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INDUSTRIAL MARKETS FOR OILSEED RAPEMEAL

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SUMMARY

1. Background

Within the EU, rapemeal is utilised as a source of protein for inclusion in animal feeds. The area of industrial oilseeds that can be grown in the EU is limited by that negotiated in the Blair House Agreement. If the feed by-products from non-food oilseeds on set-aside reach 1 million tonnes of Soya bean meal equivalent then the Memorandum of Understanding requires the EU to take "appropriate corrective action". One million tonnes of soya bean meal equivalent should be produced form something over 1 million ha of oilseed rape. The quantity of industrial oilseeds harvested in 1995 produced close to the 1 million tonne limit. Consequently it is increasingly recognised in the EU that development of industrial oilseeds cropping may be significantly restricted. This is all the more serious in the light of the development of a number of new oilseed rape varietal types offering greater potential for industrial use, which are likely to be introduced over the next 5 years.

One solution to the Blair House restrictions would be to ensure that the meal was used for non-feed purposes. The objectives of this research is to identify non-feed uses for rapeseed meal, evaluate their potential value and indicate areas of research where new developments could markedly improve the value of the meal for industrial purposes.

2. Chemical composition

Rapemeal consists mainly of protein and fibre, but also contains complex carbohydrates, minerals and vitamins. The protein content of rapemeal is lower (approximately 40%) than that of soya meal (approximately 50%).

The proteins of rapemeal are predominantly of the globulin class of protein. Globulins are the major form of storage protein in dicotyedenous plants in general and tend not to be present in large quantities in cereals. In terms of amino acid composition, rapemeal contains less lysine than soya meal but is higher in the sulphur amino acids methionine and cysteine.

Up to 3% starch, 10% sucrose and 5% cellulose occur in rapeseed meal. Rapemeal also contains about 1.5% tannins and a variety of phenolic compounds. Levels of saponins in rapeseed meal have been found to range from 0.62 - 2.85 (check units) and the meal contains 2 - 5% phytic acid.

The gross energy content of rapeseed meal is approximately 19.7 MJ/kg. This is similar to the energy content of wood.

3. Potential low value markets

3.1 Fuel use

Rapemeal has a good energy content in comparison to other solid fuels and can be processed in to a fuel that performs well and is easy to handle. However, the price obtained for rapeseed meal as a fuel is likely to be well below the market price for

rapemeal. The fuel would have to be available to domestic consumers at a price in the region of £55 - 60/t. If the meal was sold directly by the crusher, the price obtained may be close to this but, if an intermediate processor for pelleting and distributor was involved, the price obtained for the meal would be significantly lower.

The best option in terms of price per tonne for fuel use would be to market the meal in the domestic heating market but larger quantities of the meal could be potentially used for district heating or power generation.

3.2 Animal bedding

For this type of use rapemeal would be competing with sawdust which is available to farmers for £21/tonne or £29/t delivered, i.e. well below the market price of rapeseed meal. If rapemeal were to be used for dairy cow or chicken bedding, measures would obviously have to be taken to prevent the animals from eating the meal, in order to satisfy the conditions of the Blair house agreement. Due to the low price which could be achieved for meal in this market, it would not be of interest unless no other higher value used were possible.

3.3 Composts

The most important ingredient of horticultural composts is peat. Annual consumption in the UK has been estimated at 2 - 3 million m^3. However, environmental concerns with respect to the degradation of peat bog habitats has resulted in the development of alternative "peat free" composts and plant growing media. Although when first introduced, peat-free products retailed at a premium, competition in this sector appears to have increased and peat-free products are now priced competitively with peat based products. The bulk price for peat is approximately £12 - £15/tonne delivered.

The best opportunities for peat free composts are in the garden market rather than for use in commercial horticultural production. Rapemeal is quite different in composition to other materials used as a base for peat free composts. However, some practical work would be required to assess its performance on composting as it has some nutrient value in its own right.

3.4 Seed coatings and bait pellets

Pelleted seed is commonly used for high value row crops such as sugar beet and vegetables. This has the combined advantage of creating a uniform seed size and providing physical protection of the seed during germination. The pellets can also be carriers of nutrients and fungicides. A range of clays are currently used for sugar beet pellets but given the potential of rapemeal as a slow release fertiliser there may be a case for examining its suitability.

Organic carriers with some feed value are also used for products such as slug pellets and rat poisons but experience suggests that the EU would regard this as a food use.

