1. First, and most important, these results refer to only one set of conditions (e.g., protein concentrations, mixing regime, etc.). They are chosen for illustration only as it is well known that the technical performance of protein stabilizers does exhibit significant concentration effects.
2. Table II indicates the descriptions conventionally applied to these proteins and illustrates that they do have very different intrinsic molecular characteristics as previously mentioned.
3. Under the very schematic conditions outlined, we see an increase in technical performance depending upon whether the preparation regime was hot or cold.
4. Under cold processing conditions, there also appears to be a difference in technical performance among the various ingredients.

In Table III these technological observations have been combined with the molecular characteristics as they have been *inferred* from the best available N.M.R., or D.S.C. data. The author feels it appropriate to stress that the information in Table III is intended to be illustrative rather than definitive.

Comparing the relative performance of the four proteins under cold preparation conditions, caseinate would seem (under the specific conditions used) to be the least effective. All of the other proteins considered, however, appear to have significant emulsifying ability even under cold preparation conditions. When we look at the N.M.R. results shown in Table III, there does seem to be a possible correlation between the N.M.R. observable apolar residues and emulsifying ability. Thus the *actual* presence, and *availability* of appropriate apolar residues would seem to be a necessary protein characteristic in the initial fat emulsification being discussed. This is further substantiated by the effectiveness of caseinate under hot preparation conditions, and the observation of a well developed apolar residue N.M.R. spectrum at higher temperatures. Blood albumen has some emulsifying ability under cold preparation conditions, but this ability is clearly enhanced under hot preparation conditions. The combined N.M.R., and D.S.C. results for albumen show that the availability-mobility of the apolar residues increase with temperature (N.M.R.), and that a molecular unfolding (denaturation) also occurs upon heating (D.S.C.). It is tempting to infer that increased emulsifying ability of albumen with temperature rise correlates directly with increased *availability* of apolar residues.

The two soy ingredients differ in technical performance, but only soy ingredient "a" appears to undergo a molecular unfolding giving rise to a D.S.C. transition. The technological results would seem to be consistent with the statement that ingredient "a" undergoes a structural change upon heating allowing more apolar residues to become available. On the other hand, ingredient "b" has – during manufacture – clearly undergone some processing step resulting in a loss of native structure – hence, no D.S.C. transition is evident. However, the relatively modest indication of mobile apolar amino acids as indicated by the N.M.R. results cautions us not to seek too simple a correlation in this highly complex product environment!

Though detailed analysis of the kind of information schematically presented in Table III could suggest that there is a correlation between the state of the protein and the availability of the apolar amino acids and its fat emulsification ability, it is essential to bear in mind that many other factors (e.g., viscosity, geleation) are very likely to be involved in this situation. Furthermore, as stressed previously, the results are intended to be indicative of the types of information that it should now be possible to generate, rather than purporting to be the actual observations in those technological situations. However, combining the indications presented in Tables II and III should enable us to infer that in fat emulsification two protein characteristics of major importance are likely to be: a.) availability-distribution of polar-apolar residues both for solubility and amphipathicity; and b.) conformational flexibility at appropriate temperatures.

It is not possible to give a meaningful answer to the question raised in the introduction. The purpose of this presentation was merely to indicate that techniques and approaches may now be becoming available to enable us to ask the question in a scientifically acceptable way, and to draw attention to the magnitude of our ignornance of the role of processing in changing protein characteristics and particularly our ignorance of how protein characteristics really relate to product situations. It is suggested that considerable systematic work, possibly using techniques such as those briefly outlined in this presentation, and selecting very carefully defined model systems, could go some way towards rectifying this situation.

