FUNCTIONAL PROPERTIES OF RAPESEED OIL AND PROTEIN PRODUCTS - A SURVEY

By Ragnar Ohlson
AB Karlshamns Oljefabriker
Research Laboratory
S-292 00 Karlshamn, Sweden

SUMMARY

The use of rapeseed oil for human consumption in margarine and other foods for cooking, frying and baking, has a very long history. Low-erucic acid rapeseed oils have been introduced over the last years and their properties extensively studied. The oxidative stability is relatively high but techniques to improve it are discussed. The crystallization behaviour has been studied particularily for hydrogenated rapeseed oils. Techniques to improve the use as e.g. interesterification has been developed.

The surface-active properties of the phospholipids from rapeseed have been evaluated and it has been found that better production techniques can improve their uses.

The protein content of rapeseed is high and the amino acid profile is better balanced than in any other vegetable protein known. The functional properties of rapeseed protein concentrates and isolates have been studied in different food systems as e.g. meat extender and in bread. The flavour is blend. The water binding capacity of the carbohydrates in rapeseed is extremely high and interesting applications can be developed.

All together rapeseed is shown to give attractive products for both the food industry and the consumer.

RAPESEED OIL

The use of rapeseed oil in margarine and shortening or as cooking and frying oil has a long tradition in many countries.

What has essentially happened since the 4th International Rapeseed Conference in Giessen is, that oils from the new low-erucic acid rapeseed varieties have come into use in several countries. The principal changes in composition of rapeseed oils are shown in Figure I.

As the content of erucic acid is drastically reduced, changes in the crystallization and polymorphic behaviour appear, as has already been pointed out by Riiner (1). (Figure II).

FIG. I

COMPOSITION OF RAPESEED OILS

A = LOW ERUCIC
D = TRADITIONAL

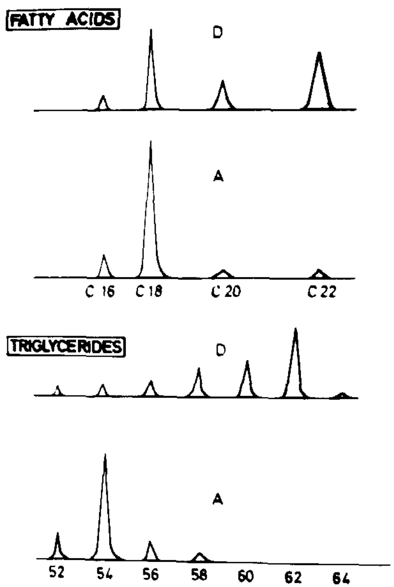


FIG. II

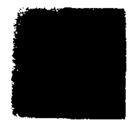
POLYMORPHIC CHARACTERISTICS OF RAPESEED OILS

TRADITIONAL TYPE ("HIGH ERUCIC")

$\ell \longrightarrow \alpha \longrightarrow$

NEW TYPE ("LOW ERUCIC")

$\ell \dashrightarrow \alpha \longrightarrow$



As another consequence the relative number of crystal particles during storage is drastically changed as shown in Figure III. The very restricted distribution of fatty acids (mainly C18) and triglycerides (C54) is the main reason for this. The major changes in physical properties occur when the erucic acid content is reduced below 10% of the fatty acids. All these changes have technical implications on the use of the low erucic acid rapeseed oils. (Figure IV).

In a serie of work the properties of medium (18%) and low (6%) erucic acid rapeseed oils were compared with the standard oil in gross quality aspects. The physical change in behaviour due to reduction of erucic acid appeared as a higher resistance of liquid oil to clouding at refrigeration temperature. The hydrogenated oils showed a continuous change in polymorphic behaviour visible as a greater tendency towards β-formation. The melting is characterized by changes in the dilatation curves. These effects however only become significant when the erucic acid content is low. In fat blends, e.g. for margarine, the effects are depressed and they are in practice insignificant at moderate levels of erucic acid (2).

