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DEFRAPLAST: NEW PLASTICISERS AND STABILISERS FROM UK-GROWN CRAMBE OIL

(NOT TO BE PUBLISHED)

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1. Production of erucic acid and its implications

1.1. Introduction

The majority of plant derived erucic acid comes from the high erucic acid rape (HEAR) varieties. In the UK the acreage of oil seed rape is expanding especially now with the push towards the production of biodiesel. This may lead to problems of cross pollination between the different varietal types of oil seed rape that produce oils with different oil profiles according to their end uses. Currently at least 50m isolation distances are required between low and high erucic varieties. Cross pollination could lead to the oil profiles been altered and therefore made inadequate for their intended applications. Agricultural crops once again may provide a significant percent of the raw materials for industry and therefore researchers and breeders are continually looking at crops that may be of benefit to industry. One such crop is Crambe abyssinica.

Crambe has a high erucic acid content averaging 56-58% of the total oil in the seed, approximately 9-10% higher than HEAR. Crambe was introduced in to the US in the 1940's and became commercially grown in the 1990's (Knights S.E. 2002). The production of crambe as a source of erucic acid has a number of advantages over HEAR and these will be discussed.

1.2. Crambe background

Crambe is believed to be of Mediterranean origin. It has been grown in tropical and subtropical Africa, the Near East, Central and West Asia, Europe, the United States and South America (Oplinger *et al* 1991). Crambe is family *cruciferae* and therefore does not cross with commercial oil seed rape (OSR) varieties. The plants are erect, herbaceous annuals with large, pinnately lobed leaves. It has a straight stem which is moderately branched (Figure 1). The white flowers are clustered in racemes and the fruits are spherical, almost always one seeded, and indehiscent. The silique wall or hull remains attached to the seed during harvest but can be removed via processing.

Figure 1. Crambe in flower.

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1.3. Agronomy

The cultivation of crambe is similar to that of spring grown oil seed rape requiring moderate inputs. The benefits of this are that the same readily available equipment and chemicals can be used for crambe as already exist for OSR.

In mainland UK the crop is sown in April to May when there is less risk of severe frosts. The crop emerges with in 5 to 7 days in warm soil conditions and is harvested approximately 100-120 days from emergence, making it a very fast growing crop. Crambe can be grown in a range of soil types but highest yields are on sandy loams and soils with a pH of 6.0 and above. Nitrogen applications of 150 kg per hectare have given the highest yields in the UK.

The crop can be harvested by direct cutting with a combine, swathing in to wind rows and then combining or by desiccation (spraying off the crop) and combining. Due to the indehiscent nature of crambe, swathing and desiccation allow immature seeds to ripen and therefore may give a more even seed sample.

The hull surrounding the seed gives it a very low bulk density. With the hull the oil content is 35% of the seed density when the hull is removed this is up to 46%. Post harvest handling of the seed is straightforward for transportation and drying.

The crop is an excellent break crop in the UK agricultural crop rotation and cereals grown after crambe often show yield benefits. Replacing OSR with crambe in the rotation can alleviate weed, pest and disease build up. As there is no cross pollination with OSR farmers are not restricted by isolation distances, as with food / non-food varieties of OSR. Trial work is being carried out to increase agronomic knowledge for production in the UK and for the development of new strains with higher seed and oil yields.

1.4. Processing

The seed is cleaned of impurities (down to a maximum level of 2%) and dried to 9% moisture so that it can be stored without risk of deterioration. The seed can be extruded with the hull on or off, but better oil yields are obtained if the hulls are first mechanically removed. If the hulls are removed the cake left after extracting the oil has an higher protein content and therefore is more valuable as a ruminant feed additive. After extrusion of the oil the resulting cake (oil content 10 to 12 %) is solvent extracted with hexane to remove more of the oil, this then leaves a meal with approximate oil content of 1 to 2%.

