PURIFICATION, MODIFICATION, AND PROPERTIES
OF AIR-CLASSIFIED PEA STARCH

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ABSTRACT

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Methods for purifying air-classified pea starch from yellow field peas (*Pisum sativum*) were developed, including a unique method by which damaged granules were removed with the hull fragments. Pea starch has a relatively low swelling power, which results in a stable hot paste viscosity curve. Evaluation of functional properties of purified pea starches and chemically modified derivatives have shown that the characteristic acid and thermal stabilities of unmodified pea starch are readily destroyed by preparation of acetate or monophosphate derivatives. These pea starch derivatives have properties similar to those of the corresponding corn starch derivatives. Acetylation of a cross-bonded pea starch, however, did not affect its thermal stability. The hot paste viscosities of pea starch have been shown to be sensitive to the mechanical treatment and processing conditions used in purification. The hot paste viscosities of pea, faba bean, and wheat starches were increased in 5% salt and pH 4.35 buffer solutions. Birefringence end point temperature ranges, swelling power measurements, and hot paste viscosities of several commercial starches and pea starches were compared.

In the search for new food protein resources, researchers at the Prairie Regional Laboratory (Saskatoon, Sask.) of the National Research Council of Canada have developed a method for producing a 60% pea protein concentrate by air-classifying pea flour of less than 325-mesh particle size obtained by pin milling smooth-seeded yellow field peas (*Pisum sativum*) (1). Yellow pea flour contains about 24% protein (N × 6.25) (2). The major fraction from the air-classification process is the low protein or starch fraction. It is separated from the finer protein fraction by setting a cut point around 800 mesh (1). Present technology results in an air-classified pea starch that has a minimum protein content of about 3%; this by-product is obtained in about a 65% yield in the production of a 60% pea protein concentrate. The economic viability of manufacturing pea protein concentrate is naturally dependent on finding applications for the pea starch fraction.

The purposes of our investigations were to 1) study the properties of air-classified pea starch, 2) develop methods for producing a purified pea starch from the air-classified material and compare its properties with those of other common food starches, and 3) prepare pea starch derivatives using standard modification procedures and compare these products with modified corn starches.

Schoch and Maywald (3) studied the properties of legume starches, which they prepared by aqueous processing techniques. They found the purified starches from lentil, yellow pea, navy bean, and garbanzo show restricted swelling power when heated in water and also give stabilized Brabender hot paste viscosities similar to those of cross-bonded starches. Lineback and Ke (4) found similar results for chickpea and faba bean (horsebean) starches. Relative to regular corn and cereal starches, legume starches have rather high (30—40%) amylose

contents. The proportion of linear starch in yellow pea flour has been determined by Sosulski et al (5) as 36% amylose. This probably explains in part the reduced swelling power and increased stability of the granules toward mechanical fragmentation, but these expected correlations of swelling power, granule stability, and amylose content of starches are not absolute (3); ultimately an explanation of the unique properties of legume starches will be more complex than a statement of amylose content.

MATERIALS AND METHODS

Pea Starch Samples

Samples of air-classified pea starch were obtained from Pro-Star Mills Ltd., Saskatoon, Sask. Two types of materials were used for these investigations: pea starch-w samples were prepared from ground whole peas, and pea starch-d samples were prepared from ground dehulled peas (1). Both products contained 3–4% protein, but they differed in their appearance. Pea starch-d was almost white (pale yellow), whereas pea starch-w had a grayish appearance. This is believed to be due to hull fragments in pea starch-w.

Purification

Pea starch-d (1 kg) was slurried in 4 L of water with occasional stirring for 40 min. The starch solids were collected by vacuum filtration in a Buchner funnel and then reslurried for 15 min with 1 L of water. This wash procedure was repeated and the collected, purified pea starch-d was dried by one of three methods—freeze-drying, air-drying, or drying at 40° C in a vacuum oven. Pure white products were obtained.

Pea starch-w was purified in the same manner, except the starch was recovered by centrifugation. The reason for this was that the insoluble solids of sample-w sedimented in three distinct layers during centrifugation—a thin yellow pigment top fraction, a spongy grayish middle layer, and a dense white bottom layer. The top pigment layer was skimmed off before drying, and the other two layers were readily separated after freeze-drying the material in the centrifuge tubes. The bottom layer is the purified pea starch-w. The spongy middle layer is believed to be a mixture of hull fragments and mechanically damaged starch granules.