Hard fat products for use in margarine fat blends have been prepared by hydrogenating rapeseed oil with an erucic acid content of 5% to an iodine value between 30-70 and randomly interesterifying the hydrogenated product with 10-50% coconut oil. The fat is stable in β'-crystal form. It shows no substantial consistency changes and has an acceptable taste during storage when used in margarines (3).

A margarine-type fat emulsion, having a viscosity sufficiently low to permit easy pouring from a package and improved storage properties, has been developed (4). The hard fat used is based on a three-component-system of a Brassica oil, in particular a high-erucic acid rapeseed oil, which is hydrogenated to three different melting points.

It has been proved that this new rapeseed oil is not suitable for forming the solid phase in liquid phase.

Butterines of good flavour and acceptable physical properties were made from rapeseed oil and 50% milk fat (5).

Hydrogenated rapeseed oil was found to be suitable for frying of pommes frites (6).

Frying of pancakes and potato cutlets has been studied by Ziombski and Luszcz (7). Rapeseed oil was inferior to lard and groundnut oil but superior to soya bean and sunflower oils.

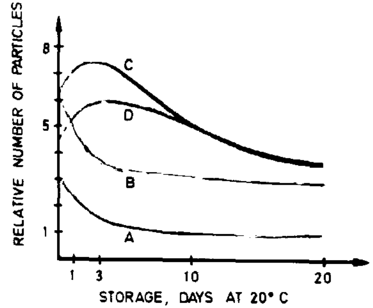
Rapeseed oil is used as a release agent in bread baking in e.g. Australia.

Mustard seed oil in for instance India has a rather strong flavour due to the technique of preparation. Experiments have been made to produce rapeseed oils with an identical flavour (8).

FIG. III

RELATIVE NUMBER OF CRYSTAL PARTICLES

- PROPORTIONAL TO S^3



SOLIDIFICATION: 50°C → 0° → 20°C

FIG. IV

TECHNOLOGICAL OUTLOOKS

OF LOW ERUCIC RAPESEED OILS

BASIC

- POLYMORPHISM: $\beta' \rightarrow \beta$

  → CRYSTAL GROWTH

- FUNCTIONAL CONSEQUENCES:

  CONSISTENCY / TEXTURE
  APPEARANCE
  EATING PROPERTIES
  OTHERS

TECHNICAL

- LIMITATIONS OF PERCENTAGES
- SELECTION OF OTHER COMPONENTS
- PROCESSING CONDITIONS

RAPESEED LECITHIN

The use of rapeseed lecithin in food has so far been very limited in comparison with the use of soya bean lecithin. The main reason for this is the inferior properties as e.g. flavour and colour. This is mainly due to non-optimal conditions during processing.

The composition and emulsification properties of rapeseed phosphatides have been studied by Larsson et al (9) in Sweden.

The importance of the glycolipids is discussed by Zajac and Niewiadomski (10).

RAPESEED PROTEIN PRODUCTS

During the 1970's somewhat different methods to produce rapeseed protein concentrates (RPC) for human consumption have been developed in e.g. Canada, Sweden and Poland (11).

A corresponding method to produce mustard seed protein has been developed in Mysore in India. Rapeseed protein isolates have also been prepared (12). Texturizing of RPC has also been studied in Europe and North America.

The composition of the rapeseed protein concentrate is shown in Table I.

TABLE I

ANALYTICAL DATA FOR RAPESEED PROTEIN CONCENTRATE (RPC)

Compound	Content, % of dry matter
Protein (N x 5.5)	57
Fat	3
Crude fibre	8
Other carbohydrates	23
Phytic acid	6
Other ash components	2
Other N-compounds	1
Sum	100
Moisture	7.5%
Protein (N x 6.35)	65% of dry matter
Ash	7.5% of dry matter
Glucosinolates	0.02%

The crude protein content is 65% of dry matter, but as is usual with vegetable proteins, the true protein level is lower (57%). The RPC contains a relatively high level of phytic acid. The residual glucosinolate content in RPC is very low (<0,2 mg/g), which means that more than 99% of the original glucosinolates can be removed.

