between specific gravity, dry matter and starch content. There were large positive correlations between these measurements and the 31-44 and 22-31 micron granules at each examination, but the correlations with the +53, 44-53, and —22 micron fractions showed no consistent pattern.

The correlations were calculated between the sensory panel texture scores and the analytical data expressed on the fresh weight basis. These coefficients from the five examinations were then tested using the procedure described by Snedecor (16) to ascertain whether they could be combined to give single pooled estimates. For each item of interest it was found that the differences between values for the different examinations were not significant and so the values were pooled. The results are given in Table 2.

The correlation between the panel score and specific gravity agrees with the findings of Kirkpatrick *et al* (7) and Alexander *et al* (1). Since the sensory panel score is based on granularity or mealiness, the correlations with both specific gravity and dry matter are in agreement with the literature on mealiness cited earlier. Panel scores were positively cor-

TABLE 1.—*Analytical data on November and July tuber samples.*

Source		Specific gravity[1]		Dry matter %[2]		Starch as % of fresh weight[2]		Starch fractions as percentage of total starch										Total wt. loss % of tubers
								+53 microns		44—53 microns		31—44 microns		22—31 microns		—22 microns		
		Nov.	July	Nov.	July	Nov.	July	Nov.	July	Nov.	July	Nov.	July	Nov.	July	Nov.	July	July
Eastern	1	1.0800	1.0821	20.8	20.6	13.50	14.22	8.8	9.0	13.6	15.4	41.8	44.6	25.6	22.8	10.2	8.2	10.1
	2	.0821	.0899	21.5	22.0	15.10	15.27	9.7	11.8	14.9	19.0	41.0	41.7	26.1	22.2	8.3	5.3	8.3
	3	.0729	.0750	19.3	19.2	12.89	12.10	12.1	4.5	11.0	12.5	33.5	36.9	29.0	28.7	13.5	17.4	6.2
	4	.0808	.0886	20.3	20.9	15.78	15.64	11.3	11.0	13.9	16.2	36.2	36.5	25.9	23.5	12.7	12.8	7.7
	5	.0825	.0857	20.6	20.4	15.12	14.37	14.5	9.9	17.2	16.7	40.8	35.8	18.6	25.3	8.9	12.3	8.6
Ontario		.0718	.0752	19.4	19.2	13.81	12.93	13.2	10.1	13.8	15.7	41.3	34.2	22.5	26.8	9.2	13.2	8.6
Western	1	.0917	.1018	26.3	25.7	18.58	18.04	7.5	5.9	11.4	13.9	45.1	33.4	24.3	30.0	11.7	16.8	10.5
	2	.0976	.1020	25.4	25.7	18.23	17.95	9.8	13.4	15.1	15.7	38.8	41.8	26.4	23.4	9.9	6.5	4.3
	3	.1058	.1040	26.7	26.2	19.66	18.62	5.0	6.1	13.2	16.5	41.4	35.5	27.2	28.9	13.2	13.0	4.0

[1]Whole tubers.
[2]Central portions of tubers.

TABLE 2.—*Comparison of texture evaluations with analytical data. (Correlation coefficients)*

Analytical factor	Sensory panel score	Objective measurement
Specific gravity	0.761**	0.875
Dry matter %	0.787	0.878
Starch as % F.W.	0.764	0.866
31-44 micron starch as % F.W.	0.671	0.830
22-31 micron starch as % F.W	0.714	0.818

**$r = 0.45$ is significant at $P = 0.01$.

related with total starch, and 31-44 and 22-31 micron starch, but showed no relationship with the largest or smallest granules. There were no significant associations between panel score and the ratios of the starch fractions to each other or the fractions calculated as percentage of total starch.

The possibility of relationships involving more than two variables was considered. The multiple correlation coefficients of different combinations of variables (in each case including panel score) were examined but little evidence of more complicated relationships was found.

The data from the objective measurements of texture, expressed as H/D_t, were processed similarly to those of the panel scores. Once again it was found that the correlation coefficients could be pooled to give single values. The results are given in Table 2.

These values are seen to be higher than those for the sensory panel scoring. Again, the multiple correlation coefficients of several combinations of variables were calculated, but it was found that consideration of the bivariate case was sufficient.

Determinations of viscosity were made on starch fractions from one Eastern and one Western sample. Since the amounts of the largest and smallest granules were insufficient for testing, the +53 and 44-53 micron fractions were mixed together, as were the 22-31 and —22 micron fractions. Measurements were made at each sampling date. The viscosities of each fraction remained relatively constant throughout storage, thus confining the findings of Nutting and Whittenberger (11). The average viscosities of the +44, 31 — 44 and —31 micron fractions were 30, 39 and 43 cmg respectively for the Eastern material, and 18, 27 and 30 cmg for the Western. The higher Eastern viscosities were associated with the poorer texture, in contrast to the findings of Unrau and Nylund (19) on whole boiled tubers. The increase of viscosity with decrease in particle size is in agreement with the report of Kopriva (8). It must be kept in mind that the present work involved the use of central sections of the tubers only.

The heating times required to reach maximum viscosity were consistently slightly lower for the Eastern material than for the same fractions in the Western. This heating time decreased somewhat during storage for both samples, the final value being relatively slightly lower for the Eastern.

In the viscosity study marked differences were found in the development of the curves and these are shown in Table 3. The rate of break-

TABLE 3.—*Viscosity trends of starch fractions at termination of heating cycle.*[1]

Date of examination	Fraction +44 microns		31-44 microns		—31 microns		Unsieved	
	East	West	East	West	East	West	East	West
November	+[2]	+	0	+	—	+		
January	—	+	—	+	—	0		
March	0	+	—	—	—	—	—	—
May	—	+	—	—	—	—	—	—
July	—	+	—	—	—	—	—	—
(av. decrease in viscosity after maximum cmg/min. during 5 min.)	0.3	—	1.0	0.3	1.1	0.6	1.0	0.3

[1]The cycle consisted of heating from 25 C at 1.5 C per minute during 45 minutes, then holding at 92.5 C for 15 minutes.
[2]+ = viscosity increasing; 0 = relatively steady during several minutes; — = viscosity decreasing.

down upon holding of the pastes from any one set of granules remained practically constant at successive examinations. This thinning effect has been reported as being greater in potato starch than in other common starches (Mazurs et al 10).

The fully pasted state has probably been reached in the starch of cooked French-fries and it may be conjectured that in the two present samples the poorer texture of the Eastern sample is due to its more rapid loss in starch viscosity along with the shorter time required to reach maximum viscosity.

Examination of swelling power was made on starch fractions from one Eastern and one Western sample in the season 1966-67. The values for the 44 — 53, 31 — 44, and 22 — 31 micron granules were 32, 36 and 41 g respectively for the Eastern material and 29, 33 and 40 for the Western. This greater swelling in the Eastern starch accompanied the poorer fry texture. It is seen that swelling power increased with decrease in particle size in both Eastern and Western samples. These facts are in agreement with the above findings on viscosity.

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