Other Samples

Other samples used in this investigation and their suppliers were: pea flour, Pro-Star Mills Ltd.; faba bean starch, Pro-Star Mills Ltd., prepared by air-classification (1); wheat starch, Industrial Grain Products Limited; cornstarch, St. Lawrence Starch Company Ltd.; potato starch, British Drug Houses Ltd.; Amylon VII, National Starch Co.; the modified waxy maizes SWM705, St. Lawrence Starch Company Ltd.; and Col Flo 67, National Starch Co. Rhozyme 33 was obtained from Rohm and Haas.

Modifications

The starting materials were the air-classified pea starch-w and regular corn starch. Since the reactions involved aqueous washings, recovery in a Buchner funnel, and air-drying, the pea starch was purified during preparation of the derivatives. For each modification with pea starch, a reagent blank reaction was

completed under the same conditions of pH, temperature, time, concentration, and workup.

Acetylation

The general method was used that Wurzburg (6) reported for producing food-grade starches with a low degree of substitution. The degree of substitution (DS) was varied either by varying the ratio (r) of the moles of acetic anhydride per mole equivalent of anhydroglucose or by completing two consecutive reactions at r 0.1 (standard conditions). DS was determined by the standard method (7).

Phosphatization (Monoester)

Starch monophosphate derivatives with low degrees of substitution were prepared by heating with sodium tripolyphosphate using the standard conditions that Paschall (8) reported. DS was varied by altering the reaction temperature over the range of 140–150° C. Reaction temperatures could not exceed 150° C due to degradation resulting in browning.

Cross-Linking

A slurry of 515 g of pea starch (3 mole equivalents of anhydroglucose) in 2 L of water was adjusted to pH 10 with $0.75N$ NaOH (70 ml). The mixture was stirred mechanically while slowly adding (1 hr) a solution of 1.5 ml of phosphorus oxychloride (0.006 mol) in 20 ml of carbon tetrachloride. The pH was kept at 10, with simultaneous addition of $0.75N$ NaOH (140 ml). The pH was adjusted to 5.5 with $0.5N$ HCl and the starch recovered and washed in a Buchner funnel.

Cross-Linked, Acetylated Pea Starch

The cross-linked pea starch product was acetylated in the usual manner (6).

Analytic Methods

Protein determinations were made on a Kjel Foss Instrument and are reported as N × 6.25. Phosphorus determinations were made using a colorimetric procedure that Harrow et al (9) described.

Diastatic Activity (10–12)

The inherent amylase activity of pea flour and air-classified starch was measured using AACC Method 22-15. Samples were incubated in pH 4.7 buffer at 30° C for 1 hr and also for 5 hr to accentuate the effect. Reducing sugars were determined by AACC Method 80-60 and the results reported as milligrams of maltose per 10 g of flour. Initial (blank) determinations of reducing sugar content were also made.

Damaged Starch (10,13–15)

The procedure described in AACC Method 76-30A was followed. Samples were incubated in pH 4.7 buffer with 10% w/w Rhozyme 33 at 30° C for 15 min. The maltose values obtained by the AACC procedure were adjusted by subtracting the initial reducing sugar content of the samples. The reported percentage of damaged starch was obtained by multiplying these adjusted values by the conversion factor 1.65.

Water Absorption (10,16—18)

Cold water absorptions were determined by a centrifuge method as described in AACC Method 56-20 (10) for hydration capacity. Our results (expressed in percent), however, are calculated as water absorbed per weight of unhydrated starch.

Water absorptions at elevated temperatures were determined by the method of Sandstedt and Abbott (17). A 2% starch slurry was heated at the rate of 1°C/min. At 5°C intervals, samples were removed, cooled, and centrifuged and the water absorbed was measured.

Birefringence End Point Temperature Range

Birefringence end point temperature ranges were determined using a polarizing microscope with a Kofler hot stage. The procedure that Watson (19) described was used. The sample was heated at the rate of 1.5°C/min, and the temperatures at 2, 50, and 98% loss of birefringence were recorded.

Amylograms

Amylograms were obtained on the Brabender Visco/amylo/Graph® with the 350 head at 75 rpm and heating rate of 1.5°C/min with a 15 min hold at 92°C before the cooling cycle to a final temperature of 35°C; 8% starch suspensions (40 g/460 ml) in distilled water were used. Amylograms in 5% NaCl solutions and at low pH were also obtained. The pH 4.3 buffer was composed of equal parts of 0.1M sodium citrate and 0.1M citric acid; the pH 2.2 buffer was 0.2N citric acid. The amylogram results reported are the Brabender viscosities at the peak temperature, at the beginning and end of the 92°C hold period, and the final viscosity after the cooling cycle (35°C).