4. Potential uses for the near term

This section identifies uses which may require a relatively low level of investment for their development, and for which a price similar to the current market price for rapemeal may be obtained.

4.1 Fertiliser

One of the few commercial applications of rapemeal already established is use as a slow release fertiliser. In Canada a company, CIC Organics, manufacture a fertiliser product under the name Soil Doctor, which is marketed for use on fine turf. Use of rapemeal as a speciality fertiliser appears to be a promising market in which rapemeal is likely to fetch the market price.

4.2 Use as a component of microbial culture media

Culture media for micro-organisms must provide a balanced mixture of the required nutrients at concentrations that will permit good growth. Although substances such as soya meal, cotton seed meal and corn steep liquor are all used for this purpose, no rapemeal derived products appear to be marketed as components for culture media. There have, however, been some reports in the literature of studies on the suitability of rapemeal for this use. The steps required to encourage use in the market may be at the level of demonstration and promotion, although work with a wider range of micro-organisms may be beneficial in establishing rapemeal as a suitable source of nutrients for microbial culture media.

4.3 Low matrix wood composites

Considerable research has been performed on the use of agricultural crops and residues as substitutes for wood based panels. No reports on the use of rapemeal have been found, but in the US a product based on soya bean meal has been recently introduced. The suitability of rapemeal for this type of market is an area worthy of study.

4.4 Mushroom compost supplementation

Mushrooms require a balanced compost with respect to nitrogen and carbohydrates. Where the compost is not balanced, carbohydrate and protein supplements are quite widely used. A number of different protein based supplements are on the market. Some of these are based on soya meal or cotton seed meal, but no information was found during the source of this study which indicated that rapeseed meal has been used as a mushroom compost supplement. The composition of rapemeal suggests that it may be suitable for this use but some practical work is required to assess its suitability. A potential problem may be the presence of glucosinolates as these compounds may be toxic to some fungi.

4.5 Use as an absorbent material

Markets for absorbents include pet litter and use as an absorbent for oil spills.

Clay materials have been successfully used as animal litter granules, but recently alternatives have been introduced to the market. Products based on wood and paper waste are available in super markets, and are marketed as "environmentally friendly" and "biodegradable". Preliminary work carried out, as part of this study, on the absorptive capacity of oilseed rape meal indicates that from this respect it may be a suitable raw material for the production of cat litter, but further work will be required to assess its suitability with respect to other performance characteristics.

The preliminary work carried out also showed that oilseed rape meal performed as well as a commonly used oil absorbent in terms of quantity of crude oil absorbed per g of absorbent. Oilseed rapemeal therefore appears to have potential as a cost effective, multifunctional absorbent which could find usage in a broad range of industrial applications.

5. Potential uses for the far term

This section looks at some potential markets for rapemeal which would require longer term investment in research and development before they could be commercially exploited. These uses are largely based on the extraction of protein and its plasticity, strength, solvent and adhesive qualities.

5.1 Biodegradable plastics

Proteins have been used for various non-food applications e.g. gelatin and collagen for medical purposes, but their suitability as bioplastics has always been limited. Nonetheless, potential may be indicated by the fact that proteins are polyamides, and Nylon, one of the leading synthetic polymers is a polyamide. The first recognised work on plant protein was reported as early as 1913, and many attempts to improve the quality of plant protein plastics have been made. Protein derived plastics generally have the advantage of being edible and biodegradable but they can only be used where water is not present because of their hydrophilic properties. Research effort into biodegradable plastic is quite active and examination of protein polymers derived from rapeseed used alone, or in combination with other polymers should be considered as a longer term target.

5.2 Soluble and edible coatings

It has been reported that soybean protein is used for edible films for food wrapping in the far east. The suitability of wheat gluten for the production of food coatings or soluble sachets has also been studied. In Europe, other forms of soluble packaging are used to separate the components of pizzas and pastries before cooking and there is an established market for coating fresh fruit with soluble sucrose esters to enhance shelf life and reduce losses during shipments. Soluble films are also being used in the agrochemical industry. Liquid formulations are packaged in soluble sachets which dissolve quickly in the spray tank. Although much work has been carried out in this field, it has not been focused on oilseed rape meal.