Yield and Functional Properties of Air-Classified Protein and Starch Fractions from Eight Legume Flours

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ABSTRACT

Eight legumes were pin-milled and air-classified into protein (fine) and starch (coarse) fractions and their functional properties compared with those of soybean and lupine flours. The fine material which represented 22.5 to 29% of the original flours contained from 29 to 66% protein as well as a high proportion of the flour lipids and ash. The coarse material contained 51 to 68% starch and much of the crude fiber which was dense and concentrated in the starch fraction. Generally legumes which showed highly efficient starch fractionation gave lower recoveries of protein in the fine material. High values for oil absorption, oil emulsification, whippability and foam stability were characteristic of the protein fractions, while starch fractions gave high water absorptions, peak and cold viscosities. Gelation occurred in both air-classified fractions. Pea and northern bean, chickpea and lima bean flours, and air-classified fractions gave generally higher values in the functional property tests, while fababean, field pea, mung bean and lentil gave high protein fractionation in the air classification process.

INTRODUCTION

Grain legumes are normally consumed as whole or split

TABLE I

Composition of Legume Flours, Protein Fractions (PF) and Starch Fractions (SF) in Percent, Dry Basis

	Crude protein[a]			Crude fat			Crude fiber			Ash			Starch		
	Flour	PF	SF	Flour	PF	SF	Flour	PF	SF	Flour	PF	SF	Flour	PF	SF
Soybean	52.5	54.2	50.5	0.6	---	---	2.6	---	---	6.4	---	---	4.7	---	---
Lupine	41.4	43.3	30.0	7.6	---	---	3.0	---	---	3.0	---	---	3.5	---	---
Chickpea	19.5	28.9	15.3	7.4	10.8	5.8	3.3	1.9	3.1	3.0	3.9	2.6	50.0	30.3	57.3
Pea bean	24.7	52.4	15.2	1.7	3.3	1.0	4.5	2.2	5.6	4.0	7.4	2.7	38.4	1.4	51.6
Northern bean	24.0	53.5	15.6	1.7	3.9	1.3	4.5	2.1	5.4	4.0	7.8	2.9	40.3	1.4	51.5
Fababean	29.8	66.6	14.4	1.3	2.6	0.8	8.0	2.5	10.6	3.4	6.9	2.1	42.4	1.4	57.5
Field pea	25.3	61.3	14.5	1.1	2.6	0.7	7.0	2.2	7.8	2.7	5.4	2.1	45.9	2.1	60.0
Lima bean	23.0	47.7	13.9	0.9	2.0	0.7	5.0	2.8	5.8	4.1	7.8	2.6	45.5	0.0	61.1
Mung bean	26.5	60.4	12.3	0.9	2.2	0.6	3.9	2.1	5.1	3.4	6.8	1.9	50.0	6.1	67.7
Lentil	23.9	57.9	12.2	1.1	2.4	0.7	3.8	2.5	4.4	2.8	5.5	2.0	52.8	7.5	68.2

[a]% N x 6.25.

TABLE II

Yield of Air-Classified Protein (Fine) and Starch (Coarse) Products and Efficiency of Protein and Starch Fractionation

	Product yield: Fine/Coarse Ratio	% of total protein in fine fraction	% of total starch in coarse fraction
Soybean	72:28	74.1	---
Lupine	82:18	85.7	---
Chickpea	29:71	43.0	81.4
Pea bean	26:74	55.2	99.4
Northern bean	22.5:77.5	50.0	99.9
Fababean	28:72	62.6	98.6
Field pea	24:76	58.1	99.2
Lima bean	27:73	56.0	98.0
Mung bean	29:71	66.1	96.3
Lentil	26:74	63.0	95.6

legumes with only a small quantity being processed into flour. As protein sources, many species have the disadvantage of being low in protein (1) as well as displaying a wide range in protein level due to growing conditions (2,3). Many grain legumes contain a high proportion of starch (1), and a commercial procedure has been developed for separation and concentration of protein and starch components by fine grinding and air classification (3,4). Investigations of cereals have shown that pin-milled flours contain a high proportion of light protein particles while the dense material is composed primarily of starch (3). With field peas and fababeans, the enrichment of protein and starch in the light and dense components, respectively, are much greater than in cereals (3,4). In contrast to wet concentration methods, the dry process has low capital and labor requirements; there is no costly effluent disposal requirement; sanitation problems are minimal; and there are no by-products except possibly hulls.