Freeze-Thaw Stability

The cooked pastes from the amylogram determinations were frozen and thawed to obtain an indication of freeze-thaw stability.

RESULTS AND DISCUSSION

The results reported in Table I show that pea flour has significant diastatic activity, although less than that of wheat flour. The air-classified pea starch retains some of the amylase enzymes. The high initial values indicate that both

TABLE I
Diastatic Activity
(mg maltose/10 g flour)

Sample	% Protein	Incubation Time (30°C)		
		0	1 hr	5 hr
Hard wheat flour	13.5	49	176	267
Pea flour	23.5	109	179	240
Pea starch-w	3.7	40	61	130
Purified pea starch-w	0.6	0	0	0

TABLE II
Damaged Starch Analysis

Sample	Maltose (mg/10 g)	Adjusted Maltose Values	% Damage
Hard wheat flour	379	330	5.4
Pea flour	229	120	2.0
Pea starch-w	325	285	4.7
Purified pea starch-w	115	115	1.9
Wheat starch	255	255	4.2
Corn starch	75	75	1.2
Potato starch	55	55	0.9

TABLE III
Water Absorption
(g/g starch)

Time (min)	Temperature (°C)	Starch			
		Corn	Wheat	Purified Pea	Amylon VII
0	50	0.9	1.2	1.4	1.1
5	55	1.0	1.7	1.7	1.1
10	60	1.3	4.5	2.3	1.1
15	65	3.3	5.8	3.3	1.2
20	70	6.5	6.3	4.6	1.7
25	75	6.9	6.7	5.4	1.8
30	80	7.4	7.0	5.9	2.1
35	85	7.8	7.3	6.0	2.5
40	90	9.9	7.9	6.3	2.6
45	95	12.1	9.2	6.6	2.7

TABLE IV
Soluble Solids
(mg/g starch)

Time (min)	Temperature (°C)	Starch			
		Corn	Wheat	Purified Pea	Amylon VII
0	50	1.2	3.8	6.4	5.4
5	55	1.2	7.0	7.0	5.8
10	60	2.0	16	10	5.8
15	65	8.4	26	20	7.4
20	70	20	32	40	8.4
25	75	28	35	60	16
30	80	31	43	75	24
35	85	43	49	88	36
40	90	72	86	101	54
45	95	122	209	112	83

pea flour and the air-classified starch contain reducing sugars.

The results in Table II show that in dry-milling pea flour, mechanical damage of the starch occurs. If whole peas are used, the damaged starch is removed largely with the fiber fraction during purification as indicated by the lower value for purified pea starch-w. The adjusted maltose values were obtained by subtracting the initial reducing sugar content and were then used to calculate the percent of damage. The degree of damage that we observed in the pea starch sample analyzed is actually quite low compared with that found in other air-classified samples (20), and other pea starch samples used in this study likely had more than 5% damaged starch granules.

One effect that mechanical damage has on starch granules is to increase the cold water absorption values. We determined cold water absorption values for corn starch, purified pea starch-w, and several purified pea starch-d samples. The respective values were 80, 92, and 96–105%. These results are consistent with the expected effects from a dry-milling versus a wet-milling process. The lower absorption value for the pea starch-w sample is another indication that damaged starch granules have been removed during its purification. Although the differences in cold water absorption values between corn and purified pea starches are not large, they do result in significant viscosity differences in high starch solids applications such as batters.

Results from the swelling power determinations of regular corn, wheat, pea, and 70% amylose corn (Amylon VII) starch are reported in Tables III and IV. Although pea starch initially had the highest absorption, it picked up water at a slower rate than did either corn or wheat starch. As expected, Amylon VII had the lowest swelling power. The absorption values at 95° C show a definite order of decreasing swelling power of corn, wheat, pea, and Amylon VII starches. Potato starch has a much higher swelling power than does corn starch (18). These data do not correlate with the soluble solids data in Table IV. Pea and wheat starches generally gave higher soluble solids, this likely being due to the dry milling used in processing wheat and pea flours.

