Water retention and flow behaviours of protein isolates from peas.

J. Lefebvre

► To cite this version:

J. Lefebvre. Water retention and flow behaviours of protein isolates from peas.. Qualitas Plantarum Plant Foods for Human Nutrition, 1983, 33, pp.201-208. hal-02721405

HAL Id: hal-02721405
https://hal.inrae.fr/hal-02721405

Submitted on 1 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Inventaire
N° 372

Qual Plant Plant Foods Hum Nutr 33 (1983) 201–208
© 1983 Martinus Nijhoff/Dr W. Junk Publishers, The Hague. Printed in The Netherlands

Water retention and flow behaviours of protein isolates from peas

JACQUES GUEGUEN and JACQUES LEFEBVRE

Laboratoire de Biochimie et Technologie des Protéines, Centre Agro-Alimentaire,
Institut National de la Recherche Agronomique, Ministère de l'Agriculture,
44072 Nantes Cédex, France

Key words: Pea protein isolates, proteinates, soy bean isolate, chemical composition, functional properties

Abstract. Protein isolates from pea flour were prepared by extraction of protein at pH 7.0 or 9.0 which was followed by precipitation as isoelectric isolates or as proteinates. After spray-drying, chemical composition, water retention capacities, thickening properties, and flow behaviours were determined and compared to those of a soybean protein isolate (Supro 620).

Introduction

Processes for the production of pea protein isolates have been developed. The commercial potentials of these products depend partially on their functional properties.

We have thus studied the water retention capacity and thickening properties of pea protein isolates prepared under various conditions. They are compared for these functional properties with a commercial soybean isolate.

Materials and methods

Isolates from pea flour were prepared by the extraction of protein at pH 9 (P9) or pH 7 (P7) and their subsequent precipitation. They were obtained as isoelectric isolates when spray dried at their precipitation pH (P9, P7) or proteinates if previously brought to pH 7 with sodium hydroxide (P9 Na, P7 Na), potassium hydroxide (P9 K) or calcium hydroxide (P9 Ca). The commercial soybean isolate used was Supro 620 from the Ralston Purina Company.

The biochemical compositions of the isolates are compared in Table 1. In all cases, the products contained at least 90% protein (N x 6.25 on a dry basis). The protein content was the highest for the pH 7 extracted isolates. It can be seen that pea isolates – and particularly that extracted at pH 9 – have more lipids than the soybean isolate Supro 620.

Table 1. Biochemical composition and water retention capacity of the isolates

	Pea						Soybean
	P9	P9 Na	P9 Ca	P9 K	P7	P7 Na	Supro 620
Protein[a] (N × 6.25)	91	91	90	90	94	93	92
Lipid[a]	8.2	7.8	7.8	7.7	5.5	5.4	3.4
Ash[a]	1.2	5.4	6.4	6.2	2.5	2.3	3.8
Water retention[b]	1.2/ 1.4	3.4/ 3.6	1.4/ 1.6	3.6/ 3.8	N.D.[c]	N.D.	4.9/ 5.1

[a] Expressed in % on a dry basis.
[b] g per g dry matter.
[c] N.D.: not determined.

Water retention capacity

The water retention capacity of the isolates was determined by centrifugation following the experimental conditions described in the original method of Quinn and Paton [1].

Thickening properties

The thickening properties of the isolates were evaluated through the flow behaviour of a dispersion prepared under standard conditions.

Sample preparation. χ g of sample were dispersed in 75 ml of water or NaCl solution during 1 min by a screw stirrer. During the mixing, the pH was adjusted to the chosen value by 1 N sodium hydroxide or 1 N hydrochloric acid. After adding 25 ml of water, the dispersion was homogenized by a Polytron homogenizer for 3 min and then centrifuged at 300 x g for one minute to remove the air bubbles enclosed in the mixture.

Flow curves recording. We use a Rheomat 30 rotational viscometer with a Couette geometry, equipped with a programmer (Rheoscan 30). Flow curves (stress σ against shear rate $\dot{\gamma}$) are automatically recorded on a X–Y plotter. Each sample was submitted to two successive cycles of shearing (duration of each: 4 min), with no resting period between them, the shear rate varying linearly with time from 0 up to a maximum value and then down to 0; the maximum value was $6.98\ s^{-1}$ for the first cycle, $698\ s^{-1}$ for the second one.

