FACTORS AFFECTING THE COMPOSITION AND USE OF CAMELINA

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CONTENTS

Section 1

Yield Potential/Agronomy

SUMMARY

Camelina (*Camelina sativa)*, a member of the mustard family, is a summer annual oilseed plant. Winter hardy types also exist. False flax and Gold of Pleasure are the popular common names for the crop. The crop was widely grown in Eastern Europe and Russia up to the early 1940's but was replaced with the introduction and widespread use of oilseed rape.

The revival of interest in camelina oil is due to its high linolenic acid (38%) content. Linolenic acid is one of the OMEGA-3 fatty acids which are generally found in substantial quantities only in linseed and fish oils. Camelina offers an opportunity to supply the growing demand for high quality edible oils rich in OMEGA-3 fatty acids.

A three year study established that camelina is a very suitable crop to grow in Ireland, producing 2.5 t/ha of high quality seed (42-47%) with no agrochemical inputs required. The oil contains 35 to 40% linolenic acid compared to 8% in rape and soya oils. The oil does not deteriorate during refining or storage and can be used in a number of oil based products such as spreads and salad dressings.

INTRODUCTION

Camelina (*Camelina sativa*), a member of the mustard family, is a summer annual oilseed plant. Winter hardy types also exist. The seeds are yellow to yellow-brown with a thousand grain weight (T.G.W) in the range 0.8 to 2.0 grams. Unlike oilseed rape the pods are more or less shatter-proof, which makes the crop much less weather-dependent, resulting in more consistent harvested yields. False flax and Gold of Pleasure are the popular names for *Camelina sativa* (Putnam et al., 1993). Seeds and capsules of the crop have been found in archaeological excavations from the Bronze Age in Scandinavia. The crop was widely grown in Eastern Europe and Russia up to the early 1940's with some production lasting up to the 1950's. Camelina was replaced with the introduction and widespread use of oilseed rape (Hubbard, 1998). It is suggested that camelina, with its high content of unsaturated fatty acids (approx. 90%), was more difficult and expensive to hydrogenate than rape oil and this led to its decline.

Recent studies in the field of human nutrition have focused attention on the relative nutritional value of the various oils or fats. A low proportion of saturated fatty acids and a high ratio of OMEGA-3 to OMEGA-6 fatty acids have been identified as desirable in edible oils. Camelina, with its high content of OMEGA-3 fatty acids, (38% of the total fatty acid content), offers an opportunity to supply the growing demand for high quality edible oils (Zubr, 1997).

The objectives of the work reported here were to establish the seed yield potential of camelina, the main agronomic factors which influence seed yield, the oil content of the seed, the quality characteristics of the oil and the suitability of the oil for selected food products.

METHODS

A series of field experiments were carried out at Oak Park (light textured soil) and Knockbeg (medium/heavy textured soil). Seeds were sown in with a row spacing of 12 to 14 cms. Fertiliser input varied according to soil analysis, with phosphate and potassium applied at 16 to 35 kg/ha and 50 to 100 kg/ha respectively.

Nitrogen application was split with 30 kg/ha applied to the seedbed and a further 50 kg/ha applied at the four-leaf stage. No herbicides, fungicides or insecticides were used except where stated. The plots were harvested directly without swarthing or desiccation with a standard plot combine fitted with a 3 mm screen. At harvest two samples were taken from each plot, one to determine moisture content, which was dried at 100^0C for 24 hours and one for chemical analysis which was dried at 40^0C for 48 hours. Yields are expressed at 9% moisture content (mc).

RESULTS AND DISCUSSION

Growth and development

Camelina germinates very quickly and is visible within 5 to 7 days after sowing. The crop grows rapidly and competes very effectively against developing weeds. In three years over a range of sites and sowing dates the crop was successfully produced without herbicides. Fat hen (*Chenopodium album*) and volunteer rape are the most weeds likely to compete with camelina. To-date Treflan (trifuralin) is the only broad-leaf herbicide product which can be used on camelina (see weed control section).