The water-insoluble part of the carbohydrates are left in the RPC. It consists mainly of cell wall carbohydrates of the dietary fibre type (13).

The amino acid composition of RPC is shown in Table II.

TABLE II

AMINO ACID CONTENT OF RAPESEED PROTEIN CONCENTRATE (RPC) AND SOYABEAN FLOUR (g/16 g N).

Amino acid	RPC	Soyabean flour	WHO/FAO Scoring Pattern 1973
Isoleucine	4.2	4.2	4.0
Leucine	7.3	7.0	7.0
Lysine	5.8	5.8	5.5
Phenylalanine	4.1	4.5	6.0 (Phenylalanine + Tyrosine)
Tyrosine	3.1	3.1	
Cystine	2.6	0.7	3.5 (Cystine + Methionine)
Methionine	2.3	1.1	
Treonine	4.5	3.8	4.0
Valine	5.2	4.3	5.0
Tryptophan	1.4	1.3	1.0
Histidine	2.7	2.4	
Arginine	6.6	7.0	
Aspartic acid	7.1	10.2	
Glutamic acid	17.9	16.5	
Serine	4.7	5.0	
Proline	6.1	4.8	
Glycine	5.3	3.8	
Alanine	4.6	3.9	

Rapeseed protein has a substantially higher content of sulphur containing amino acids than soya protein, as well as adequate amounts of the other essential amino acids.

This is well reflected in the nutritional value obtained in feeding trials (14).

Functional properties of protein preparations can provide information about the action of the protein when incorporated in a food. Solubility, water and fat binding, emulsifying and foaming of RPC have therefore been studied together with their organoleptic properties. Very bland RPC can be produced. The relation of variables obtained in the instrumental analysis to those obtained in the sensory analysis has also been studied.

Solubility is normally the first property to be tested when a new protein product is to be studied. The solubility of the native protein of dehulled and defatted rapeseed in aqueous solutions has been determined in various studies.

Radwan and Lu (15) determined the solubility at different temperatures from 25-55°C in the pH range. It was found that the points of minimum nitrogen solubility occur at pH values from 4.5 to 7.2.

Gillberg and Törnell (12) studied the dissolution of nitrogen and phosphorus containing substances from defatted rapeseed (and the subsequent precipitation of these substances by acid). The dissolution of the substances was found to vary in a complicated manner with the pH of extraction (Figure V). The curves in the figure are from the extraction of a meal that was defatted without heating.

Rapeseed protein concentrate produced in a technical process on a pilot-plant scale has a rather limited solubility due to the heat treatments.

Modifications have been made on rapeseed protein concentrate of limited solubility. Alkali, acid and enzymes were used in the solubilization procedures (16). All modified products had higher values of solubility, emulsifying and foaming indices and three of the seven modified preparations had a better swelling ability than the original RPC-sample however the taste of the products was too strong and the functional properties were still too poor to be of practical interest.

The water absorption (swelling) of rapeseed protein products is very high. That this property compares favourably with those of soya bean products has also been shown by Sosulski (17). Water absorption, and water holding capacity of rapeseed and soya proteins are shown in Figure VI.When the protein products are texturized the water absorption decreases.

Rapeseed protein products are also superior to soya bean flour and rate in fat absorption with rapeseed protein concentrate showing the highest value.

Whippability and foam stability and gelation of rapeseed products have also been studied with poor results for RPC and good for rapeseed protein isolate.

The colour of RPC is light with a tendency to turn darker during heat treatments especially extrusion cooking. Rapeseed protein isolates are usually greyish.

Taste and fllavour

The characteristic flavours of textured rapeseed and soya proteins have been analyzed organoleptically (18). Very bland rapeseed protein products can however be produced.

