I'Tec_B1
December 2006

Keywords: Grinding, grain size, protein, pea

The pea grinding process in a pregrind diagram
Influence of grain size on pea protein distribution in a series of grain size fractions

1. Focus

The aim was to study how the grain size distribution of pea flour affects protein dispersion in a series of grain size fractions.

2. Equipment and apparatus

2.1. Peas

The test used a batch of peas sourced at an industrial site.

2.2. Grinder

The test used a Forplex brand laboratory blade grinder (with hammers fixed on the rotor). The machine had a peripheral blade speed of 59.4 m/s. The grinder was equipped with an adjustable aperture screen.

2.3. Sifter

A Retsch sifter was used according to the method developed at Tecaliman.

3. Methods

The pea batch was ground in a pilot workshop using a laboratory grinder to obtain median grain diameters of approx. 200, 500 and 1000 µm (Table 1) by varying the screen type and/or number of grinding operations.

Desired d50 (µm)	Grinding procedure
200	1st operation: 2-mm screen 2nd operation: 1-mm screen
500	Single operation: 2.5-mm screen
1000	Single operation: 7-mm screen

Table 1: Grinding methods

The measured variables were:

- Flour grain size (Tecaliman, 1996)
- Dumas nitrogen and dry matter content of the various size fractions (Laboratoire IEEB - European Institute for the Environment of Bordeaux).

The grain size fractions obtained during the grain size measurement were grouped in order to gather a sufficient quantity of products for analysis.

4. Results and discussion

The results were compared with those of a previous 2000 study by Maaroufi.

4.1. Flour grain size

Table 2 shows the characteristic diameters obtained from these distributions. Statistical parameters were either interpolated, or calculated using the standard Gaussian logarithmic model in order to compare the results of this study against those of Maaroufi (2000). The interpolated median diameters were then used to designate the flours.

Pea flour	Gaussian logarithmic model			Interpolation		
	d50	d16	d84	d50	d16	d84
200 µm (Theoretical)	**247**	140	436	**215**	120	419
500 µm (Theoretical)	**485**	215	1095	**525**	164	984
1000 µm (Theoretical)	**1155**	543	2456	**1157**	470	2223
Maaroufi (2000)	**669**	336	1331			

Table 2: Grain size - Statistical flour parameters

Table 3 gives the size distributions of the various flours.
The grain sizes obtained were close to those sought. Despite being much finer grained (deviation of 204 µm with respect to the Gaussian logarithmic d50), the pea flours that corresponded most closely with those used by Maaroufi (2000) were the 500-µm flours.

SIEVE (µm)	FLOUR (Theoretical)			SIEVE (µm)	FLOUR (Theoretical)			SIEVE (µm)	FLOUR (Theoretical)		
	200 µm	500 µm	1000 µm		200 µm	500 µm	1000 µm		200 µm	500 µm	1000 µm
3150	0	0	6.3	**800**	0.5	12.9	9.3	**200**	17.2	4.5	6.5 (a)
2500	0	0	9.5	**630**	2.5	12.9	7.1	**160**	11.3	3.3	
2000	0	0	10.4	**500**	9.1	11.8	5.5	**125**	12.0	4.4	
1600	0	0	12.8	**400**	11.3	8.1	3.5	**100**	7.3	3.0	
1250	0	9.6	12.8	**315**	12.2	6.7	2.8	**80**	4.0	6.9 (a)	
1000	0.4	10.7	11.5	**250**	10.7	5.5	2.2		1.2 (a)		

(a) Sieved volume of the last sieve shaker used

Table 3: % by weight of flour per grain size category – Pregrind diagram

4.2. Protein content

4.2.1. Total flour protein content

As the three flours produced during the study were derived from a single source, their total protein contents were identical. These contents were lower than the protein contents of the pea flour used by Maaroufi in 2000 (Table 4).

Pea flour	Protein content (%DM)
215 µm	22.5
525 µm	22.6
1157 µm	22.6
Maaroufi (2000)	23.7

Table 4: Protein content of the various types of flour - Pregrind diagram

Sieve (µm)	Flour protein content % DM			
	215 µm	525 µm	1157 µm	Maaroufi (2000)
3150			21.96	
2500			21.62	22.1
2000			21.11	
1940				21.8
1600			20.44	
1520				22.4
1250		19.81	20.41	
1040				21.9
1000		21.03	20.59	
800		20.39	21.51	
760				24.2
630	17.24	21.51	22.32	

Sieve (µm)	Flour protein content % DM			
	215 µm	525 µm	1157 µm	Maaroufi (2000)
500	18.29	21.36	22.38	25.2
400	20.91	22.30	22.84	
315	22.26	22.98	23.79	
250	22.98	23.51	24.87	
230				25.5
200	22.88	23.96	25.36 (a)	
160	23.00	24.37		
125	22.66	23.90		
122				25.7
100	22.75	22.44		22.5 (a)
80	22.69 (a)	22.59 (a)		
Mean	**21.57**	**22.32**	**22.25**	**23.48**
C.V.%	**9.8**	**6.4**	**7.2**	**7.0**