Table 1: Growth and development patterns of spring-sown camelina - 1993

Sowing date	Start of flowering	End of flowering	Flowering period (days)	Days from sowing to flowering	Date of maturity
12 Feb	18 May	10 June	23	161	02 Aug
15 March	02 June	22 June	20	77	14 Aug
01 April	08 June	28 June	23	63	22 Aug
15 April	14 June	06 July	22	56	03 Sept
11 May	05 July	26 July	21	42	24 Sept
04 June	23 July	13 August	21	42	11 Oct.

The data shows a relatively compact flowering period, independent of the sowing date, resulting in an even ripening of the crop facilitating an early harvest. Camelina seed is very small (TGW: 0.8 to 2.0 gms) and requires care at sowing and harvesting to avoid losses. It is likely that a pneumatic drill would be required to achieve even shallow sowing. A 3-mm lower sieve should be fitted to the combine, otherwise any combine will easily handle the crop. When handling such small seed combine harvesters and trailers should be carefully sealed to avoid seed losses.

Time of sowing x seed rate trial

Three seeding rates 5, 8 and 11 kg/ha were drilled on six dates in a split plot randomized trial. The plots were harvested as they matured. The results are presented in Table 2.

Table 2: Effect of sowing date on the yield (t/ha) and other crop characteristics of spring-sown *Camelina sativa*, averaged over three seed rates - 1994

Date of sowing	Yield t/ha at 9% mc	Crop height (cms)	% Plants diseased	Harvest date
15 March	2.49	95	24.0	18 August
01 April	2.05	85	15.7	25 August
15 April	2.61	77	14.3	06 Sept.
11 May	2.52	71	23.7	27 Sept.
04 June	2.32	62	21.3	10 October
*14 June	-	54	-	-

*This crop had not matured by 1 November and was discarded

The figures presented in Table 2 are means over the three seed rates, as the seed rate effects were not significant. Apart from the 1 April treatment, date of sowing had very little effect on yield, but did significantly reduce crop height. The major effect of late sowing is a reduction in crop height and a late harvest. The data suggest that there is no yield penalty in sowing up to the middle of May. The average yield over the experiment was 2.40 t/ha (0.95 t/ac). This is consistent with the two previous years and in line with published data on camelina. Although the levels of *Botrytis* were relatively high in all plots (Table

2) much of the infection was located on side branches rather than on the main stem and did not reduce yields.

The above trial was repeated the following year. Again three seeding rates 5, 8 and 11 kg/ha were drilled on five dates in a split plot randomized trial. The plots were harvested as they matured, the results are presented in Table 3.

Table 3: Effect of sowing date on yield and other crop characteristics of spring-sown camelina averaged over three seeding rates - 1995

Sowing date	Start of flowering	End of flowering	Date of maturity	Yield t/ha
15 March	04 June	27 June	20 August	2.7
16 April	16 June	05 July	02 Sept.	2.6
08 May	05 July	23 July	21 Sept.	2.4
27 May	10 July	29 July	29 Sept.	2.0
15 June	10 August	26 August	06 October	1.6

The yield results again suggest that the optimum sowing date for spring camelina is mid-March to mid-April. Later-sown crops are prone to heavy weed infestation as well as maturing very late in the season. Crops sown after mid-May show a significant loss in yield potential.

As in the previous experiment, seed rate had no effect on yield over the range 5 to 11 kg/ha. Assuming a germination of 90% and a TGW of 1.5 grms, a seeding rate of 5 kg/ha will produce approximate 300 viable seeds per sq. metre. The data supports UK findings that there is no yield response above 220 plants/m^{-2}. In practice a seeding rate of 5 kg/ha should be sufficient in most situations.

Response to nitrogen

Six rates of nitrogen (Tables 4 and 5) were applied as a top dressing immediately following full emergence in 1993 and 1994. The 1993 experiment was sown on a light sandy soil at Oak Park. The results are presented in Table 4.