Flow behaviour analysis (see Figure 1). First, an apparent yield stress σ_0 was measured directly on the records as the intersection of the down curve of the first cycle with the stress axis. Then σ_0 was subtracted from the values of σ corresponding to the up curve of the second cycle, and a plot of log $(\sigma - \sigma_0)$ against log $\dot{\gamma}$ was established. These plots exhibit a linear region

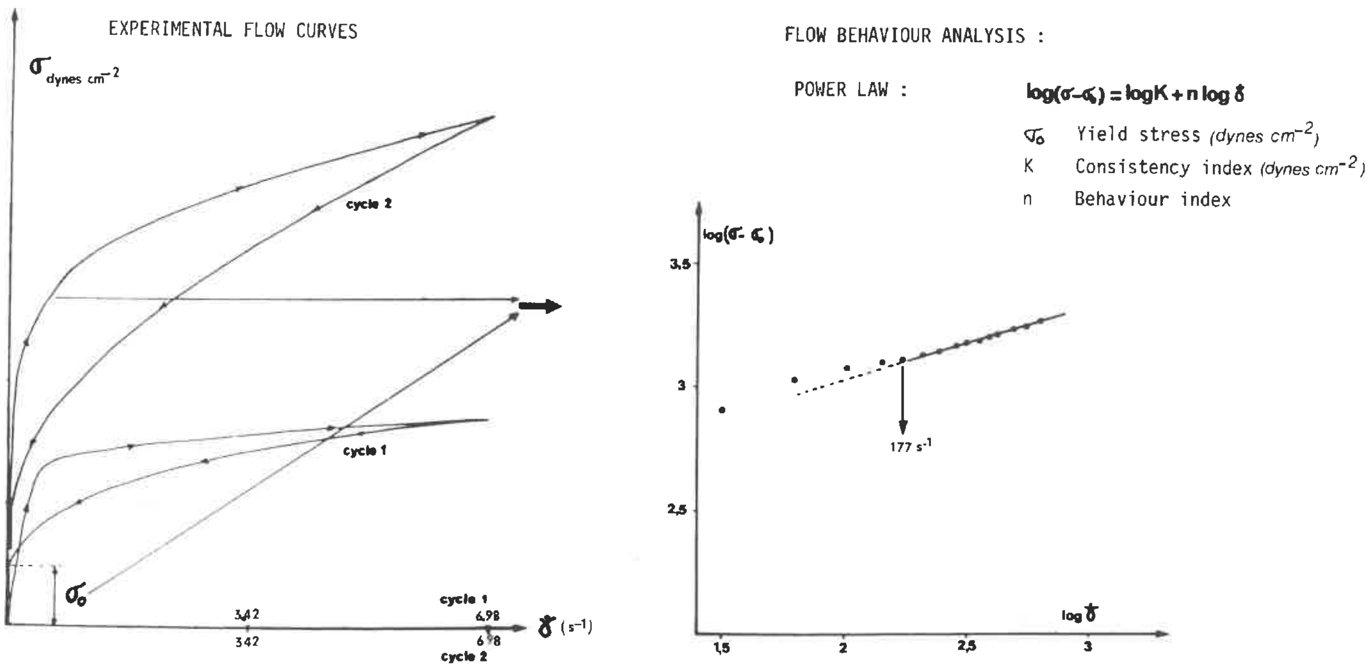

Figure 1. Experimental flow curves of the isolate dispersion and their analysis.

