*Pak. J. Food Sci., Vol. 7, No. 3-4, 1997.*

# PHYSICOCHEMICAL CHARACTERISTICS OF OIL FROM THE SEEDS OF *CRAMBE ABYSSINICA*

**Shahnaz Hamid, Hamid Ahmad & K.H. Naqvi***
*PCSIR Laboratories Complex, Lahore.*
**Department of Chemistry,*
*Govt. Dyal Singh College, Lahore.*

## ABSTRACT

The seed oil of *Crambe abyssinica* brought from United States has been analyzed for its physicochemical properties. The seeds upon extraction with n-hexane and chloroform-methanol (2:1) mixture yielded 35.82 per cent and 32.33 per cent oil, respectively. The saponification value of 168.30 shows that more fatty acids present in the oil have a higher number of carbon atoms whereas the iodine value of 95.00 indicates the extent of the unsaturated fatty acids. Erucic acid (58.52%) is the dominant fatty acid followed by oleic acid (18.20%). The oil was composed as hydrocarbon (1.80%), wax esters (3.10%), sterol esters (0.92%), triglycerides (64.20%), free fatty acids (4.90%), 1, 3-diglycerides (6.40%), 1, 2-diglycerides (2.50%) and monoglycerides (4.40%). The presence of erucic acid (58.52%) in the oil of *Crambe abyssinica* indicates its importance in lubricants, plastic and nylon.

**Key words:** oil; *Crambe abyssinica*; physicochemical properties; saponification value; fatty acids.

## INTRODUCTION

Crucifereae or mustard family is a large family including about 220 genera and 3000 species. They are widely distributed but are much more abundant in warm and cold parts of the world than in the tropics. Many of them are alpine plants. Most plants of the family have been reported to grow in Pakistan. Familiar plants are *Brassica compestris* (*sarson*), *B. rapus* (turnip), *Raphnus sativus* (reddish), *B. oleracea* and *botrytis* (cauliflower). These plants are annual or perennial herbs, rarely shrubby with water juice which is often acidic.

Despite all known uses and properties, very little is known about the quality and chemical composition of their fatty acids and essential oils in Pakistan. Vegetable oils and proteins are highly essential to our national economy. In view of the increasingly large demand for oil and protein to support a burgeoning population, oil seeds are being considered as primary nutritional and economical sources (Weber, 1997). The seeds of *Crambe abyssinica* render it fit for many industrial uses. Its oil has been utilized successfully for the manufacture of lubricants (Nieschlag, 1977), plasticizer (Mod, 1969; Neischlag, 1969), nylon (Carlson, 1977) and others (Neischlag, 1971). It has been shown that proper conditions during seed processing make the meal useful for beef cattle feeding (Vanetten, 1977). Leading steel producers have found Crambe oil superior to others in continuous casting of steel (Nieschlag, 1971). A vulcanized product made from Crambe oil has given excellent results in commercial evaluation (Vanetten, 1977). The interest in Crambe stems from high erucic acid contents of the seed oil with its usefulness as a raw material from which other chemicals can be made. However, the contents of this acid may limit the use of Crambe oil for edible purposes because recent investigations have shown that the oil with high erucic acid content causes changes in heart tissues of experimental animals (Perry, 1979; Nieschlag, 1964). Due to the coordinated research efforts between the government and industrial sector. *Crambe abyssinica* has emerged as a new industrial crop in Canada. (Carlson, 1985).

Carlson (1985) reported Crambe meal as protein source for cattle feed. The *C. abyssinica* and *Brassica rapa rabifora* hybrid (typhon) is a new material for the production of oil and proteins. This paper describes some physicochemical characteristics of the oil from the seeds of *Crambe abyssinica*.

## MATERIALS AND METHODS

The seeds of *C. abyssinica* were brought from the United States. These were cleaned by removing pebbles, sticks and other unwanted matter. The pale yellow seed coats were removed. The seeds were then ground to a

fine particle size. Crude oil contents were determined from 10 g sample by extracting the oil using Soxhlet apparatus. The extraction was brought about using n-hexane and chloroform-methanol (2:1) mixture. The solvent was removed by rotary evaporator to get the oil. The yields of the oil with n-hexane and chloroform-methanol (2:1) mixture are reported in Table 1.

**Table 1. Percentage recovery of oils from seeds of *Crambe abyssinica***

| Seed | Solvent used in extraction | Weight of seeds (g) | Yield of oil (g) | Percentage of oil |
|---|---|---|---|---|
| *Crambe abyssinica* | n-hexane | 10.00 | 3.582 | 35.82 |
| *Crambe abyssinica* | Methanol | 10.00 | 2.233 | 32.33 |

**Physicochemical properties**

The physicochemical properties like moisture, refractive index, specific gravity, colour, acid value, free-fatty acids (FFA), iodine value, unsaponification value, saponification value, etc. of the lipids were determined by standard AOAC methods (Horvitz, 1970) and the results are given in Table 2.