Table 4: Effect of six nitrogen rates on the yield of camelina (1993)

N rate kg/ha	Yield t/ha	% diseased plants	Crop height cms	Oil content
0	1.63	13	79	44.61
25	1.71	23	85	44.51
50	1.95	21	88	44.72
75	2.07	32	92	44.63
100	2.29	28	99	44.18
125	2.47	29	99	44.15
S.E. ±	0.11	1.15	1.62	0.09

Each increment of nitrogen increased both seed yield and crop height. There was an increase in the % of *Botrytis* (diseased plants) infected plants as the nitrogen level increased.

Table 5: Effect of six rates of nitrogen on the yield of camelina (1994)

N-Rate kg/ha	Yield t/ha	% Diseased plants	Crop height cms	Oil content
0	1.70	5.0	80	43.81
25	2.20	14.5	85	43.61
50	2.40	13.2	90	43.63
75	3.10	18.0	96	43.71
100	3.20	23.0	99	43.21
125	3.20	23.5	105	43.11
S.E. ±	0.22	1.25	1.92	0.11

In 1994 there was no significant yield response above 75kg/ha of nitrogen. The response to high levels of nitrogen in 1993 is attributed to leaching in the light soil due to heavy rainfall. It is likely that the optimum economic response to nitrogen application would be achieved at 75 kg/ha.

Despite the high levels of nitrogen applied no serious lodging was recorded in either year although higher levels may be required in light soils in high rainfall seasons. Nitrogen level had no significant effect on oil content.

Weed control

As with any new, non-commercially grown crop very little data is available on the crops response to herbicides. Although camelina can be grown successfully without herbicides, situations can arise where a herbicide may be required. To cover this eventuality a range of herbicides were screened in field trials over a number of years. Of the twenty-eight products tested only five (Table 6) proved relatively safe to use. All the rest caused crop damage, including the yield potential of the crop.

Table 6: Herbicides with a low phytotoxic effect on camelina

Products	Chemical	Rate	Timing
Treflan	Trifluralin	2.5 l/ha	Pre-emergence
Devrinol	Napromide	2.0 l/ha	Pre-emergence
Stomp	Pendimethalin	2.5 l/ha	Pre-emergence
Butisan-S	Metazachlor	2.0 l/ha	Post-emergence
Stratos	Cycoxydim	2.0 l/ha	Post-emergence

To-date only one product Treflan (trifluralin) incorporated before sowing has proved successful giving good weed control without crop damage. The two post-emergence products Butisan-S (metazachlor) and Stomp (pendimethalin) look promising but require further testing.

Varieties

Very little breeding work has been carried out on camelina. As a result very few named varieties are available. Most of the genetic material available is either breeders selection lines or old land races. A collection of twelve such lines were assembled and evaluated in a randomized block field trial over two years. The differences between the entries were small and non-significant for yield except for one new line produced in Denmark. This line yielding 11% above the trial mean, with an oil content of 41.9 (% DM). The oil content over the twelve varieties ranged from 39.3 (% DM) to 41.9 (% DM). The thousand grain weight (TGW) ranged from 0.8 grms to 1.54 grams.

Pests and diseases

A number of fungal diseases have been recorded on camelina over the years of the project. *Sclerotinia*, *Botrytis*, *Peronospora* (on seedlings and later on seed pods) and *Ustilago* have been recorded on most crops. Two trials carried out to assess the losses caused by *Botrytis*, the most common and potential most damaging disease, failed to show a response to the fungicide (Table 7).

Table 7: Effect of fungicide treatment on the yield of camelina (average over two trials)

Treatment	Timing	Yield t/ha
Bravo + MBC @2 l + 1 l/ha	Full flowering	2.58
Bravo + MBC @ 2 l+ 1 1/ha	End of flowering	2.70
Bravo + MBC @ 2 l + 1 1/ha	Full flower and end of flowering	2.50
Control		2.62
S.E. ±		0.42

The results and observations suggest that because of the short growing season, no significant seed losses occurred. The only serious threat to the crop was downy mildew (*peronospora*) in late-sown crops. Every year downy mildew has infected emerging seedlings of crops sown in May. No problems were encountered in March or April-sown crops. Where downy mildew is a problem spraying with a mixture of carbendazim and metalaxyl fungicides is necessary.