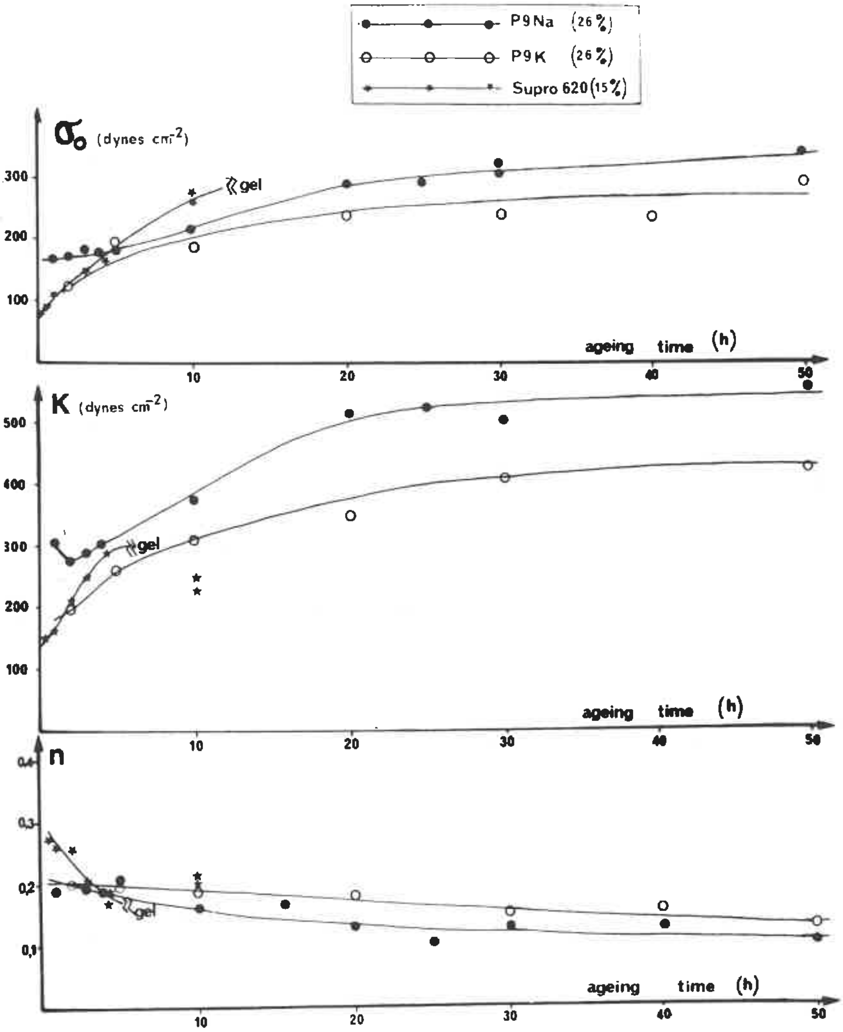

Figure 2. Influence of the ageing time on the flow behaviour of the isolate dispersions (pH 7).

from about 177 s^{-1}, that is to say that the power law $\log(\sigma - \sigma_0) = \log K + n \log \dot{\gamma}$ is obeyed for shear rates $180 < \dot{\gamma} < 700\ s^{-1}$. So, the flow behaviour of each dispersion is characterized by three parameters: σ_0 (yield stress), K (consistency index) and n (flow behaviour index).

No attempt has been made to account for the thixotropy in the description of the flow behaviour.

Results and discussion

Water retention capacity

Results are summarized in Table 1. Water retention capacity is very low for the isoelectric isolate P9 (1.2–1.4 g H_2O per g dry matter [d.m.]) and the calcium proteinate P9 Ca (1.4–1.6 g H_2O per g d.m.) but reaches 3.4 to 3.8 for the sodium and potassium proteinates P9 Na and P9 K. In all cases, the water retention capacity is lower for the pea proteinates than for the Supro 620 [4.9–5.1 g H_2O per g d.m.].

Flow behaviours

Because of their low water retention capacity, the flow behaviours of P9 and P9 Ca were not studied. In the other cases, the three parameters σ_0, K and n have been studied as a function of the ageing time of the dispersion, its concentration and the level of added NaCl.

