A Review of Rapeseed Oil Uses for Edible Purposes[1]

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ABSTRACT

Food technological aspects on the use of rapeseed oil and other *Cruciferae* seed oils as salad oils, in margarine, shortenings and some other foods are briefly reviewed. It is concluded that these oils in hydrogenated or nonhydrogenated form may compete favorably with other vegetable oils and animal fats.

INTRODUCTION

Rapeseed oil has been used as food for a long time but the more systematic evaluation of *Cruciferae* seed oils from the food technological point of view began in Canada in connection with or immediately after the Second World War (1,2,3). In this paper a brief survey of publications in this field will be given with the emphasis on examples in which properties that are specific to *Cruciferae* seed oils are of importance for the properties of the food. General considerations on, e.g., shelf life and uses of vegetable oils are not included. We are facing a development which will make oils available commercially with erucic acid contents varying from 0-55%, and further food technological evaluations of oils from various plant breeded varieties are to be expected.

A critical summary of the literature is not attempted, as the evaluations (physical, chemical or organoleptical) of oils and products containing oils are made from greatly varying starting points and with varying objectives. The opinion of the authors is expressed by the selection of and the comments on the literature.

FLAVOR AND FLAVOR STABILITY

Downey et al. (4) have formulated practical limits for the plant breeding work with regard to fatty acid compositions.The zero erucic varieties have already been obtained, but there are difficulties in simultaneously reducing the linolenic acid contents below certain levels. Therefore it may be assumed that in the future *Cruciferae* seed oils will also fall in the same category as soybean oil with regard to flavor stability. Linolenic acid as the source of the off-flavor (flavor reversion) of these oils has been studied by Moser et al. (5) and others (6,7), and Cowan (8) has recently reviewed the comprehensive work that has been carried out on the flavor and flavor stability of the related soybean oil.

Holm et al. (9) reported on the type of off-flavor in rapeseed oil and other oils by stating: "Thus rapeseed and soya oils with aldehyde contents over 2 had a noticeable oily, green off-taste after a couple of days while cottonseed oil and peanut oil formed a nutty, metallic, or bitter taste only at higher aldehyde contents." The type of off-flavor that develops can thus be characterized as similar to that found in soybean oil, and therefore comparisons between these two oils can be fruitful.

In the work of Moser et al. (5) a specific flavor effect in *Cruciferae* seed oils is established. The flavor characteristics and oxidative stability of crambe seed, mustard seed, rapeseed and soybean oils were studied. The oils were produced in the laboratory and the flavor evaluations were made by a test panel of 20 trained judges; analyses of variance and F-tests were used to test the means on a 10-point scale. The description of the flavor of freshly deodorized oils was dominated by the term "buttery," with "nutty" or "beany" flavors present in minor amounts. After 4 days' storage at 60 C the terms "rancid," "beany," "painty" and "grassy" were given to oils when they did not contain citric acid. The presence of citric acid markedly protected the oils and there was no general difference between soybean oil and the samples of the *Cruciferae* seed oils. However when samples with added citric acid were exposed to light for two hours, the soybean oil was given the same descriptive terms as the oil without citric acid, while the *Cruciferae* oils exhibited a significant drop in flavor scores and developed a definite "rubbery" flavor that was often accompanied by a "garlic" or "onion-like" flavor (see Table III in Reference 5). The authors state that this effect may be due to isothiocyanate compounds introduced into the oils from the meal during extraction and not completely removed by deodorization. Whatever the cause, the compounds in question must exhibit specific photochemical reactions in the presence of citric acid. In any case it is a remarkable and specific effect caused by minor components in the *Cruciferae* seed oils which, as stated by the authors, "projects a new problem for study." Moser et al. (5) also report results on industrially produced Swedish and Canadian rapeseed oils obtained in alkali refined and bleached form and deodrized in the laboratory. These results (see Table IV in Reference 5) indicate the extrapolation of the results with the laboratory-produced samples to products obtained from large scale operation with the processing praxis prevailing before 1965. The positive effect of citric acid on the flavor stability when the oils were kept in darkness was demonstrated in all samples, as well as the deleterious effect of citric acid on the rapeseed oil produced in Sweden when exposed to the standarized illumination for 2 hr. However the Canadian oil did exhibit a higher flavor score with citric acid than without, also in light, being the only exception to the off-flavor inducing effect of citric acid in the presence of light. The authors remark, however, that the characteristic "rubbery" flavor was found in all samples but evidently less pronounced in the Canadian oil. The peroxide value after 8 hr of treatment under the Active Oxygen Method procedure conditions are also reported (5) for the laboratory samples of soybean oil and the *Cruciferae* oils. It may be noted that the effect of citric acid treatment is most marked for the soybean oil investigated. The oxidative stability is indicated to be less for the soybean oil than for the rapeseed oil before treatment with citric acid but superior after treatment with citric acid. These stability tests, performed at ca. 100 C, are in good agreement with the flavor evaluations except for the stability to light.