To-date no pest problems have been encountered. Pollen beetle, a serious pest of oilseed rape does not attack camelina. Seed-eating small birds can cause some damage to ripe crops.

Time of harvest/desiccation effects

The ability of any crop to withstand adverse weather conditions at harvest is important. The objective of this trial was to measure the effects of a delay in harvesting well beyond the actual date of maturity. In Table 8 the effects to delayed harvesting on untreated plots of camelina are given.

Table 8: Yield of camelina. harvested on four dates, with no pre-harvest treatment

Date of harvest	Yield t/ha	Seed mc % at harvest
27 August	1.59	16.5
06 September	1.62	14.0
16 September	1.57	13.9
27 September	1.66	16.3

The results show no loss of yield despite a month's delay in harvest, in what was a very wet month.

Desiccation, using Reglone (diquat), is a standard practice in the harvest of many combinable crops. It is used as a means of acceleration or evening out the ripening process or as a means of removing weeds and other green material, prior to combining. Desiccation can result in a crop becoming vulnerable to seed losses and to severe lodging as in the case of peas. To examine the effects of desiccation on camelina, plots were desiccated on four dates relative to the natural maturity date of the crop.

Harvesting was then carried out at various intervals up to 34 days after the desiccant was applied. The results are presented in Table 9.

Table 9: Yield of camelina, desiccated and harvested on different dates

Date of desiccation	Date of harvest	Interval between desiccation and harvest	Relative Yield %	Seed mc % at harvest
Early (24 July)	04 August	11 days	100	25.7
At maturity (06 August)	18 August	12 days	141	15.8
11 days after maturity (17 August)	06 Sept.	20 days	137	15.3
18 days after maturity (24 August)	27 Sept.	34 days	136	15.6

Again no loss of yield was recorded even where plots were allowed stand for eighteen days after the crop matured, then sprayed with Reglone and allowed stand for a further 34 days before being harvested. The only significant reduction in yield was recorded when the plots were desiccated two weeks before they reached maturity (Treatment 1, Table 9).

Yield comparisons

Camelina has a number of attractive features for the producers which include:
(a) low production costs,
(b) high yield stability
(c) an early harvest and
(d) not favoured by pigeons.

Its main competitor is spring oilseed rape. The results of field trials comparing camelina and the two spring rape types in commercial use are presented in Table 10.

Table 10: Yield and maturity dates for four spring-sown oilseed crops - 1995

Species	Variety	Yield (t/ha)	Date of maturity
Brassica napus (spring rape)	Starlight	3.3	18 Sept.
Brassica napus (spring rape)	Mars	3.2	18 Sept.
Brassica rapa (turnip rape)	Kulta	2.9	15 Aug
Camelina sativa	Hoga	3.1	25 Aug
S.E. ±		±0.15	

The results show no significant differences in yield between the rapes and camelina. Camelina matured about three weeks earlier than the spring rapes. The weather during August and September of 1995 was exceptionally dry and calm. The trial was repeated in 1996 which was a late wet year with poor harvest weather. Results are shown in Table 11.

Table 11: Yield of three spring oilseed crops in two contrasting years - 1995 and 1996

Crop	1995		1996	
	Yield (t/ha)	MC %	Yield (t/ha)	MC %
Spring rape	3.3	13.3	2.6	18.8
Turnip rape	2.9	10.1	3.0	13.8
Camelina	3.1	11.5	2.9	16.5
S.E. ±	0.15		0.14	

The spring rape yielded significantly less than the turnip rape and camelina. The poor performance of the spring rape was due to pod shattering and seed losses prior to the harvest.