Objectives of the present investigation were to determine the efficiency of pin-milling and air classification for concentration of components in the common bean, chickpea, lima bean, mung bean and lentil as well as the nonstarchy legumes, lupine and soybean. In addition the effects of protein and starch concentration on the functional properties of the legume products were determined. Field pea and fababean were included in the study for comparative purposes.

MATERIALS AND METHODS

Seeds of soybean (*Glycine max*), white lupine (*Lupinus angustifolius*), chickpea (*Cicer arietinum*), white pea bean and great northern bean (*Phaseolus vulgaris*), small fababean (*Vicia faba minor*), field pea (*Pisum sativum arvense*), baby lima bean (*Phaseolus lunatus*), mung bean (*Vigna radiata*) and lentil (*Lens culinaris*) were grown on experimental plots at the University of Saskatchewan. The seeds of soybean and lupine were dehulled by cracking between corrugated rolls, followed by air aspiration. Ground seed of soybean was defatted with diethyl ether and the solvent removed using vacuum at 40 C. All legumes including the soybean meal were pin-milled to less than 325-mesh (Tyler) particle size in an Alpine Pin Mill model 250 CW. About 10 kg of each legume was fractionated into light and dense particles by a single pass through an Alpine Air Classifier Type 132 MP using a cut point of ca. 800 mesh (15 μ diameter) between the light and dense particles (4).

Proximate analyses of the products were conducted by the AACC (5) procedures for moisture (air-oven method), crude protein (micro-Kjeldahl procedure, N x 6.25), crude fat (method 30-25), crude fiber (method 32-15) and ash (600 C, 3 hr). Starch contents were determined by the polarimetric method (5).

Functional property tests were conducted in duplicate on product samples adjusted to an equal dry weight basis. The pH and water and fat absorption capacities were determined by the procedures of Lin et al. (6), while oil emulsification was conducted by a modification (6) of the Inklaar and Fortuin (7) method. Whippability and foam stability were measured on 3% (w/v) slurries (6) with colors being recorded for the slurries and foams.

A Brabender viscoamylograph was used to measure viscosity during a heating and cooling cycle according to the AACC (5) method 22-10 in which the slurries were heated from 30 to 97.5 C to determine peak viscosity and, after holding at 97.5 C for 15 min, the slurries were cooled at 1.5 C per min for 30 min to obtain the cold paste viscosity values. Gelation experiments were conducted by heating 15% (w/v) slurries in sealed stainless steel containers to 90 C for 45 min in a water bath (1). After cooling rapidly in an ice bath to 25 C, the volume of pourable slurry was measured to determine, by difference, the degree of gelation.

RESULTS AND DISCUSSION

While the protein contents of soybean and lupine flours

TABLE III

Functional Properties of Legume Flours, Protein (PF) and Starch (SF) Fraction in Percent, Dry Basis

	pH	Water absorption			Oil absorption			Oil emulsification		
	Flour	Flour	PF	SF	Flour	PF	SF	Flour	PF	SF
Soybean	6.6	129	---	---	134	---	---	99	---	---
Lupine	5.5	173	---	---	125	---	---	90	---	---
Chickpea	6.3	75	69	78	78	85	67	94	92	79
Pea bean	6.2	89	84	93	70	83	61	64	66	20
Northern bean	6.3	122	144	113	73	85	66	92	98	57
Fababean	6.4	86	33	124	74	94	61	47	77	24
Field pea	6.4	80	72	103	72	94	61	48	48	20
Lima bean	6.3	63	32	102	63	81	54	53	70	27
Mung bean	6.3	72	41	92	65	90	49	64	64	22
Lentil	6.3	85	95	93	66	92	51	56	58	50

TABLE IV

Whippability and Foam Stability of Legume Flours, Protein (PF) and Starch (SF) Fractions