**Table 2. Physicochemical characteristics of oil of *Crambe abyssinica***

| | |
|---|---|
| Moisture content | 5.94% |
| Refractive index at: | |
| 25°C | 1.466 |
| 40°C | 1.462 |
| 60°C | 1.459 |
| Specific gravity at 25°C | 0.90 |
| Colour | Pale yellow |
| Acid value | 0.56 |
| Free fatty acid value | 0.282 |
| Iodine value | 96.00 |
| Saponification value | 168.30 |
| Unsaponification (%) | 0.50 |
| Fixed seed oil (%) | 35.82 |
| Smoke point at 520°C | 269 |

**Thin layer chromatography (TLC)**

The thin layer chromatograms of 0.5 mm thickness were prepared by using 50 g silica gel and 100 mL water. These were activated at 105°C in thermostated oven for one hour and later used for the separation of neutral and polar lipids by using n-hexane, ether and acetic acid in 60:20:2 v/v, respectively. The saturated solution of antimony trichloride in chloroform was used for the identification of sterols as well as sterol esters. Appearance of red violet spots on thin layer chromatograms when kept at 100°C for 10 minutes confirmed the presence of these compounds (Raie *et al.*, 1989).

The general composition of the neutral lipids component as revealed by TLC is given in Table 4.

**Identification of fatty acids**

Methyl esters of fatty acids were prepared (Raie *et al.*, 1983) and analyzed on Schimadzn. GC 14A gas chromatograph with flame ionization detector using 1.6 m 3 mm (id) glass column packed with diethylene glycol succinate 15% coated on Scimalite AW 201 (60-80 mesh) column. Temperature was programmed at 153°C for low and then with a rise of 5°C per minute to 200°C. Injector and detector temperatures were 250°C and 300°C, respectively. Nitrogen was used as carrier gas with a flow rate 40 mL per minute. The methyl esters were identified by comparing their retention times with those of authentic methyl fatty esters under the same conditions. The percentage of various acids were determined by Scimadzn-CR4, chromatopack computing integrator. The results are given in Table 3.

**Table 3. Fatty acid composition of *Crambe abyssinica* seed oil**

| | | |
|---|---|---|
| Palmitic | $C_{16:1}$ | 2.76 |
| Palmitoleic | $C_{16:1}$ | 0.19 |
| Stearic | $C_{18:0}$ | 0.16 |
| Oleic | $C_{18:1}$ | 18.20 |
| Linoleic | $C_{18:2}$ | 11.23 |
| Linolenic | $C_{18:3}$ | 7.50 |
| Erucic | $C_{18:3}$ | 58.52 |

**Table 4. Percentage composition of neutral lipids of *Crambe abyssinica* by TLC**

| Lipid | Percentage |
|---|---|
| Hydrocarbons | 1.80 |
| Wax esters | 3.10 |
| Sterol esters | 0.92 |
| Triglycerides | 64.20 |
| Free fatty acids | 4.90 |
| 1, 3-diglycerides | 6.40 |
| 1, 2-diglycerides | 2.50 |
| Monoglycerides | 4.40 |

## RESULTS AND DISCUSSION

The results presented in the Tables show that the values of various physical properties of Crambe oil are generally on the higher side as compared to other domestic vegetable oils. The physical properties are summarized in Table 2. Some properties along with the visible characteristics are compared with those of other common Crucifer seeds. All other parameters are comparable except the acid value which is less in case of *Crambe* seeds. On the other hand, erucic acid is higher in it.

Glucosinulates are natural toxicants common in vegetable and seed meals from the plants of the family Cruciferae. It has been noted that proper conditions during seed processing can make the meal useful for animal feeding. The glucosinulate content of the processing can make the meal useful for animal feeding. The glucosinulate content of the fraction is about 8 per cent which is too high to feed to monogastric animals. However, if it is maintained at 5-9 per cent level, weight gains in ruminants are satisfactory. Glucosinulates and their breakdown products are known to effect humans and animals in various detrimental ways. They have been linked with thyroid disturbance, liver damage, throat abscesses, appetite depression, tongue swelling and abortion in animals (Princon, 1984).

The saponification value of 168.3 shows that more fatty acids present in the oil have a higher number of carbon. The presence of erucic acid (55-60%) is comparable to the rape seed oil which has 40-55 per cent erucic acid by weight. Rapeseed oil is already being used as lubricant in steel manufacturing. Erucic acid or its derivatives are used in plastics, foam suppressants and lubricants. Use of Crambe oil in all these applications has been found quite satisfactory or even superior and hence it seems to be a good substitute for higher erucic acid rapeseed oil which has been reported in one of the most novel applications (Carlson, 1977).