In several studies Holm et al. (9) and Holm (10,11) have established the importance of the degree of pre-oxidation, i.e., the content of primary and secondary oxidation products in crude oil on the flavor stability of deodorized rapeseed oils. The nonvolatile carbonyl compounds that are present in the oils as a result of the decomposition of primarily formed hydroperoxides, and are not eliminated during the deodorization, were measured by the benzidine test and the results correlated with the flavor stability of the oil under the given conditions. These results emphasize the importance of a protected storage and handling of rapeseed oil during extraction and processing, quite in

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[1] One of nine papers published from the Symposium, "Cruciferous Oilseeds," ISF-AOCS World Congress, Chicago, September 1970.

TABLE I

The Relationship Between Linolenic Acid Content and Stability of Hydrogenated Canbra and Soybean Oils (22)

Oil	*Linolenic acid, %*	AOM stability, hr	Schaal oven test, days
Canbra oil	3.2	35	18
Canbra oil	2.9	50	21
Soybean oil	2.1	25	14

accordance with the principles established during years of research and development work on soybean oil (8). It is therefore evident that comparison between flavor and flavor stabilities of different batches of oils must be made with careful consideration of the pretreatment of the samples. A deficiency in the carefully performed work of Moser et al. (5) is that the degree of pre-oxidation of the crude oils is not documented.

There are several reports showing that rapeseed oil is superior to, e.g., soybean oil and sunflower oil (12,13,14,15,16). There are also reports in which rapeseed oil was found to be inferior to soybean oil, e.g., in the presence of citric acid and light as discussed above (5). This only stresses the well-known point that many factors influence the flavor of vegetable oils and fats, some of which are general for all oils and some of which are specific for a certain oil.

MELTING AND SOLIDIFICATION

The high content of erucic acid in rapeseed oil would imply a high melting point of this oil. The melting point of the most stable polymorphic form of trierucin is ca. 30 C (17). However it has been shown that erucic and eicosenoic acids are preferentially situated in the 1 and 3 positions of the glycerol residue (18), thus leading to mixtures of molecules containing oleic, linoleic and linolenic acids in the 2 position. These compounds have not yet been characterized, but melting points between 4 C and 6 C have been reported for rapeseed oils from West Pakistan, Sweden and Canada (19). Riiner (20) investigated a number of *Cruciferae* seed oils with X-ray and thermal methods and found generally the same polymorphic behavior for oils containing between 8% and 63% erucic acid. Below 8% the polymorphism was no longer determined by the erucic acid containing glycerides. It was concluded that the requirement for a *Cruciferae* oil to remain clear at 0 C is that the erucic acid content is below ca. 39% for oils from *Brassica napus* and below ca. 43% for oils from *Sinapis alba*. The behavior on melting and crystallization was shown to vary regularly with the erucic acid content, and thus the phase behavior of a certain oil can be predicted from its fatty acid composition. This can perhaps be of value when oils for foods that are stored and used at low temperatures are under consideration.

SPECIFIC EDIBLE USES

Salad and Cooking Oil

Without doubt the rapid expansion of rapeseed oil utilization in Canada has been brought about or promoted by the careful evaluation of the use of rapeseed oil in foods, referred to above (1,2,3). From these works it may be concluded that carefully processed *Cruciferae* seed oils may compare favorably with other commercial oils both in hot and cold applications of salad and cooking oils.

A single flavor evaluation of Canbra oil reported by Vaisey and Shaykewich (13) can not be taken as evidence for a statement that Canbra oil is inferior to ordinary rapeseed oil in flavor stability. As the melting point of Canbra oil is below -10 C it is, however, possible to hydrogenate it in order to increase the oxidative stability without too large an increase in the content of solids at low temperatures. Teasdale (21) claims that the reduction of the linolenic acid content to 3% improved the flavor stability only slightly whereas a reduction to levels below 1% gives a substantial improvement. Winterization of hydrogenated Canbra oils with 0.4-0.9% linolenic acid at 7-8 C was reported to give a salad oil yield of approximately 95%. This high yield is compared to yields from rapeseed oil with 25-40% erucic acid and to yields from soybean oil. At 1% residual linolenic acid these yields are of the order of 75%. A description of the manufacture of hydrogenated cooking and frying oils from Canbra oil without winterization is also in the patent literature (22). The stabilities obtained are illustrated in Table I.

From the results of the study by Riiner (20) it can be concluded that *Cruciferae* oils with erucic acid contents above 40-45% can give rise to breakage of emulsions of food dressings and mayonnaise distributed under refrigeration, owing to crystallization. There is, however, in the patent literature a specific application of hydrogenated rapeseed oil in the manufacture of food dressings with an oil phase in fact containing crystalline phases (23): Solid fats (2-8%) are melted with liquid oil (92-98%), mixed with the aqueous phase, and chilled. The solid fat portion, with iodine value less than 12, consists of a blend of a so-called β-tending fat and hydrogenated rapeseed oil in proportions ranging from 1:4 to 4:1. The expression β-tending refers to the polymorphic form that is attained after tempering.