FIG. V

SOLUBILITY IN RELATION TO pH

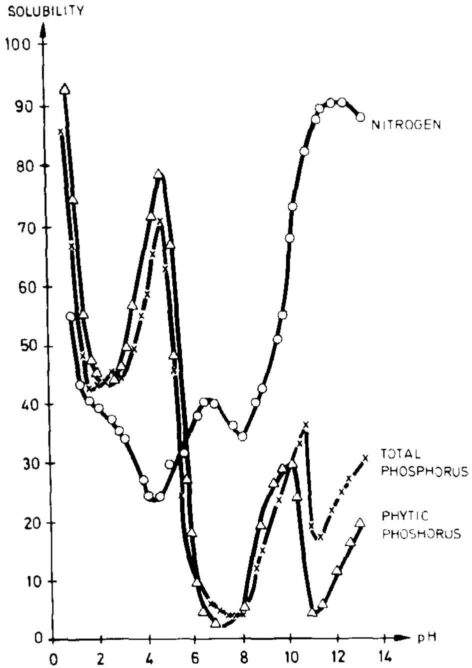
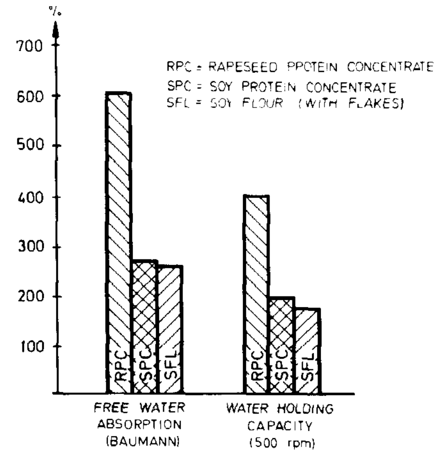


FIG. VI

WATER ABSORPTION AND HOLDING CAPACITY OF RPC AND SOY PROTEIN



Quist has made an extensive study of unconventional proteins as aroma precursors (19,20). Over 110 compounds were identified by GLC-MS from the head space gas of a low temperature distillate from more or less heated RPC. The odour of rapeseed protein samples depends on the presence of low molecular weight, straight and branched chain aldehydes and sulphur compounds. Several furan derivatives and nitrogen-containing compounds are probably also important. Mean panel intensities of three odour qualities for soya (S) and rapeseed (R) proteins heated in model systems for 60 min at temperatures between 75 °C and 120 °C are shown in Figure VII.

RPC in meat products

The functional properties of protein preparations can provide information about the action of a protein when incorporated in a food. Capacities for emulsification, water absorption and fat absorption are examples of such properties. Andersson tried to find relevant methods of instrumental and sensory analysis of meat patties containing untextured rapeseed protein concentrate. The addition of untextured RPC required the same force at 50% penetration with an Instron testing machine as the addition of textured soya flours, and it gave far better results than did additions of soya protein isolate or casein (21).

The consistency of meat patties with textured vegetable proteins has been studied. The total impression of consistency can be equalized between patties with soya or rapeseed proteins by other binding ingredients such as bread crumbs and potato flakes. (Figure VIII).

To determine whether fat was absorbed or lost during deep fat frying the patties were fried either in rapeseed oil or in coconut oil. These oils were chosen because they have different fatty acid compositions from that of meat. Fatty acid analysis of the oil was made before frying and of the patties before and after frying. The analyses of the fatty acid compositions showed that the control batter released a considerable amount of the original fat and at the same time absorbed a great deal (Figure IX).The net balance was negative, i.e. more fat was released than absorbed.

Batter with texturized soya flour released about half the amount released by the control, and absorbed about the same amount, but less than the control batter. The net balance was slightly positive i.e. some more fat was absorbed than released. Batter with RPC released about the same amount as batter with textured soya flour but absorbed as much as the control batter. The net balance was strongly positive i.e. twice as much fat was absorbed than released.

The frying loss (fat and water loss) was measured in patties with RPC, textured soya flour or soya protein concentrate. Patties with RPC had the lowest frying loss and the control patties the highest (Figure X).