Thin layer chromatography of the oil shows that its major constituents are mainly the triglycerides (84.2%). The neutral as well as the polar lipids were identified by comparing the Rf values with standard. The results of thin layer chromatography analysis of the oil are given in Table 4. The lipids are classified by thin layer chromatography into various neutral lipids such as hydrocarbons, sterol esters, triglycerides, 1, 3-triglycerides, 1, 2-triglycerides, monoglycerides and free fatty acids by using solvent system as hexane-ether and acetic acid.

The results indicate that the percentage of polar lipids were very low as compared to neutral lipids. So, like other unsaturated vegetable oils, Crambe oil may be vulcanized reacting with sulphur or sulphur-derivatives. The familiar art gum eraser is made of vulcanized vegetable oil. The vulcanized vegetable oils are also blended with neutral and synthetic rubbers to facilitate processing to provide soft elastic products with improved resistance to light and ozone and to increase tolerance towards liquid plasticizers (Bailey, 1964). A vulcanized product made from Crambe oil has given excellent results in commercial evaluation (Nieschlag, 1971).

Leading steel producers have found Crambe oil to be superior to other oils for continuous casting of steel. It should be beneficial in formulating lubricants since addition of high erucic triglycerides to mineral oil is known to increase oiliness of base stock and hence improve durability under high speed and high pressure operation (Nieschlag, 1977). The high content of erucic acid limits the use of Crambe oil for edible purposes because investigations have shown that a high erucic acid content causes damage to the heart of experimental animals (Perry, 1979).

Current trends in most countries especially in Canada, towards production of low erucic acid rapeseed variables for improved nutritional quality of the oil, have increased the importance of Crambe oil as a domestic source of high erucic oil for industrial purposes. It is interesting to mention here that as a result of cooperative research between Government and the industry, undertaken in Canada, *Crambe abyssinica* has now emerged as a new industrial crop in that country.

## REFERENCES

Bailey, S., 1964. Industrial Oil and Fat Products. 3rd Ed., John Wiley & Sons, New York.

Carlson, K.D, W.E. Sohns, R.B. Perkins, Jr. and E.I. Huff, 1977. Brassylic acids chemical intermediates from high erucic oils. Ind. Eng. Chem. Prod. Res. Rev., 16: 95.

Carlson, K.D. and E.C. Baker, 1985. Processing of *Crambe abyssinica* in commercial extraction facilities. JOACS, 62 (5): 897-905.

Harvitz, W., 1970. Official Methods of Analysis. Assoc. Agri. Chemists, Washington.

Mod, R.R., F.C. Magne, F.I. Kau, H.J. Neischlag, W.H. Tallent and A. Waff, 1969. Preparation and plasticizing characteristics of some N, N-disubstituted analysis of erucic and Crambe acid. Ind. Eng. Chem. Prod. Res. Dev., 8: 176.

Nieschlag, H.J., W.A. Tallent and L.A. Wolf, 1969. Simplified preparation of diester plasticizer from Crambe seed oil. Ind. Eng. Chem. Prod. Res. Dev., 8: 216.

Nieschlag, H.J. and I.A. Wolf, 1971. Industrial use of high erucic oils. JOACS, 48 (11): 723.

Nieschlag, H.J., C.F. Spencer, R.V. Madrigal and J.A. Ruthfus, 1977. Synthetic wax esters and diesters from Crambe acid. Ind. Eng. Chem. Prod. Res. Dev., 16: 202.

Perry, T.W., W.F. Kowlek, L.H. Tookey, W.M. Princon and M.T. Mohler, 1979. Crambe meal as a source of supplemental protein for growing beef cattle. J. Anim. Sci., 48: 758-763.

Princon, L.H. and J.A. Rothfus, 1984. Development of new crops for industrial raw materials. JAOCS, 61 (2): 283.

Raie, Y., I. Ahmad, M.A. Javed and I. Waheed, 1989. Lipid classes umbelliferae. Pak. Acad. Sci., 26 (3): 200.

Raie, Y., M. Ahmad and S.A. Jafri, 1983. Chromatographic studies of cotton seed oil. Fette Seifen Anstichmittel, 7: 279-280.

Vanetten, C.H., W.E. Daxebehler, W. Sehrieder, L.H. Princen and T.W. Perry, 1977. Test for epi-progoitrin-derived nitrites and goitrin in body tissues from cattle fed on Crambe meal. Canadian J. Anim. Sci., 57: 75.

Weber, C.W., J.W. Berry and T. Philips, 1977. *Citrullis, Apondonthera, Cucurbita* and *Hibiscus* seed protein. J. Food Technol., 182: 31.