	Initial foam volume, ml			Final foam volume, ml			Color of product	
	Flour	PF	SF	Flour	PF	SF	Slurry[a]	Foam[a]
Soybean	960	---	---	805	---	---	Tan	White
Lupine	57	---	---	2	---	---	Yellow	Yellow
Chickpea	7	25	5	0	0	0	Cream	White
Pea bean	747	970	415	610	760	322	Cream	White
Northern bean	615	1,055	367	492	800	285	Cream	White
Fababean	220	500	117	162	395	95	Brown	Brown
Field pea	335	815	246	4	10	42	Cream	White
Lima bean	435	900	315	322	715	200	Cream	White
Mung bean	832	1,025	485	546	730	255	Green-Brown	Tan
Lentil	435	850	400	360	695	302	Tan	Tan

[a]All protein fractions produced white foams.

were 52.6 and 41.4%, respectively, the grain legumes contained 19.5-29.8% protein (Table I). The total contents of protein and starch, however, averaged over 76.5% in mung bean and lentil flours with pea and northern bean containing less than 65%.

Air classification of the pin-milled soybean and lupine flours gave only slight enrichment of protein in the light (PF) material with much of the protein remaining in the dense (SF) material (Table I). Since air classification appeared to be of no benefit in refining these legumes, only the flours were evaluated for their functional properties.

Except for chickpea, the protein contents of the light material were increased to 47.7-66.6% while the dense components contained only 12.2-15.6% protein (Table I). Starch separation was very efficient in most species, the protein fractions containing only 0.0-7.5%, while the levels in the starch fractions ranged from 51.5-68.2%. The significant quantity of lipid in chickpea flour appeared to interfere with the air classification of the pin-milled flour, apparently because of the tendency for the flour to agglomerate.

Other cellular constituents were also fractionated by the air classification process. Most of the lipid and ash appeared with the light material while the crude fiber, primarily hulls (4), segregated with the large, dense starch particles (Table I). Vose et al. (4) found that field pea and fababean starch fractions contained 8-10% crude fiber from whole seed milling and 1% crude fiber from dehulled seeds. On the other hand, the protein fractions were similar in composition whether or not the seeds were dehulled before pin-milling.

Except for chickpea and the controls, the yields of protein fraction varied between 22.5 and 29% of the flour weight and protein recoveries ranged from 50.0 to 66.1% (Table II). Concentration of starch in the dense material was over 95% efficient in the latter flours, although there was an inverse relationship between protein and starch recoveries. Mung bean and lentil showed high protein recoveries, but 3-4% of the starch remained in the light material. However, fababean gave a high yield of light material and high recoveries of protein and starch.

Vose et al. (4) remilled the field pea and fababean starch fractions, and by air classification recovered additional light material containing intermediate levels of protein and starch. The resulting dense material contained over 70% starch with less than 5% protein. However, starch damage was found to be proportional to the number of pin-millings (8), and since functional tests were to be conducted on the products, only the single pass procedure was used in the present study.

The pH value for the aqueous dispersion of soybean flour (6.6) was slightly higher than those of the starchy legumes (6.2-6.4), but lupine flour had a more acid pH of 5.5 (Table III). The protein and starch fractions had essentially the same pH as the original flours.

Among the flours, soybean and lupine gave high values for water and oil absorption, and oil emulsification (Table III). Northern bean flour, protein, and starch were high in water absorption and oil emulsification, while chickpea products showed good oil absorption and emulsification properties. Generally, the starch fractions showed the strongest water absorptions, while the protein fractions were superior in oil absorption and emulsification. Differences in functionality between the protein and starch fractions were not large in chickpea and lentil which had exhibited poor starch or protein fractionation.