FIG. VII

MEAN PANEL INTENSITIES OF THREE ODOR QUALITIES FOR SOY (S) AND RAPESEED (R) PROTEIN HEATED IN MODEL SYSTEMS FOR 60 MINS. AT TEMPERATURES BETWEEN 75° AND 120°

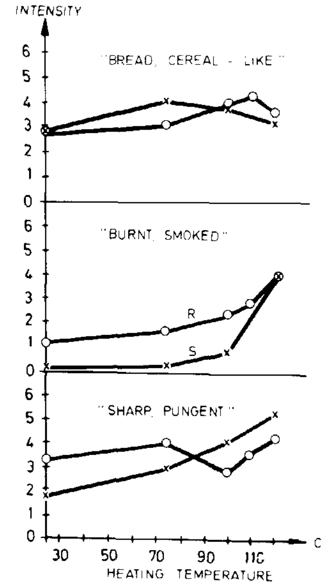
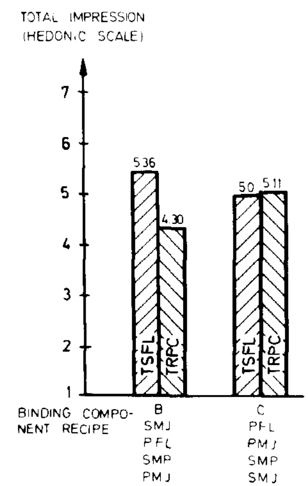


FIG. VIII

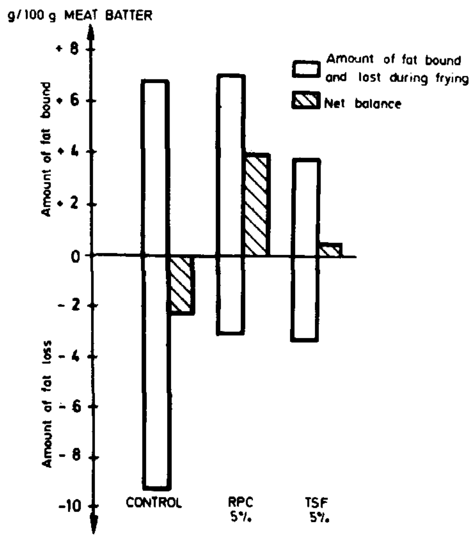
IMPRESSION OF CONSISTERING IN MEATPATTIES



PFL = POTATO FLAKES
PMS = POTATO STARCH
SMJ = BREAD CRUMBS
SMP = SKIM MILK POWDER

FIG. IX

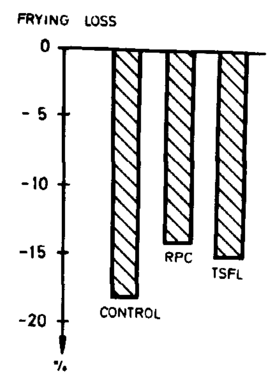
CHANGE IN THE TOTAL AMOUNT OF FAT BOUND AND LOST DURING DEEP FAT FRYING AND NET BALANCE OF FAT AFTER FRYING



RPC = Rapeseed proteinconcentrate
TSF = Textured soy flour

FIG. X

FRYING LOSS IN MEAT PATTIES DURING DEEP FAT FRYING (g/100 g MEAT BATTER)



The quality of wieners supplemented with rapeseed protein concentrates has been studied by e.g. Sosulski (22). Wieners containing an additional 20% of rapeseed protein were lower in fat content and emulsion stability, but showed less shrinkage during the smokehouse and cooler treatment.

Experiments have shown that RPC has a good stabilizing effect on sausage emulsions because of good fat and water binding properties. The consistency of the sausage is somewhat mushy because of the lack of gelation ability in RPC.

Very bland rapeseed protein products can be produced. The remaining flavour in RPC seems to be better covered in meat systems than that from soya protein products (Table III).

TABLE III

ORGANOLEPTIC ANALYSIS OF MEAT PATTIES

Laboratory panel

Flavour Scale 1-7	5% TSFL	5% TRPC	8% TRPC
Poor - good	3.5	4.5	3.5
Meat flavour	3	4.5	3.5
Off flavour	5	4	5

TSFL = textured soya flour
TRPC = textured rapeseed protein concentrate

This may be due to the fact that we are used to the taste of glucosinolate split products through our consumption of e.g. mustard or cabbage. This is one advantage for RPC over soya protein products.