5.3 Adhesives for wood bonding

The use of proteins in the production of adhesives is not new. The main protein based adhesive in the US has been derived from soy protein. The abundance of supply and relatively low cost was a driving force for development in the 1930s. At its peak, in 1956, use of soybean flour for adhesive in the US was 45 000 tonnes per year, but today annual consumption is just 80 - 90 tonnes. The main disadvantage of soybean glue is the lack of water resistance. The potential for soybean based adhesives will be largely determined by their relative price in comparison with other protein sources or synthetics. Although their disadvantages are well known, they may be partly overcome by protein modification or formulation. The properties of rapemeal should be investigated in order to establish whether it has a potential place in the market.

5.4 Coatings for paper

Coatings are used on paper to fill irregularities of the surface and to give the required finish, gloss and smoothness appropriate for accepting print and for enhancing appearance. In Europe, starch is used as a coating agent. In the US. soybean protein coating agents are widely used. This use represents by far the largest industrial market for soybean protein with an annual consumption of 22 - 45 000 tonnes. Protein coatings were favoured in the US. compared to starches due to their better water resistance. Examination of the potential of proteins derived from rapemeal for this use should be undertaken.

5.5 Textile and fibre applications

Wool and silk are proteins and consequently early research, during the 1930s, into the production of synthetic fabrics looked at the concept of mimicking these natural fibres by reconstituting proteins from other sources. Work to develop this market for soya protein is on-going and studies on the qualities of rapemeal in comparison with other plant proteins that have been examined for this use could be justified.

5.6 Pesticide effects of glucosinolates

The breakdown products of glucosinolates are thought to be involved in the resistance of *Brassica* species to a number of fungal pathogens. Work is being carried out to assess the biocidal potential of glucosinolates extracted from the whole rapeseed plant via a biorefinery process. If the project is successful, in the long term, oilseed rape meal may be used to provide a source of glucosinolates for the production of natural biodegradable pesticides, with the residue being used for other industrial uses.

6. Conclusions

As a commodity, rapemeal has been under-utilised and under investigated. This is because there has been a ready market for meal in the feed industry. In addition, no organisation has been promoting the use and marketing of rapeseed meal. In contrast, there has been a great deal of research into different markets for soya meal and there are a number of commercially viable non-feed uses, not only for soya but also for other similar substances such as cotton seed meal.

This report has shown that a number of significant non-feed markets could be developed for rapeseed meal and that this could be achieved with minimal investment in research and time. Although some of these markets may not represent a huge volume, cumulatively they could represent a significant tonnage so easing pressure on the Blair House restrictions. Disposal markets could be considered if volume use is an over-riding need rather than economic return.

Furthermore, some of these markets together with those requiring longer term research to reach commercial fruition justify further research irrespective of Blair House considerations as they appear to offer a real opportunity for wealth creation.

Recommendations

1. It is recommended that the next stage for the development of industrial uses of oilseed rapemeal should be a co-ordinated series of "look see" studies, e.g. 6 month trials, in order to evaluate the potential for use of rapemeal in markets such as speciality fertiliser, component of microbial culture media and use as mushroom compost supplement , before allocating any major projects. Where the results of these studies confirm the suitability of rapeseed for a particular market, the results could be used in order to promote the potential of rapemeal to possible industrial users.

2. More extensive work may be required for development and formulation of rapemeal for use in markets such as cat litter, oil absorbent and composites. This work may be best carried out through industrial collaboration.

3. Work is required to determine the characteristics and performance of the material remaining after protein is extracted from oilseed rapemeal. Development of this approach could have a major impact on the economics of rapemeal utilisation. If the protein is extracted for the production of, for example, paper coatings, textiles or plastics, it may be possible to utilise the remaining material in some lower value markets such as fuel, animal bedding or peat free compost. If the fibre is considered as a by-product of the higher value protein, then it may be economically viable to utilise it in this way. It may even be possible to use the fibre in some of the higher value markets such as absorbents.

CHAPTER 1 INTRODUCTION

1.1 Background to the review

In 1992, measures to reform the Common Agricultural Policy (CAP) were adopted which introduced area payments for cereals, oilseeds and proteins. The reforms also required that 15% of the total area on which these area payments were claimed were set aside from food production. However, the Arable Area Payment Scheme does allow the growing of non-food crops on the land set aside, providing that certain conditions are met. The principal conditions are that the grower must enter a contract with a processor or processor's agent (collector); the produce must be processed into an acceptable non-food product, and that the "economic valuation of the non-food products obtained by any processing of the raw materials must be higher than that of all other products for food or animal consumption obtained during the same processing".