The results of determining the gelatinization temperatures of various starches by observing the loss of birefringence are reported in Table V. Pea starch is not unique in this respect; in fact, pea, wheat, corn, and potato starches all have

TABLE V
Birefringence End Point Temperature Ranges

Starch	Range (°C)
Amylon VII	( )–84–91
Pea-w	56–62–66
Purified pea-w	54–60–66
Acetylated pea (DS = 0.12)[a]	44–48–54
Cross-linked pea	55–61–65
Corn	59–62–67
Acetylated corn (DS = 0.12)	46–53–58
Wheat	55–59–62
Potato	58–61–65

[a]DS = degree of substitution.

TABLE VI
Pea Starch—Effects of Purification on Amylograph Results

Starch	Temperature (°C)		Viscosities (BU)		
	Initial	Peak	92° Begin	92° End	Final
Pea-w	71	Nil	140	240	550
Purified pea-w	71	Nil	170	300	640
Pea-d$_1$	71	Nil	120	330	840
Purified pea-d$_1$	70	Nil	670	800	2,000
Pea-d$_2$	71	Nil	130	250	580
Purified pea-d$_2$	72	Nil	330	440	1,350

TABLE VII
Effects of pH and Salt on Amylograph Results

Starch	Processing Conditions	Temperature (°C)		Viscosities (BU)			
		Initial	Peak	Peak	92° Begin	92° End	Final[a]
Purified pea-w	Water	71	Nil	Nil	170	300	640
	4.35 pH	74	Nil	Nil	740	970	1,955
	2.2 pH	71	79	840	560	120	960
	5% Salt	80	Nil	Nil	480	760	1,530
Purified pea-d	Water	70	Nil	Nil	670	800	2,000
	4.35 pH	73	Nil	Nil	1,010	1,260	3,260
	2.2 pH	69	81	970	540	70	1,040
	5% Salt	77	Nil	Nil	1,000	1,240	2,710
Pea-d (3.7% protein)	Water	71	Nil	Nil	120	330	840
	4.35 pH	73	Nil	Nil	500	700	1,680
	2.2 pH	70	80	645	580	215	1,380
	5% Salt	78	Nil	Nil	565	710	1,450
Corn	Water	71	92	1,200	1,200	1,040	2,600
	4.35 pH	80	92	1,250	1,190	1,040	2,440
	2.2 pH	73	85	850	330	5	130
	5% Salt	82	92	1,320	1,170	1,280	2,240
Wheat	Water	76	92	520	520	510	970
	4.35 pH	85	92	660	440	650	1,910
	2.2 pH	79	83	460	160	20	240
	5% Salt	86	92	980	980	970	1,990
Potato	Water	61	ND[b]	4,000+	ND	ND	4,000+
	4.35 pH	64	85	3,310	3,250	2,000	3,240
	2.2 pH	61	70	2,580	400	20	40
	5% Salt	62	89	3,440	3,330	2,300	3,940

similar gelatinization temperatures. This is in contrast to their respective swelling powers and serves to emphasize that starch granule birefringence is lost after a small increase in water absorption. Unless the granule has restricted swelling power (eg, Amylon VII), birefringence will be lost too quickly to reflect the rate of water absorption.

Like other legume starches, pea starch has a stable hot paste viscosity curve. We have found that the viscosity curves of pea starch are sensitive to the mechanical and physical methods used in isolating and purifying the starch fraction. Further, this unique stability is readily lost by chemical modification. In addition to demonstrating stability to shear during heating, unmodified pea starch has good acid resistance. These findings are illustrated by the amylograph results given in Tables VI—XI.

The effects of purification of pea starch on the aqueous solution hot paste viscosities are shown in Table VI. Purification of the pea starch-w sample had a relatively minor effect, whereas purification of the pea starch-d samples resulted

TABLE VII (continued)