Their dependencies on these factors show similar trends. The yield stress (σ_0) and the consistency index (K) of the 26% pea isolate dispersion increase with the ageing time at pH 7 and reach a constant value after twenty hours (Figure 2). This phenomenom is probably correlated with association reactions between proteins which induce high viscosity dispersion. In the case of the 15% soybean dispersion, gel formation happens after about 12 hours. This observation is in good agreement with the results obtained by studying the influence of the protein concentration on the flow behaviour of the dispersion (Figure 3). It is shown that pea isolates have consistencies much lower than the soybean isolate. So, to reach the same values of σ_0 and K as for a 15% dispersion of Supro 620, it is necessary to use a concentration of up to 26% for P9 Na and P9 K and even higher than 35% for P7 Na. On the whole, P9 Na and P9 K present nearly the same characteristics. For pea, as well as for soybean isolates, log K and n vary linearly with the concentration.

The rheological behaviour of pea isolate P9 Na is not appreciably affected until the salt concentration reaches 3%, whereas 0.5% suffices to cause appreciable changes in the case of Supro 620 (Figure 4). But above 5%, the yield stress σ_0 and the consistency index K decrease very rapidly for pea isolate whereas these parameters vary little for soybean isolate under these conditions.

Conclusion

The thickening behaviour of P9 Na and P9 K pea isolates show the same general characteristics as Supro 620 soy isolate, but to a much lesser degree. They are, however, more stable than Supro 620 in the presence of salt at pH 7.

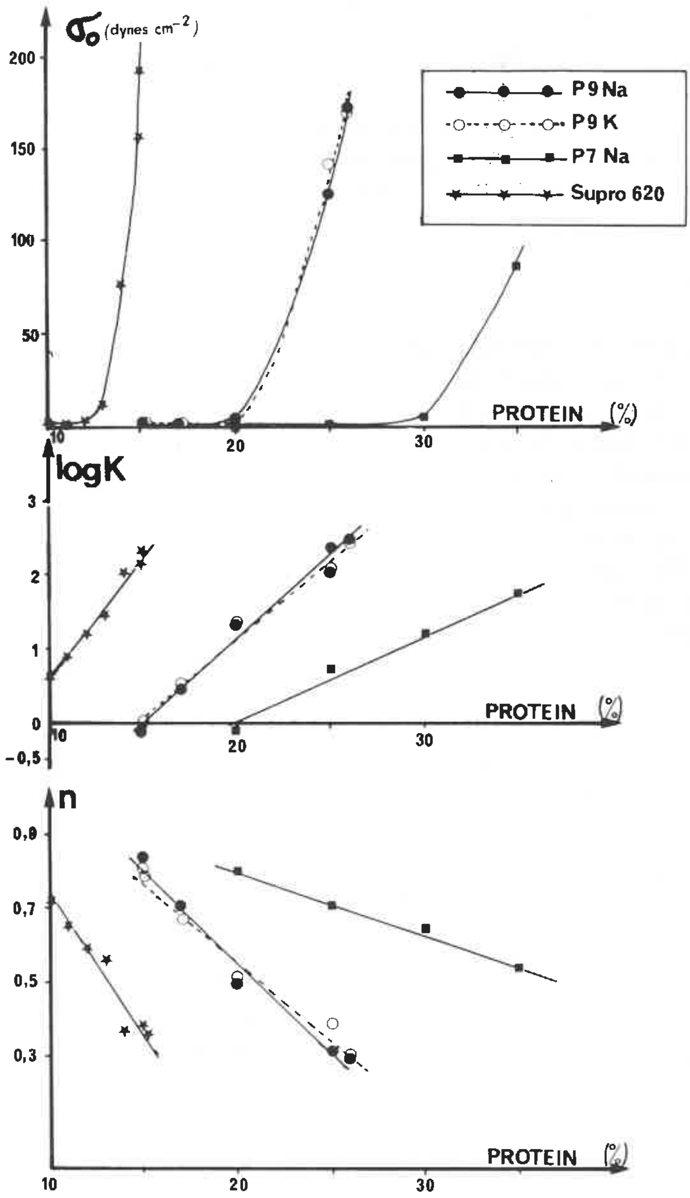

Figure 3. Influence of the protein concentration on the flow behaviours of the isolate dispersions (ageing time: 2 h, pH 7).