(a) Sieved volume of the last sifter

Table 5: Protein content per size fraction in the various flours

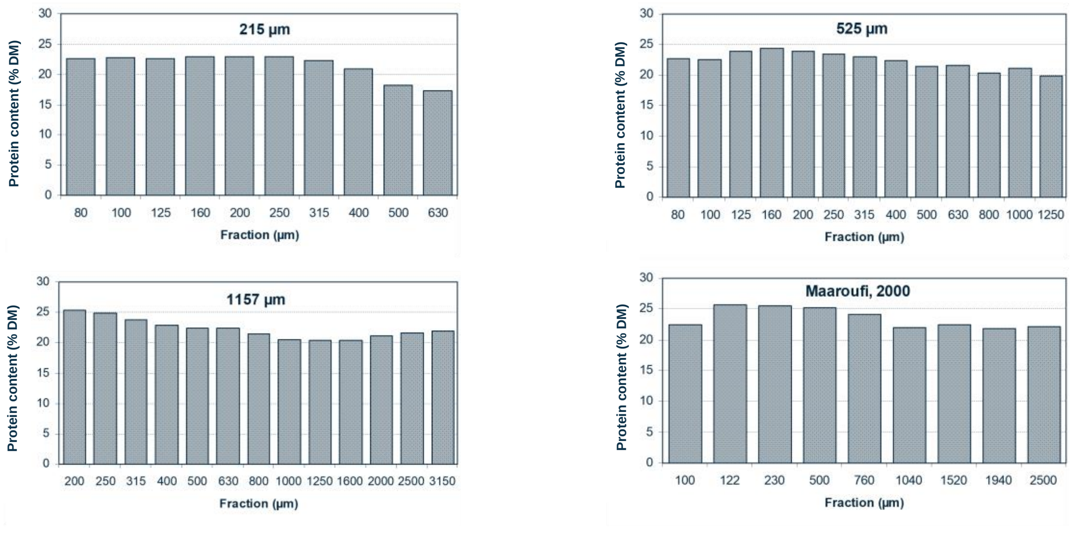

Figure 1: Changes in protein content per size fraction in the various pea flours

4.2.2. Protein contents in the various grain size fractions

The results illustrated in Table 5 and Figure 1 demonstrate that:

- the fluctuations in protein content in the various grain size fractions for any given flour were below 10%.
- generally speaking, protein content, expressed as a percentage of dry matter, increases with decreasing grain size.
- the highest contents were recorded in the fractions lying between 122 and 200 µm
- grain size fractions above 1520 µm (Flour 1157 µm) had a higher protein content than those between 1000 and 1520 µm.
- the lowest protein content recorded in fractions below 100 µm was most likely due to these fractions having a higher starch content.

4.2.3. Quantity of protein provided by the various grain size fractions in the flours

This quantity is expressed as a percentage of total pea flour protein (Table 6). These results demonstrate that:

- in flour with a median diameter of 215 µm, 90% of the protein is contained in the fraction below the 500-µm mark.
- when the flour's median diameter doubles (525 µm), the portion of protein carried in size fractions below 500 µm is halved (44.7%).

Sieve (µm)	Flour type (interpolated d50)					
	215 µm		525 µm		1157 µm	
	%N Total N		%N Total N		%N Total N	
	%	Cumulated %	%	Cumulated %	%	Cumulated %
3150	0.0	0.0	0.0	0	6.4	6.4
2500	0.0	0.0	0.0	0	9.4	15.8
2000	0.0	0.0	0.0	0	10	25.8
1600	0.0	0.0	0.0	0	12.2	38
1250	0.0	0.0	8.7	8.7	12.1	50.1
1000	0.0	0.0	10.3	19	11	61.1
800	0.0	0.0	12.1	31.1	9.1	70.2
630	2.1	2.1	12.7	43.8	7.3	77.5
500	7.8	9.9	11.5	55.3	5.7	83.2
400	11	20.9	8.2	63.5	3.7	86.9
315	12.8	33.7	7	70.5	3.1	90
250	11.4	45.1	5.9	76.4	2.4	92.4
200	16.2	61.3	4.9	81.3	7.6	100.0
160	12.6	73.9	3.6	84.9	0.0	100.0
125	14.5	88.4	4.9	89.8	0.0	100.0
100	7.3	95.7	3.1	92.9	0.0	100.0
80	4.3	100.0	7.1	100.0	0.0	100.0