Starch	Processing Conditions	Temperature (°C)		Viscosities (BU)			
		Initial	Peak	Peak	92° Begin	92° End	Final[a]
SWM705	Water	70	Nil	Nil	3,200	3,400	4,000+
(retort stable)	4.35 pH	82	Nil	Nil	3,500	3,780	4,000+
	2.2 pH	70	80	2,770	620	360	400
	5% Salt	79	Nil	Nil	3,000	3,280	4,000+
Col Flo 67	Water	64	73	3,270	3,000	3,270	4,000+
(acid stable)	4.35 pH	69	82	3,150	3,020	3,170	4,000+
	2.2 pH	62	77	3,070	2,000	920	490
	5% Salt	74	85	3,260	3,250	3,370	4,000+
Faba bean-w	Water	71	Nil	Nil	270	330	1,180
(8% protein)	4.35 pH	73	88	590	450	595	1,610
	2.2 pH	67	820	630	520	190	1,860
	5% Salt	74	Nil	Nil	540	650	1,480
Acetylated pea	Water	64	77	1,260	1,180	1,170	2,660
(DS 0.05)[c]	4.35 pH	67	80	1,510	1,400	1,330	2,800
	2.2 pH	64	75	1,260	580	80	60
	5% Salt	71	86	1,480	1,470	1,450	2,730
Acetylated corn	Water	70	85	1,440	1,220	1,010	2,270
(DS 0.05)	4.35 pH	72	88	1,380	1,150	920	2,000
	2.2 pH	70	80	1,020	280	20	30
	5% Salt	77	89	1,380	1,340	1,240	2,500

[a]Underscores indicate final amylograph viscosities.
[b]ND = not detectable.
[c]DS = degree of substitution.

in a dramatic enhancement of viscosity values. These results indicate that it is the effects on the damaged starch granules that are largely responsible for their enhancement. In the purification of the pea starch-w sample, the damaged granules were removed largely in the fiber layer (Table II), whereas in the purification of the pea starch-d samples, the damaged granules were not removed.

The data in Table VII show the good acid resistance of pea starch. The final amylograph viscosities at pH 2.2 are underlined. The purified pea starches have values of 1,000 BU ± 40, whereas corn, wheat, potato, and even retort-stable and acid-stable cross-linked waxy maize starches have much lower values. The only starches with higher final viscosity values were unpurified pea and faba bean starches. Acetylation destroys the acid stability of pea starches.

The hot paste viscosities of unmodified pea starch determined in pH 4.35 buffer and in 5% salt solutions were enhanced over the viscosities determined in aqueous solution around pH 6.5 (Table VII). The sensitivity of the amylograph curves of unmodified pea starches over the pH range 4–7 has been reported recently (20), supporting the data shown in Table VII. Comparing the amylograph results of the various starches given in Table VII, one can see that the hot paste viscosities of faba bean and wheat starches are also quite sensitive to pH 4.35 buffer and 5% salt solutions. Pea, faba bean, and wheat starches are distinguished from the other starches in Table VII by their lower swelling power in aqueous solution and consequent lower hot paste viscosities in water.

TABLE VIII
Purified Pea Starch-d—Effects of Drying Method on Amylograph Results

Drying Method	Amylograph Viscosities (BU)		
	92° Begin	92° End	Final
Freeze-drying	600	760	1,970
Air drying	670	800	2,000
40° C in vacuo	820	930	2,350

TABLE IX
Pea Starch—Effects of Extraction pH and Cross-Linking on Amylograph Results

Reactants	Temperature (°C)		Viscosities (BU)			
	Initial	Peak	Peak	92° Begin	92° End	Final
pH 6.3 extraction	72	Nil	Nil	330	440	1,350
pH 8.2 extraction	72	Nil	Nil	250	370	1,000
pH 10.2 extraction	72	Nil	Nil	230	330	950
POCl$_3$	73	Nil	Nil	95	165	525
POCl$_3$						
Ac$_2$O[a]	67	Nil	Nil	110	160	540

[a] Degree of substitution = 0.065.

Presumably the higher ionic strength or lower pH environment or both cause additional swelling of the pea, wheat, and faba bean starch granules in a range critical to the development of higher hot paste viscosities.

Further evidence of the sensitivity of the amylograph viscosities of pea starch are shown in Tables VIII and IX. The results in Table VIII show a small but significant effect of drying method on amylograph viscosity. Higher temperatures gave higher viscosities. In Table IX, the effects of extraction pH are shown. Again, the effects were not large but were significant with higher pH values, giving purified pea starches with lower hot paste viscosities. In our extraction experiments, dilute alkali was a little more effective in removing protein than was water. Since we were interested in recovering the protein and wished to avoid alkali treatment, employing an extra water wash to reach the minimum protein level of 0.6 ± 0.1% was more convenient. Even with dilute