Lipids in lupine and chickpea seriously reduced the foaming properties of the flours and air-classified products, but values for defatted soybean flour were very high (Table IV). Pea, northern, and mung bean flours showed intermediate foam volumes and stability relative to soybean flour. However, a previous investigation (1) demonstrated that defatted chickpea and lupine flours have excellent foaming properties and, presumably, soybean was favored in the same way in the present investigation. The protein fractions

TABLE V

Viscoamylograph Curve Data and Gelation Properties of Legume Flours, Protein (PF) and Starch (SF) Fractions

	Peak viscosity, B.U.			Cold paste viscosity, B.U.			Degree of gelation, %		
	Flour	PF	SF	Flour	PF	SF	Flour	PF	SF
Soybean	60	---	---	60	---	---	0	---	---
Lupine	60	---	---	180	---	---	91	---	---
Chickpea	1,000	440	1,000	1,780	520	1,820	58	60	56
Pea bean	660	140	1,000	780	260	1,520	85	100	82
Northern bean	980	240	1,340	860	210	1,760	71	82	70
Fababean	460	60	700	1,020	150	2,260	74	92	59
Field pea	525	50	720	800	70	920	72	100	83
Lima bean	980	120	1,040	1,100	260	2,000	76	79	80
Mung bean	920	40	1,160	780	180	1,800	75	73	83
Lentil	640	80	980	840	260	2,400	77	95	53

showed stronger foam volumes than the flours, and only the stability of the field pea protein was poor. All protein fractions gave white foams, but the original slurries exhibited a range of colors from white to green-brown.

High peak and cold paste viscosities in the viscoamylograph curves were primarily a property of the starch fractions, and very low values were obtained for soybean and lupine flours as well as most protein concentrates (Table V). Intermediate peak viscosity values combined with high cold paste viscosity were characteristic of fababean and lentil starch fractions. Intermediate peak and cold viscosities were observed for field pea starch, while relatively high values for both parameters were obtained for northern bean starch.

Lupine flour showed good gelation properties, while the soybean flour developed into a thick pourable slurry during the heating and cooling experiment (Table V). Generally, the protein fractions tended to gel more completely than the starch fractions, but high values were obtained in both components. Pea bean and field pea proteins gelled completely while lentil and fababean proteins also gave high values.

Present data showed that a portion of the variation in functional properties among legume flours can be ascribed to the ratio of protein to starch, and other constituents such as lipids, in the original flour. In addition, the individual protein and starch fractions, even in the crude form obtained by air classification, exhibited a wide range in physiochemical characteristics. These air-classified products, possibly with future refining of the starch fraction, could serve to expand the range of functional raw materials available to the food and related industries. In general, food and industrial processors require ingredients with weak, intermediate or strong functional properties, depending on the end-use. Therefore, it is not appropriate to designate a particular air-classified fraction as being superior to another. However, it can be concluded that pea and northern bean, chickpea and lima bean flours, and air-classified fractions gave generally higher values in the functional property tests while fababean, field pea, mung bean and lentil gave high protein fractionation in the air classification process.

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Taste of Potato Protein and Its Derivatives

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ABSTRACT

Large amounts of potato protein are available from potato processing plants. Nutritionally the amino acid composition is good, but the solubility of proteins recovered normally by heat coagulation needs to be increased. One way to do this is by enzymatic hydrolysis. Bitterness is thereby developed and this is discussed in relation to the Q value thesis.

In potato starch production, large amounts of potato protein become available as by-product and at the moment are mostly used only for animal feed.

There are several different ways of obtaining the protein from the processing liquor, the most economic being heat coagulation (1). For application in foodstuffs, the solubility of the protein has to be increased, and enzymatic hydrolysis seems to provide a good method of doing this. From a nutritional standpoint, potato protein has a very good amino acid composition and also has a high proportion of hydrophobic amino acids.

As previously described (2), the bitterness of a peptide is caused by the hydrophobicity of its amino acid residues. The mean hydrophobicity Q is obtained by summing the hydrophobicities of the different amino acid residues of a peptide and dividing by the total number of the residues, thus $Q = \frac{\Delta f}{n}$ Peptides with Q-values above 1,400 are bitter, whereas peptides with Q-values below 1,300 are not bitter (2-4). As an example: the dipeptide Glutamyl-lysine has a Q-value of $\frac{550 + 1,500}{2} = 1,025$ and is not bitter, 550 being the hydrophobicity increment for Glutamic acid and 1,500