Table 6: % by weight of proteins carried by the various grain size fractions

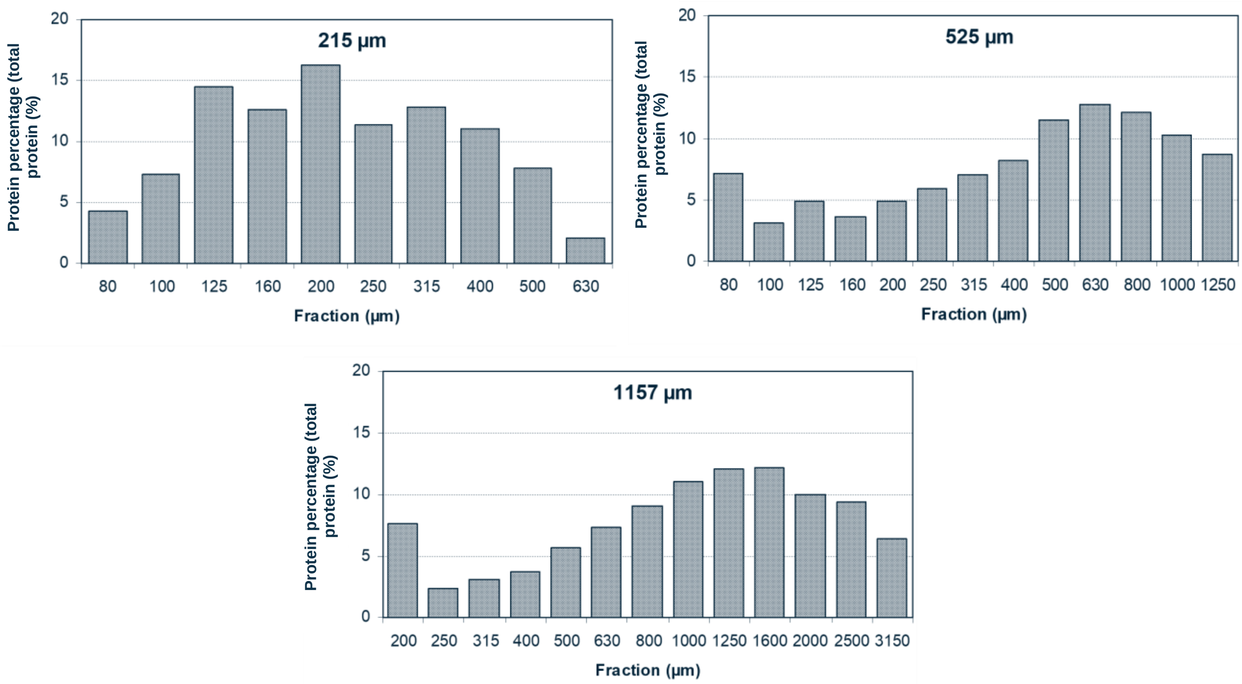

Figure 2: Changes in % by weight of proteins carried by the various grain size fractions

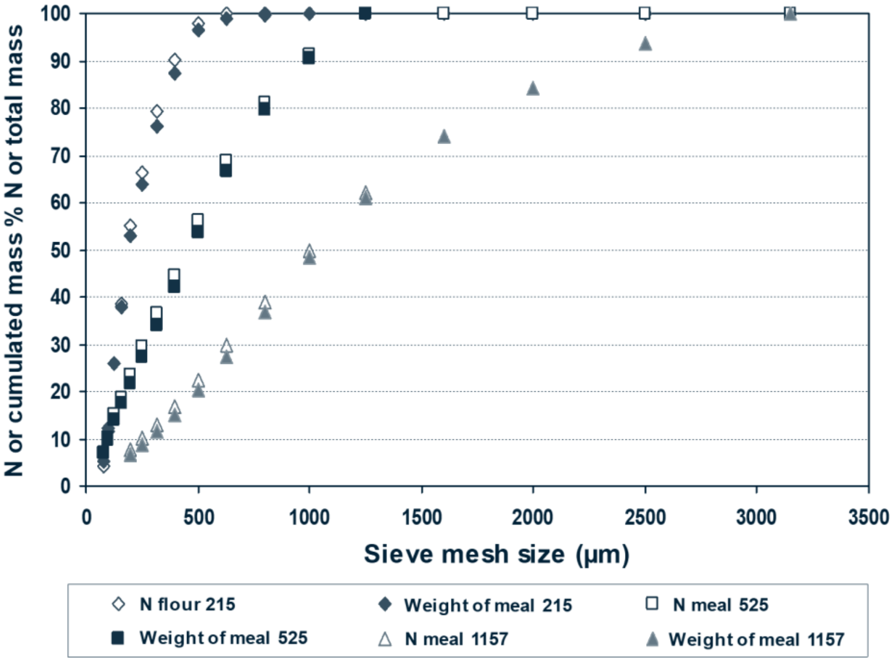

Figure 3: Nitrogen (N) or cumulated weights of the various grain size fractions as a % of total nitrogen or total weight

5. Conclusions

The fluctuations in protein content observed between the various grain size fractions (Table 5) suggest that the quantity of protein carried by each fraction when pregrinding peas mainly depends on the weight of these fractions (Figure 3 - Figure 2).

6. Bibliography

Maaroufi C., Melcion J.P., De Monredon F., Giboulot B., Guibert D., Le Guen M.P., 2000. Fractionation of pea flour with pilot scale sieving. I. Physical and chemical characteristics of pea seed fractions -.Animal Feed Science and Technology 85 (2000) 61-78.

i'Tec_B6. Method for determining and expressing the grain size of feed meals- September 1996.

i'Doc_M7. Valorisation des protéines végétales par des traitements technologiques en alimentation animale (Monogastriques) – Programmes de recherche interrégionaux Bretagne – Pays de la Loire – Rapport final. 2006