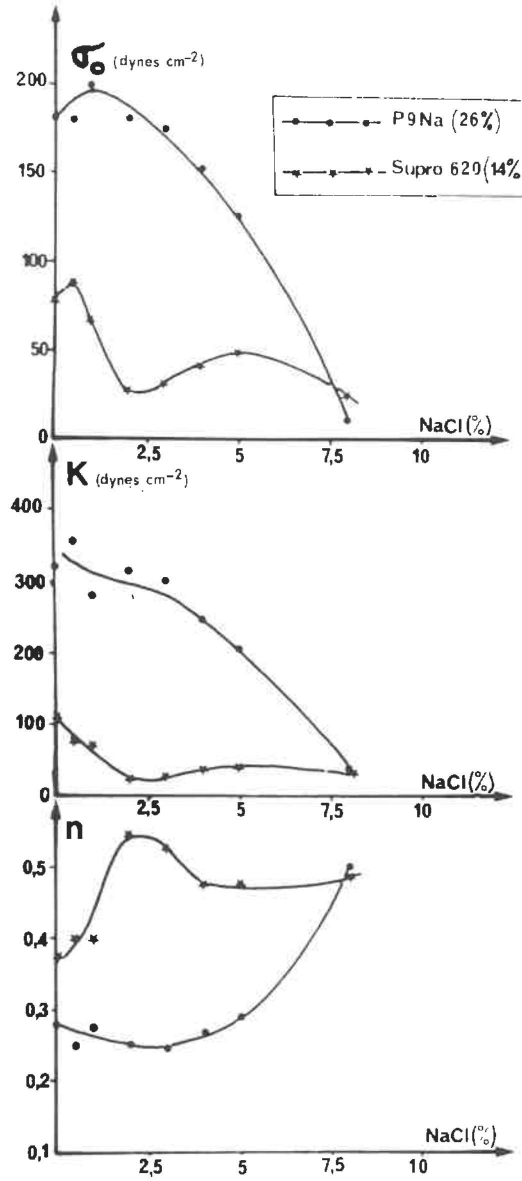

Figure 4. Influence of the salt concentration on the flow behaviours of the isolate dispersion (ageing time: 2 h; pH 7).

One of the reasons for the differences between pea and soy isolates is probably related to different values for the ratio 7 S-like protein: 11 S-like protein; it is indeed acknowledged that 7 S protein forms gels at lower concentrations than 11 S protein [2]. After separation of legumin and vicilin by ion exchange chromatography, we have estimated the ratio 7 S-like protein: 11 S-like protein to be close to 1:1.5 in the protein extract from the pea flour. In the literature, values are reported between 1:1.3 and 1:4.2 for pea flour [3]. A value of about 1.6:1 is given for this ratio in the case of soybean [4].

Comparing P9 Na and P7 Na, it appears that the processing conditions can also modify, to a large extent, the flow behaviour of the isolate dispersions. This is likely due to changes in the molecular size distribution of the protein in the isolates resulting from aggregation and dissociation phenomena during the processing. Preliminary results obtained through gel filtration on polyacrylamide-agarose gel ('Ultrogel' ACA 34) in phosphate buffer (pH 7; 0.1 M) have shown that the material extracted (70 p.100 of the isolate) by the buffer from P7 Na contains a lesser amount of high molecular weight aggregates and a higher amount of dissociated subunits than the material extracted from P9 Na. The presence of soluble aggregates might explain the higher values of the consistency index of P9 Na dispersions.

References

1. Quinn JR, Paton D (1979) A practical measurement of water hydration capacity of protein materials. Cereal Chem 56(1):38–40
2. Shimada K, Matsushita S (1980) Gel formation of soybean 7 S and 11 S proteins. Agric Biol Chem 44:631–641
3. Gatehouse JA, Croy RRD, McIntosh R, Paul C, Boulter D (1980) Quantitative and qualitative variation in the storage proteins of material from the EEC joint field bean test. In: Bond DA (ed) Vicia Faba: Feeding Value, Processing and Viruses. The Hague: Martinus Nijhoff Publishers, pp 173–190
4. Ihanh VH, Shibasaki K (1976) Major proteins of soybean seeds. A straightfoward fractionation and their characterization. J Agric Food Chem 24:1117–1121