Section 2

Chemical Composition and Food Uses

INTRODUCTION

Investigations (C.E.C. AIR 3 CT93 2178, 1996) showed that camelina seed grown in Ireland has approximately the same level of oil as linseed, 42-47%, which is somewhat less than that of rapeseed. The objectives of the work reported here were to determine the effects of variety and some key agronomic factors on the fatty acid composition of camelina oil, to evaluate the stability of camelina oil and to establish if camelina oil could be used for OMEGA-3 fatty acid enrichment of oil based food products.

METHODS

Oil was extracted from seeds and esterified by standard methods (AOAC 1984) and the fatty acid composition was determined by gas chromatography. Individual fatty acid levels of each variety represent averages of four determinations, but one determination was used for the evaluation of agronomic effects. Comparative accelerated storage tests were carried out by heating 100g of raw camelina, rape, turnip rape and linseed oils and refined fish (sand eel) and camelina oils in an open beaker at 65^{o}C for 16 days. Samples were taken every two days and p-anisidine,(IUPAC, 1979) TBA, (Eskin and Frenkel 1976) values and peroxide levels were determined by published methods.

Raw camelina oil was refined in 25 kg batches under conditions used for commercial edible oils. Free fatty acids were removed from the oil with sodium hydroxide, the neutralised product was bleached with Fuller's earth and it was heated at 200^oC under vacuum to eliminate peroxides, odours and off-flavours.

Heat stability of camelina oil was evaluated by heating 4.5 ltrs of refined oil in a heavy duty deep fat fryer at 180^oC for ten 8.5 hr days. In order to stimulate deep frying conditions potato chips were fried in the oil each day. Samples were taken every day, p-anisidine and TBA values were determined as before (IUPAC, 1979 and Eskin and Frenkel, 1976) and peroxide, oxidised triglyceride and free fatty acid levels, and viscosities were determined by standard (AOAC, 1984) methods. The experiments were repeated with commercial soya oils.

Camelina oil based spreadable fat was prepared by blending 25 kg refined camelina oil with the same amount of unhydrogenated vegetable fat-water mixture in an industrial blender. Sunflower oil based spreadable fat was made by the same process. Salad oil was formulated by blending appropriate amounts of camelina oil, vinegar and water. The preparation of both spreadable fat and salad oil was carried out at the Food Science Department of the University of Limerick in conjunction with a dairy processing firm.

RESULTS AND DISCUSSION

Fatty acid composition

The fatty acid composition of camelina oil can be influenced by both environment and variety, although the effects detected here so far were small. Nine varieties were tested and the maximum differences between oleic, linoleic and linolenic acid levels were 3, 2.4 and 2.2% respectively (Table 12). Similarly there was 2% less linolenic acid in camelina grown during a dry warm year (1995) than in the same variety grown during a normal year. While these differences are statistically significant, they are relatively small in absolute terms and have no significant effect on the properties of the extracted oil. Agronomic practices, including date of sowing and harvesting and rates of applied nitrogen had no detectable effect on the fatty acid composition of camelina oil.

Table 12: Varietal effects on fatty acid levels[a] in camelina oil

Variety	Oleic C18:1	Linoleic C18:2	Linolenic C18:3
Hoga	14.9	**15.6**	38.9
Kings	14.8	16.7	**40.5**
Lindo	**15.6**	17.7	**38.0**
M. Farm	14.7	16.5	39.8
Rosalie	14.7	16.6	39.4
Swalf	14.8	15.7	39.1
1022	**12.6**	**17.8**	39.2
8144	14.1	17.0	39.2
68202	14.9	16.7	38.1
Max. diff.	3.0	2.2	2.4
HSD[b]	0.25	0.25	1.1

[a]means of four determinations; [b]honestly significant difference

Refining

Cold pressed camelina oil had an attractive yellow colour, a mustard like taste and a characteristic, but not unpleasant odour. However, flavour and odour are subjective and the oil should be refined to a neutral product for use as a commercial edible oil.