The growing of non-food crops on set-aside by British and European farmers expanded rapidly following the introduction of the scheme. Oilseeds have dominated this industrial cropping. The area of non-food oilseeds in the UK for 1992/93 was estimated at 40 610 ha (Table 1.1). The total area in the EU for the same year was estimated at 203 210 ha. The following year, the area of industrial oilseed cropping had more than doubled in both the UK and the EU as a whole. By 1995, however, although the EU area had continued to increase to 968 080 ha, the UK area had declined by approximately 7%, and looks likely to decline further in 1996.

The area of industrial oilseeds that can be grown in the EU is limited by that negotiated in the Blair House Agreement. If the by-products from non-food oilseeds on set-aside reach 1 million tonnes of soya bean meal equivalent then the Memorandum of Understanding requires the EU to take "appropriate corrective action". One million tonnes of soya bean equivalent should be produced from something over 1 million ha of oilseed rape.

Table 1.1 Non-food oilseed area in the EU ('000 ha)

Member State	1993	1994	1995
Belgium + Lux	2.59	10.60	6.94
Denmark	18.10	41.70	34.00
Germany (16)	60.66	146.83	350.14
Greece	0.00	0.00	0.00
Spain	4.44	37.80	32.00
France	49.14	222.00	373.00
Ireland	0.00	0.50	0.50
Italy	27.15	61.58	61.00
Netherlands	0.52	0.12	0.40
Portugal	0.00	0.00	0.00
UK	40.61	91.72	85.00
Austria	-	-	16.00
Finland	-	-	1.50
Sweden	-	-	7.60
Total	203.21	612.31	968.08

Source: Member States estimates published by the Commission 21 March 1996.

The area of industrial oilseeds harvested in 1995 was close to 1 million ha. Consequently, it is increasingly recognised in the EU that development of industrial oilseeds cropping may be significantly restricted (Renshaw, 1994). This is all the more serious in the light of the development of a number of new oilseed rape varietal types offering greater potential for industrial use, which are likely to be introduced over the next 5 years (Walker, 1995).

1.2 Objectives

One solution to the Blair House restrictions on industrial rapeseed expansion would be to ensure the rapeseed meal was used for non-feed purposes. As it is the feed by-products which are limited to the 1 million tonnes of soya equivalent, industrial use of rapeseed meal would avoid adding to this total. In addition, as the first of the new industrial rapeseed varieties are likely to be transgenic, the development of non-feed uses for the meal may ease their introduction into UK agriculture. The objective of this research is to identify non-feed uses for rapeseed meal, evaluate their potential value and indicate areas of research where new developments could markedly improve the value of the meal for industrial purposes.

1.3 Report Structure

This review falls into 2 major parts. The first part reviews current knowledge about oilseed rape meal, in comparison with other oilseed meals. The second part identifies potential industrial uses and considers the research required to support development of markets.

CHAPTER 2 RAPEMEAL PRODUCTION

2.1 Oilseed processing

Oilseed rape is processed using a variety of crushing and refining technologies. The choice of technology is very much dependent on the end use and scale of operation. In general, oilseed rape enters the process at around 40% oil content. One tonne of rapeseed yields approximately 0.58 t of meal. The seed is cracked and heated to release moisture and allow easier oil extraction. Moisture content is also modified as the seed then enters the pressing stage.

Oil extraction can follow 2 routes. At low volumes (less than 150 tonnes per day) it may be cheapest in capital cost terms to follow a mechanical oil extraction route, although other methods extract a higher percentage of oil. This involves high powered pressing of the seed through a fine gauge cage to leave only 10% oil in the resulting cake, perhaps followed by a second press to extract another 1 or 2 %.

The high volume UK crushers (e.g. > 1000 t per day) follow a second route. This involves pre-pressing to extract half the oil followed by solvent extraction of the remaining oil. The rape meal residue is left with only 1 - 2% oil. (Booth *et al.*, 1993).

2.2 Domestic production and imports

Table 2.1 shows the dramatic expansion in UK oilseed rape production since 1972. Table 2.2 indicates that the increase in the area of rapeseed within the EU 15 since 1993 has been largely as a result of the increase in the crop area planted on set-aside land, for non-food use. This oilseed rape has been used mainly for the production of biodiesel. However, the area grown for non-food use in the UK was almost all HEAR for erucic acid production.