The crude vegetable oil is then sent for processing to purify erucic acid from the oil (Figure 2). The unrefined vegetable oil goes through a reactor called a splitter. Heat and pressure are used to split the triglycerides in to glycerine and crude fatty acids. The crude fatty acids are then purified via fractional distillation. The boiling point of fatty acids varies depending on the number of carbon atoms in their chain and the structure of the molecule. Depending on the boiling temperature depends on where up the column the particular fatty acids are drawn off. The longer chain molecules such as erucic acid are drawn off nearer the base of the column where the temperature is higher. The fractionation goes through two columns the first column separates the erucic acid and high boiling point impurities out and then the second column separates the erucic acid from the impurities. Approximately 95% of the erucic acid in the original crude oil is recovered.

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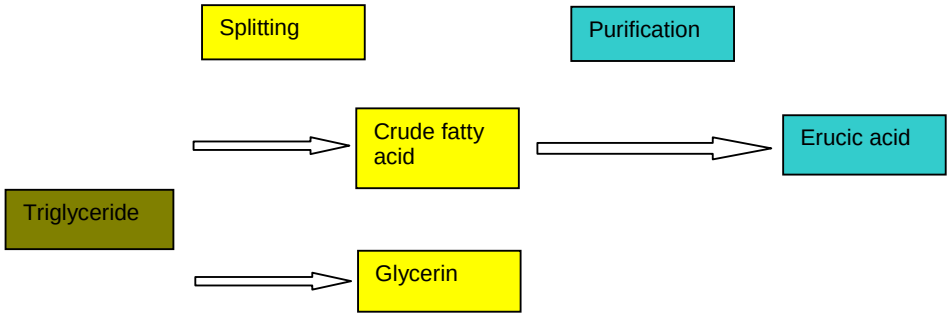

Figure 2. Erucic acid production.

1.5. Present Production

Crambe is grown primarily for the extraction of erucic acid from the oil. The erucic acid content of the oil is 58%. Erucic acid is predominantly converted into erucamide and used as a non-stick agent in polyolefin films. Table 1 shows some of the main applications of erucic acid derivatives.

Crambe has been commercially cultivated in the US since 1990 and has proven to be a viable crop. In the UK commercial production of crambe started in 2001. At the present time up to 4000 hectares of crambe are grown in the UK, although high value seed production is also grown alongside commercial areas. In the UK production of the crop is offered to farmers by Springdale on a fixed buy back contract to guarantee farmers a sale and develop confidence in the crambe oil market. Springdale have crambe production in Australia, South Africa and have trials in Chile, France, Zambia, India, NZ, Italy, Holland, Sweden and Saudi Arabia. This is to establish a year round supply of oil for industry.

Croda presently take the majority of oil produced in the UK. They have highlighted the benefits of erucic acid extraction from crambe oil compared with HEAR oil. The higher level of erucic acid in the oil tends to give a purer erucamide sample. Crambe has a lower level of polyunsaturated fatty acids compared to HEAR which simplifies downstream processing. For these reasons crambe oil tends to be preferred for erucamide production, however at present the hectarage of crambe is much lower than that of HEAR. The lower levels of production are due to crambe been lower yielding in some cases than HEAR and farmers and advisors being less familiar with the crop. New varieties are being trialed for yield improvements. Also the increased demand for crambe oil for specialist applications will lead to an increase in price to the farmer.

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Table 1. Major uses of erucic acid and its derivatives.

Derivative	Application
Erucamide	Polymer additive
Behenyl fumarate vinyl copolymer	Oil field chemical
Stearyl erucamide	Polymer additive
Behenyl trimethylammonium chloride	Personal care product
brassidolide	perfumery
Glyceryl trierucate	pharmaceutical
Erucyl erucate	cosmetics
Nylon 1313	apparel

1.6. Conclusions

Good agronomic practices have been established for crambe and it has already proven to be a commercially viable crop in the US and UK. Crambe oil has benefits over HEAR oil when further processed and these will be of particular importance when producing stabilisers and plasticisers. Trial work is already in progress to increase the economic viability of this oil and to create a stable, year round supply for industry.

References

Knight S.E., Crambe A north Dakota Case Study: RIRDC Publication No W02/005
Oplinger E.S. et al, Crambe; Alternative Field Crops Manual: July 1991

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