Pilot scale refining of raw camelina oil was successful, and it was possible to produce an odourless product with a neutral oil taste. Furthermore refining also removed most of the peroxides and free fatty acids, and the levels of these impurities in the final product were below the limits recommended for commercial edible oils.

Storage stability

A comparative accelerated storage test (Schaal test) was carrried out with raw rape and turnip rape (10% linolenic acid), linseed (56% linolenic acid) and camelina (38% linolenic acid) oils, and peroxide p-anisidine and TBA values were used to determine the extent of oxidation, hence long term stability. The results indicate that the storage stability of camelina was between that of rapeseed and linseed oils, somewhat nearer to the latter. Similar tests with an OMEGA-3 rich fish oil showed that camelina oil is much more resistant to oxidation than the edible fish oil. In addition the fish oil acquired a strong unpleasant odour during the test which did not happen to camelina oil.

At room temperature raw camelina oil was far more stable than expected from its high linolenic acid level. Peroxide levels of camelina oils stored for two years in IBC tanks without a nitrogen blanket at ambient temperature ranged from 4 to 20 mmoles/kg which is acceptable for raw oil. The storage stability must be due to the presence of natural antioxidants in the raw oil. American workers found 30% higher natural antioxidant (tocopherol) levels in camelina oil than in raw commercial edible oils (Budin, *et al.*, 1995) but data from Northern Europe did not show significant differences. It is possible, therefore, that some unidentified antioxidant, or the synergistic effect of the tocophenol mixture is responsible for the unexpected ambient temperature stability of camelina oil.

The refined oil, however, was not as stable as the raw oil, probably because the antioxidants were removed during refining. Accelerated storage tests showed that peroxide levels increased about 30% more in the refined than in the raw camelina oil. However, in spite of its reduced stability the refined camelina oil did not show signs of oxidative degradation after six months of storage at 8^{o}C. Peroxide levels increased by only 2 units and no rancid flavour could be detected.

Heat stability

The heat stability of camelina oil was evaluated under conditions used in deep frying, and it was compared to soya oil which is regarded as the least stable of the commercial edible oils.

Oil deterioration was monitored by changes in viscosities, peroxide, acid and p-amisidine values, TBA values and levels of oxidised triglycerides. During the first five days camelina oil did not deteriorate significantly more than soya oil and the properties of the two oils were nearly the same (Table 13). After five days (42.5 hr) of heating, however, camelina oil deteriorated much faster than soya oil, probably because it reached the end of its induction period. In fact after seven days the levels of oxidised triglycerides in camelina oil almost reached their recommended limit of 25%, whereas in soya oil only 14% of the triglycerides oxidised during the same time.

Table 13: The effects of heating at 180°C on soya and camelina oil

	Free fatty acids[1]		Peroxide level[1]		Viscosities[2]	
Day No.	Soya	Camelina	Soya	Camelina	Soya	Camelina
0	2.40	3.00	1.00	0.55	32.5	30.7
1	2.86	3.25	0.50	0.40	32.8	31.8
5	4.00	3.50	0.60	1.20	36.8	36.2
10	7.50	5.25	0.80	0.70	43.4	64.1

Days	p-anisidine value[3]		Oxidised triglycerides[4]		TBA value	
	Soya	Camelina	Soya	Camelina	Soya	Camelina
0	7.37	8.10	2.70	5.20	0.44	0.168
1	28.6	69.0	3.70	7.60	0.080	0.220
5	114.3	173.3	11.3	13.7	0.148	0.671
10	150.9	493.5	19.0	35.0	0.226	1.464

[1]mmoles/kg; [2]cps; [3]OD of 1% stn/ x 100 [4]%

The rapid increase of oxidised triglyceride levels in camelina oil after five days of heating was also reflected in changes of other physical and chemical properties (Table 13). The viscosity of camelina oil increased 100% by the end of the heating period, whereas that of soya oil only 30%. There was also a large difference between the aldehyde levels which are the impurities responsible for off flavours (Patterson, 1989). Total aldehyde levels (p-aniside values) were three times and malondialdehyde levels (TBA values) seven times higher in camelina than in soya oil. Peroxide levels, however, did not increase significantly during heating in either oils probably because they decomposed to secondary oxidation products. The low peroxide levels indicate that the amounts of toxic free radicals in heated camelina oil are negligible.