TABLE X
Acetylated Starches—Amylograph Results

Starch	DS[a]	Temperature (°C)		Viscosities (BU)			
		Initial	Peak	Peak	92° Begin	92° End	Final
Pea	0	71	Nil	Nil	250	370	1,000
	0.013	71	Nil	Nil	430	560	1,160
	0.019	67	92	1,220	1,220	1,220	2,180
	0.038	64	77	1,260	1,180	1,170	2,660
	0.050	64	76	1,560	1,420	1,390	3,000
	0.104	60	75	1,610	1,420	1,440	2,800
	0.118	58	69	1,780	1,570	1,590	2,950
Corn	0	71	92	1,170	1,170	1,000	2,000
	0.027	70	86	1,110	1,000	880	2,020
	0.051	70	85	1,440	1,220	1,010	2,270
	0.106	62	80	1,655	1,290	1,160	2,570
	0.128	60	77	1,510	1,030	1,130	3,000

[a]DS = degree of substitution.

TABLE XI
Starch Monophosphates—Amylograph Results

Starch	DS[a]	Temperature (°C)		Viscosities (BU)			
		Initial	Peak	Peak	92° Begin	92° End	Final
Pea	0	71	Nil	Nil	400	500	1,280
	0.003	71	92	1,000	1,000	1,000	2,720
	0.006	64	77	2,630	2,200	1,940	4,000+
	0.009	62	76	3,440	2,800	2,480	4,000+
Corn	0	71	92	1,200	1,200	1,040	2,000
	0.009	46	71	3,000	2,440	2,500	4,000+

[a]DS = degree of substitution.

alkali, obtaining a purified pea starch with a protein level below 0.5% was not possible.

The effects of chemical modification on hot paste viscosities are recorded in Tables IX–XI. As expected, cross-bonding with diphosphate linkages suppresses the viscosity. What is more interesting is that this cross-linked starch retained its excellent stability after acetylation (Table IX). This can be contrasted with the results in Table X. Pea starch is much more sensitive to acetylation than is corn starch. A DS as low as 0.02 is enough to lower the gelatinization (initial) temperature and raise the amylograph viscosity to about the same value as the analogous corn starch sample. At a DS of 0.05, the effects on the amylograph behavior of pea starch plateau, whereas the greatest effects occur between a DS of 0.05 and 0.13 with corn starch. With corn starch, the effects are primarily to lower the gelatinization and peak temperatures and raise the setback viscosity. This occurs with pea starch as well, but in addition, the hot paste viscosities increase dramatically and a peak viscosity is obtained. The net effect of acetylation is to destroy the unique properties of pea starch. Acetylated pea starch is similar to acetylated corn starch in its properties. One of these properties is freeze-thaw stability, which acetylation is known to impart to starches. The gelatinization temperatures as revealed by the loss of birefringence are also similar (Table V).

Monophosphatization of pea starch has the analogous effect of producing a derivative with similar properties to those of the corresponding corn starch derivative. A DS as small as 0.003 was sufficient to give a peak in the viscosity curve (Table XI). The peak viscosity was sensitive to the DS, with the value at 0.009 being more than three times the value at 0.003.

CONCLUSIONS

From our study of the properties of pea starches and their relationship with commercial starches, we conclude that the unique acid and heat stability of unmodified pea starch is due to the restricted swelling power of the intact, undamaged granules. Since this unique stability is destroyed by minor chemical modifications, it is likely that in addition to the chemical composition (eg, amylose content), physical structural characteristics play a major role in restricting the swelling power of the pea starch granules. Our findings of the sensitivity of hot paste viscosity to the degree of mechanical damage and the nature of the processing treatments in purification suggest methods for producing pea starches with a range of hot paste viscosities. In this regard, the amylograph viscosities of pea starches can be increased without sacrificing stability to shear under heat and acid conditions. In this way, the food industry may use pea starches as complements to corn starch to improve cooking stability.

We have studied the potential food applications of purified pea starches by evaluating them in various food formulations, eg, batters, soups, gravies, sauces, and meat binders. Pea starch would offer functional advantages over presently available commercial products in relatively few food applications. Canning applications generally require heat-stable starches that will not exhibit syneresis. Unmodified pea starch, although heat stable, forms a brittle gel with syneresis and therefore could replace only partially present canning starches (modified waxy maize starches). Unmodified pea starch would appear to offer some

functional advantages over regular cornstarch in low pH sauces and as a binder ingredient in canned luncheon meat products. Noncanning applications in sauces and gravies would be critically dependent on the thickening ability of the pea starch product.

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