Table 2.1 Area of oilseed rape in the UK

Harvest year	ha
1972	7 000
1977	55 000
1981	105 000
1984	269 000
1987	388 000
1989	321 000
1990	391 000
1991	440 000
1992	421 000

Source: FAO yearbook, 1993; Agra-Europe, October 1995.

Table 2.2 Areas of rapeseed in the UK and EU ('000 hectares)

	1993	1994	1995
UK total	377	532	454
UK non food	*41*	*92*	*88*
EU 15 total	2394	2749	2871
EU 15 non-food	*206*	*474*	*831*
EU 15 food	2188	2275	2040

Source: FAO yearbook, 1993; Agra-Europe, October 1995.

Table 2.3 shows total UK rapeseed production, rapeseed and rapemeal imports and exports since 1991. The data is plotted in Figure 2.1, but it is difficult to identify any overall trend in imports and exports since 1991, although there was a sharp increase in imports of rapeseed between 1993 and 1994.

Table 2.3 Tonnes of rapeseed produced, imported and exported from the UK - by calendar year.

'000 tonnes	1991	1992	1993	1994	1995
production	1350	1159	1133	1359	1245
imports - rapeseed	137	213	115	386	
imports - rapemeal	201	173	258	143	
exports - rapeseed	147	121	57	83	
exports - rapemeal	66	98	118	121	

source: FAO, Dalgety/oil world

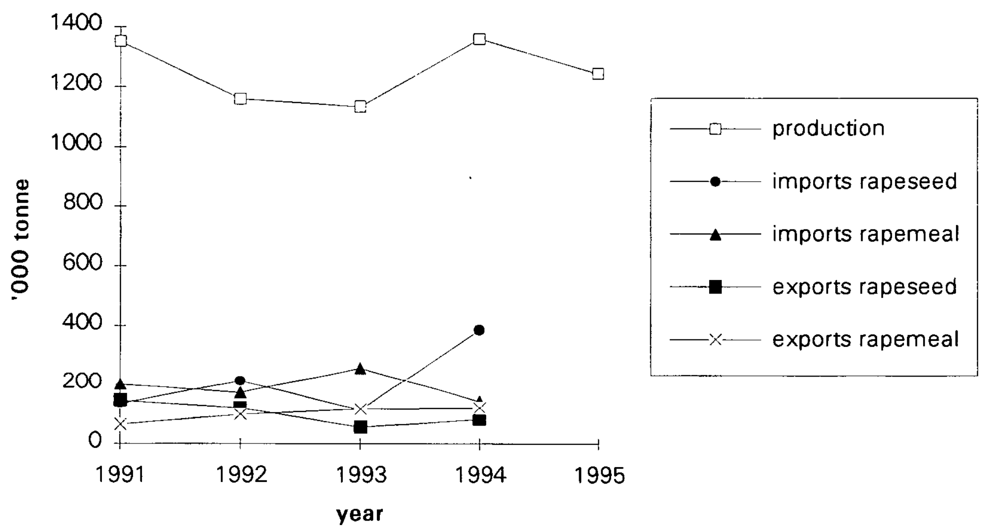


Figure 2.1 Tonnes of rapeseed produced, imported and exported from the UK - by calendar year. source: FAO, Dalgety/oil world

Figures based on a July 1st to June 30th year, however, show a definite trend (Table 2.4) of increased imports since 1993/94.

Table 2.4 Imports and exports of rapeseed to the UK ('000 tonnes)

	1993/4	1994/5	1995/6 est	1990/1 - 1994/5 average
imports	272	390	434	275
exports	43	71	71	110

Source: HGCA/MAFF

In addition, Table 2.5 shows that there has been a steady increase in the quantity of soy bean meal imported since 1991.

Table 2.5 Soya imports to the UK ('000 tonnes)

	1991	1992	1993	1994
soya bean seed	621	647	672	644
soya bean meal	1285	1298	1463	1586

Source: Dalgety/Oil World

The world-wide production of the major vegetable oils is likely to rise by 1% in 1995/96. This is a slower rate of increase than in the previous five years, but although consumption is declining, it is still above production, and consequently world stocks of vegetable oil will be at their lowest level since 1984/85.

2.3 Market prices

Table 2.6 shows the market price of rapemeal over a period of three years. Prices fluctuated between £136.50 and £200. Soya meal trades at a premium to rapemeal (of between 34 and 71%). This may be attributed to factors such as higher protein content, superior availability of amino acids and higher lysine content. The lower price of rapemeal may, however, give it a competitive advantage in some non-feed markets, if these nutritionally related factors are not important.