In addition to the quantified degradation products camelina oil also started to acquire a strong paint like flavour after five days of heating which carried over into the fried potatoes. It is not clear, however, at this stage if the off flavour in the heated oil is due to the high aldehyde levels (Patterson, 1989) or to the decomposition of non-triglyceride residues left in the oil after refining.

Camelina oil based products

Refined camelina oil can be used for the preparation of OMEGA-3 fatty acid enriched margarines. Camelina oil was blended with the same amount of unhydrogenated vegetable fat water mixture and the resulting spread had physical properties very similar to a product based on commercial sunflower oil. Camelina spread, however, has the advantage of the anticholestemic effect due to the high levels of OMEGA-3 fatty acids. The stability of the new product was satisfactory, peroxide levels did not rise significantly and no off flavours could be detected after six months of storage. Considering that camelina oil is less expensive and more stable than OMEGA-3 rich fish oils, it should be more suitable for OMEGA-3 fatty acid enrichment of spreadable vegetable fats.

In addition to margarine blends, camelina oil was also used for the formulation of salad dressings. The oil blended as well with vinegar and water as commercial edible oils, and the flavour of the blends remained stable during several months of room temperature storage.

CONCLUSIONS

- Camelina has a yield potential of 2.5 t/ha which is comparable with spring oilseed rape.
- Seed losses at harvest are minimal. Even following desiccation, which is not normally required, the crop will stand undamaged for up to six weeks.
- Production costs are low due to low seed costs (5kg/ha), low nitrogen requirement (75kg/ha) and no agrochemical inputs.
- Camelina oil contains about 35%-40% of the OMEGA-3 linolenic acid which is reputed to have beneficial anticholestmic effects in human nutrition.
- Camelina oil does not deteriorate during refining or in long term storage.
- Camelina oil can be used in a number of oil based food products such as spreads and salad dressings.
- The high linolenic acid content causes rapid deterioration of camelina oil after about 40 hours heating which makes it unsuitable in catering but it should be acceptable for domestic use.

REFERENCES

Putnam, D.H., Budin, J.T., Field, L.A. and Breene, W.M. 1993. A promising low input oilseed. *New Crops*, Wiley, New York, Eds. J. Fanick, J.E. Simon 314-322.

Zubr, J. 1997. Oil seed crop. Camelina sativa. *Industrial Crops and Products*, **6**, 113-119.

Crowley, J.G. 1997. Performance and prospects for alternative crops. *In National Tillage Conference*, Seven Oaks Hotel, Carlow, 52-62

Hubbard, A. 1998. Camelina sativa - a pleasurable experience or another false hope. *Lipid Technology*, July 1998 81-83.

C.E.C. Contract No. AIR 3 CT903 2178. 1996 Alternative oil seed crop camelina sativa. *Interim Report.*

AOAC 1984. Official Methods of Analysis, *14th edn. AOAC Inc.*, Arlington, VA.

IUPAC 1979. Standard methods for the analysis of oils and fats and derivatives. *5th edn. Blackwell Scientific Publ. Ltd.* Palo Alto, CA.

Eskin, N.A.M. and Frenkel, C. 1976. A simple and rapid method for assessing rancidity of oils based on the formation of peroxides. *Journal of the American Oil Chemists Society*, **53**, 746-747.

Budin, J.T., Breene, W.M. and Putnam, D.H. 1995. Some compositional properties of camelina seeds and oils. *Journal of the American Oil Chemists Society*, **72**, 309-315.

Patterson, H.B.W. 1989 Handling and storage of oilseeds, oils, fats and meal. *Elsvier Applied Science*, London, pp.32.