Margarine

A major use of rapeseed oil in Europe and Canada has been in margarine. Depending on specific prerequisites varying from country to country large interchangeability between rapeseed oils in hydrogenated or nonhydrogenated form and other oils, e.g., soybean oil, has been achieved from the food technological point of view. Specific pilot plant work on margarine containing rapeseed oils has been reported by Zalewski and Kummerow (24) and the applica-

TABLE II

Results of Yellow Layer Cake Test With 5% Suspensions Hydrogenated Fats in Cottonseed Oil (33)

Type of hydrogenated fat	IV	With emulsifier Batter, vol. cc/g	Cake, vol. cc.	Texture of cake	With 1.2% Myverol 18:00 emulsifier[a] Batter, vol. cc/g	Cake, vol. cc.	Texture of cake
None	—	0.98	1000	Hard	0.90	1000	Hard
Soybean oil	1	0.96	1000	Medium hard	0.96	1060	Hard
Cottonseed oil	1	0.94	1080	Medium hard	1.03	1155	Medium hard
Palm oil	2	1.05	1080	Medium hard	0.93	1155	Medium hard
Herring oil	2	0.89	1055	Medium hard	---	---	---
Lard	7	0.94	1100	Medium hard	0.85	1000	Medium hard
Rapeseed oil	1	1.01	1045	Medium soft	1.31	1165	Soft
Mustard seed oil	1	1.15	1120	Soft	1.38	1210	Soft
Plastic shortening	—	1.23	1210	Soft	1.23	1210	Soft

[a]Distilled saturated monoglycerides.

tion of transesterifications has been reported by these authors and others (25,26,27,28,29). A specific use of highly hydrogenated rapeseed oil, i.e., with iodine values below 30, and preferentially below 10, in retarding the oiling-off of margarine is claimed by Seiden (30): Small quantities of hydrogenated rapeseed oil (0.2-2.5%) in the formulae are reported to reduce the oiling-off tendency considerably, without too much adverse influence on the eating quality.

Reports on flavor evaluations of margarine are scarce in the literature. In a Canadian evaluation (12) rapeseed oil margarines were compared favorably with soybean oil margarines.

Shortenings or Compound Cooking Fats

Also in this case most of the reports in the literature emerge from Canada (2,3) and only in some specific cases, such as puff pastries, are deviations in performance compared to shortenings from other types of fats established.

As reported above, Tremazi et al. (19) compared the temperature ranges within which hydrogenated rapeseed oils and cottonseed oils could be expected to be plastic. It was stated that at comparable iodine values hydrogenated rapeseed oil shows a broader range of plasticity than hydrogenated cottonseed oil. This effect is further elaborated in the patent literature by adding highly hydrogenated rapeseed oil as a plasticizer to fat blends intended to be used for shortening (31).

Besides being useful in providing an increased range of temperature at which the products remain plastic, hydrogenated rapeseed oil is also reported to have favorable aerating properties in baking applications where this is desirable, e.g., in cake batter mixing operations where fat and sugar are first beaten (32). This effect was studied in detail by Linteris and Thompson (33) in their work with fluid shortening development. For comparison some results with 5% suspensions of a number of highly hydrogenated fats and oils in cottonseed oil, obtained by a standard yellow layer cake performance test, are given in Table II. It may be seen that even without the addition of emulsifier, which is common practice in aerating shortenings and margarines, the *Cruciferae* oils hydrogenated to low iodine values gave fair batter and cake volumes. When emulsifier was added these 5% suspensions were completely satisfactory, in contrast to the other fats investigated. The authors further conclude that fractions made from rapeseed and mustard seed oils and certain peanut oil fractions possess the properties desired for the production of a fluid shortening having aerating properties. The glycerides indicated to be especially effective in this respect were of the behenyldistearin and behenyl-stearyl-palmitin types. However the hydrogenated rapeseed oil, iodine value 1, was almost as effective as the triglyceride fractions used. It is interesting to note that no correlation was found between the polymorphic forms of the solid phases and their aeration properties in the systems investigated by Linteris and Thompson (33).

It has been a rather common opinion that fats in the β' form in general have a better creaming ability than fats in the β form (34). In this work (33) this was not the case. When hydrogenated rapeseed oil was precipitated from liquid cottonseed oil at 21 C (90 F), the solid phases were in the β' form, and when precipitated at 29 C (85 F) they were in the β form. However no difference in aeration properties was found.

Other Food Uses

Applications of rapeseed oils have been reported as confectionery fats, after hydrogenation and fractional crystallization in solvent (35,36), and as ice cream coating fats (37).

Future Uses

The plant breeding work [see, e.g., Reference (4)] will in the future create *Cruciferae* oils that are altered both with regard to major and minor constituents. At present extensive food technological evaluations of Canbra oil with nearly 0% erucic acid is being performed (38). Although the primary cause for developing Canbra oil was nutritional, a consequence was a less specific fatty acid (and triglyceride) composition that is more like the composition of other oils (soybean, peanut), no doubt having an effect on the food technological properties of the oil. In application this means that the exchangeability with other oils may increase and, as a consequence, that the specific crystallization and plasticity properties discussed in this review (19,20,30,31,32) are lost. On the other hand the development within plant breeding, growing, handling and processing may be presumed to improve the flavor and oxidative stability of the oils (39).

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