RPC in bread

The effects of RPC in bread have been studied both in Canada and Sweden. 5-15% of wheat flour was replaced by RPC. The quality of the dough was followed by farinograph, by extensograph and by SJA dough testing mashines. The results show that the water uptake of RPC was ca 230%, of SPC 175% and for textured soya flour 130% compared to 60% for wheat flour (Figure XI). Farinograms show some slow development time but quite good stability. The extensibility (Figure XII) of the respective doughs with vegetable proteins was not as equally good as in the control. The volume of the bread baked on the dough was poor. The reason for this was not poor gas development, but poor gas retention. This effect could be more than compensated for by the use of normal baking aids e.g. with stearoyllactylate (SSL) (Figure XIII). The colour of the bread is somewhat darker at high levels.

FIG. XI

WATER UPTAKE BY RPC AND SOY PROTEIN PRODUCTS IN BREAD (FARINOGRAPH) (5% ADDED)

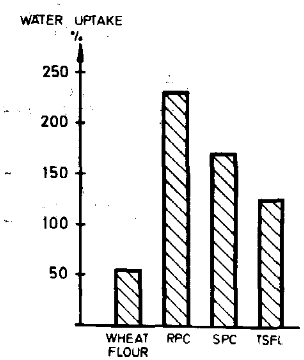


FIG. XII

EXTENSOGRAMS OF DOUGH WITH 5% VEGETABLE PROTEIN

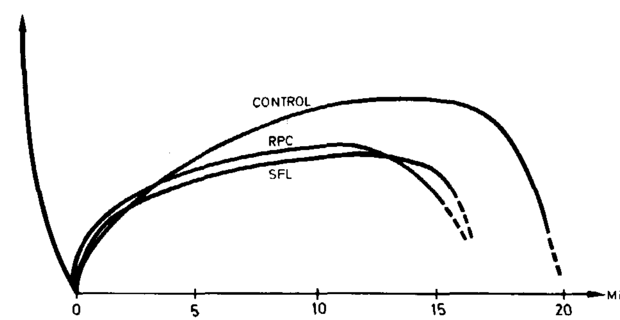
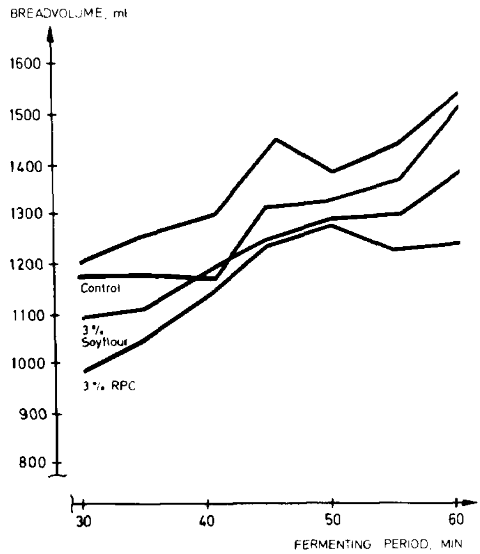


FIG. XIII

BREADVOLUME AS FUNCTION OF FERMENTING PERIOD



CONCLUSIONS

Heat treated rapeseed flours are comparable to soya been flour in water absorption and gave much higher fat absorption, oil emulsification and whippability values. The functional properties of RPC are summarized in the next table. (Table IV).

TABLE IV

FUNCTIONAL PROPERTIES OF RPC

Nitrogen solubility in water	5-10%
Nitrogen solubility in 0.2 M NaCl	15-20%
Water absorption (free)	500-800%
Water holding capacity (500 rpm)	400%
Fat binding	Excellent
Emulsification properties	Poor
Foaming properties	Poor
Gelling properties	Poor
Colour	Light yellow
Flavour	Bland
pH	6.0-6.5

Rapeseed protein concentrate and isolates show excellent water- and fat-holding capacity. The isolate is also high in oil emulsification and whipping characteristics.

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