Table 2.6 Price of oilseed rapemeal and soya meal from June 1993 to June 1996

Date	£/tonne	
	rapemeal	soya
7/6/96	136	200
3/5/96	138	218
29/3/96	121	185
1/3/96	138	185
2/2/96	138	198
12/1/96	133	199
1/12/95	117	173.50
3/11/95	102	168
6/10/95	101	159
1/9/95	88	143
4/8/95	87	149
7/7/95	84	136.50
2/6/95	94	140.50
3/6/94	111	167
4/6/93	108	158.50

Source: SAC Weekly Economic Survey, SAC, Edinburgh.

CHAPTER 3 CHEMICAL COMPOSITION

3.1 General composition

Rapemeal consists mainly of protein and fibre, but also contains complex carbohydrates, minerals and vitamins. Table 3.1 provides more detail on the chemical composition of the meal.

Table 3.1 Composition of rapeseed meal

Component	Percentage composition		
	Combined data 1978 - 1983 (Bourdon & Aumaître, 1990)	**Bourdon & Aumaître(1990)**	**Bell & Keith (1991)**
Moisture	9.7	8.1	8.5
Crude protein (N x 6.25)	39.8	39.1	38.3
Ether extract	4.2	1.9	3.4
Ash	7.3	7.7	nd
Crude fibre	13.1	12.7	12.0
Neutral detergent fibre	30.5	28.2	21.5
Acid detergent fibre	23.3	20.5	17.5

Source: Bell, 1995

Anatomically, the meal consists of two major components: oil extracted embryos and hulls. The hull fraction accounts for approximately 16% (w/w) of the whole seed and 30% (w/w) of the meal . Rapeseed hulls contain much less protein and more fibre than the embryo fraction (Bell, 1995).

3.2 Energy content

The gross energy content of rapeseed meal varies slightly depending on the sample taken. Givens and Moss (1990) found the mean gross energy content of 17 samples to be 19.7 MJ/kg (S.D. - 0.35, min = 19.1, max = 20.5). This is the same figure as given for the energy content of sunflower seed meal, and very similar to the energy content given for soya bean meal (19.5 MJ/kg).

For use as an animal feed, digestible or metabolisable energy values are of more interest. The ruminant metabolisable energy of rapemeal and some other oilseeds, are given in Table 3.6.

Table 3.6 Ruminant digestible energy and metabolisable energy values for various protein feeds

	Mean Metabolisable Energy
rapeseed meal	12.0
cotton seed meal	11.1
soya bean meal	13.3
sunflower meal	9.6

Source: Givens and Moss 1990.

3.3 Protein content

3.3.1 Classification of proteins

Proteins can be classified in a number of ways, none of which are fully satisfactory (Goodwin and Mercer, 1983). For example they can be categorised with respect to their function, i.e. metabolic, structural and storage. Proteins must be brought into solution before they can be studied biochemically, and the steps required for this led to a classification system based on solubility characteristics, known as the Osborne classification system. This system was developed in the 1930s but is still commonly referred to today, although new analytical techniques have reduced the importance of solubility as a fundamental characteristic and it is difficult to place some proteins unequivocally in these groups. The categories are:

- Albumins water soluble
- Globulins soluble in salt solutions
- Glutelins soluble in dilute acids and alkalis
- Prolamins soluble in 70 - 90% aqueous ethanol

Seeds contain mixtures of different protein types, with the balance of protein make-up varying amongst different crop types. In general, more than half the proteins of a seed are storage proteins with no known catalytic function. The requirements of storage proteins as described by John (1992) are that they "must contain a relatively high ratio of N:C in a compact structure; react appropriately to desiccation when the seed dries and to rehydration when the seed germinates; maintain a stable structure in the dry state, and be readily broken down by protease action during seed germination". In crops grown for feed, the amino acid composition of the seed storage proteins, though perhaps being ideal for nutrient supply to the young plant, is often imbalanced in relation to the nutritional requirements of the animal, with lysine being most commonly deficient. When essential amino acids are deficient, utilisation of the dietary protein for synthesis of new tissue is limited and instead it is consumed as an energy source and the excess nitrogen excreted.

Table 3.2 which shows the protein composition of some cereals and legumes, in terms of the Osborne classification system.

Table 3.2 Protein composition of some cereals and legumes

Crop	Albumin	Globulin	Prolamin	Glutelin
Wheat	9	5	40	46
Maize	4	2	55	39
Rice	5	10	5	80
Oat	11	56	9	23
Pea	40	60	0	0
Soybean	30	70	0	0

Source Payne and Rhodes, 1982

3.3.2 Proteins of oilseed rapemeal

Uppström (1995) refers to the identification of three major classes of proteins in Brassica oilseeds: albumins, globulins and oleosins.

Albumins

The albumins include enzymes and other metabolic proteins, and account for a relatively small proportion of the total protein in rapemeal.

Globulins

Globulins are storage proteins and account for 70% of the protein in the mature seed. They are the major form of storage protein in dicotyledonous plants in general (see Table 4.2 - globulins represent 70% of the protein in soya meal) and tend not to be present in large quantities in cereals. A notable exception, however, are oats, where the major protein is a globulin. Globulins are nutritionally well balanced as their amino acids are present in similar proportions to the amino acids in animal protein, except for relatively low levels of the sulphur containing amino acids, methionine and cysteine.

Oilseed rape contains two classes of globulin proteins - napin and cruciferin. The napin class of storage globulins are small, basic proteins, whereas cruciferin is a large, neutral, oligomeric protein. Napin accounts for about 25% of the total seed protein and cruciferin accounts for 50% (Uppström, 1995)

Oleosin

Oleosin was first purified from rapeseed by Murphy and Cummins (1989) and can constitute up to 20% of the total seed protein. It is not clear exactly how oleosin fits into the Oswald classification system, but it is not soluble in water or salt solutions and is an apolipoprotein. Oleosin is thought to be structural protein, constituting part of the outer membrane of the oil bodies, and is also thought to provide binding sites for lipase during germination (Huang, 1992). Oleosin is not nitrogen rich, and is synthesised later than napin and cruciferin.

3.3.3 Extraction of proteins

In general the methods required to extract proteins are dependant on their solubility classification as described above. As the proteins of oilseed rapemeal are predominantly globulins, it should be possible to extract them with a salt solution. A study carried out to determine the optimum conditions for extraction and precipitation of protein from both laboratory defatted flour and industrially produced rapeseed meal (Girault, 1973) found that a 70% yield of the total nitrogen of laboratory defatted flour was obtained by extraction with a 10% NaCl solution. Extraction with 0.1 N NaOH increased the yield to 89%. This increase in yield was presumably as a result of the extraction of the oleosin fraction, which is insoluble in salt solutions. However, yields obtained with industrially extracted oilseed rapemeal were lower (only 63% of the total nitrogen was extracted with the alkali). Girault (1973) suggested that this difference in protein yield was due to heat denaturation of protein during industrial processing.

The maximum precipitation of the extracted protein was obtained at pH 3 for the Na Cl extract and pH 6.5 for the NaOH extract, although with fairly low yields are obtained (22 and 51% of protein nitrogen respectively) in both cases.

3.3.4 Industrial use

In terms of industrial use of proteins, two broad types of use can be identified: the use of catalyticaly active proteins i.e. enzymes, to mediate industrial processes, and the use of non-catalyticaly active proteins, which are, in general, utilised for their polymer characteristics. The later type of use is of most interest with respect to protein derived from oilseed meals. The potential for industrial use of proteins as polymers had already been recognised in the early part of this century, but the introduction of petrochemically derived products at low cost restricted development of protein based products. A major limitation in performance of many protein based products is their water sensitivity. However, use of proteins is well established in some markets such as use of gelatin in photographic emulsions, soy proteins in paper coatings and casein in adhesives.

3.4 Amino acid profiles

From an animal nutrition point of view, it is the amino acid profile, rather than the protein structure which is of primary interest. Amino acid composition may also be important for some non-feed uses described in Chapter 5, for example for use as a component of microbial culture media. Proteins are composed of 20 amino acids, which are listed, together with their standard abbreviations in Table 3.3. Table 3.4 shows the amino acid profile of rapeseed meal. There are a number of specific differences in the composition and hence the feeding value of rapeseed and soya bean meal. Soya bean meal contains more protein and lysine than rapeseed meal but is lower in the sulphur amino acids methionine and cysteine. The availability of amino acids in rapeseed meal is lower than the amino-acids in soya bean meal which results in a lowering of the digestible energy value.

Table 3.3 The amino acids of proteins (John 1992)

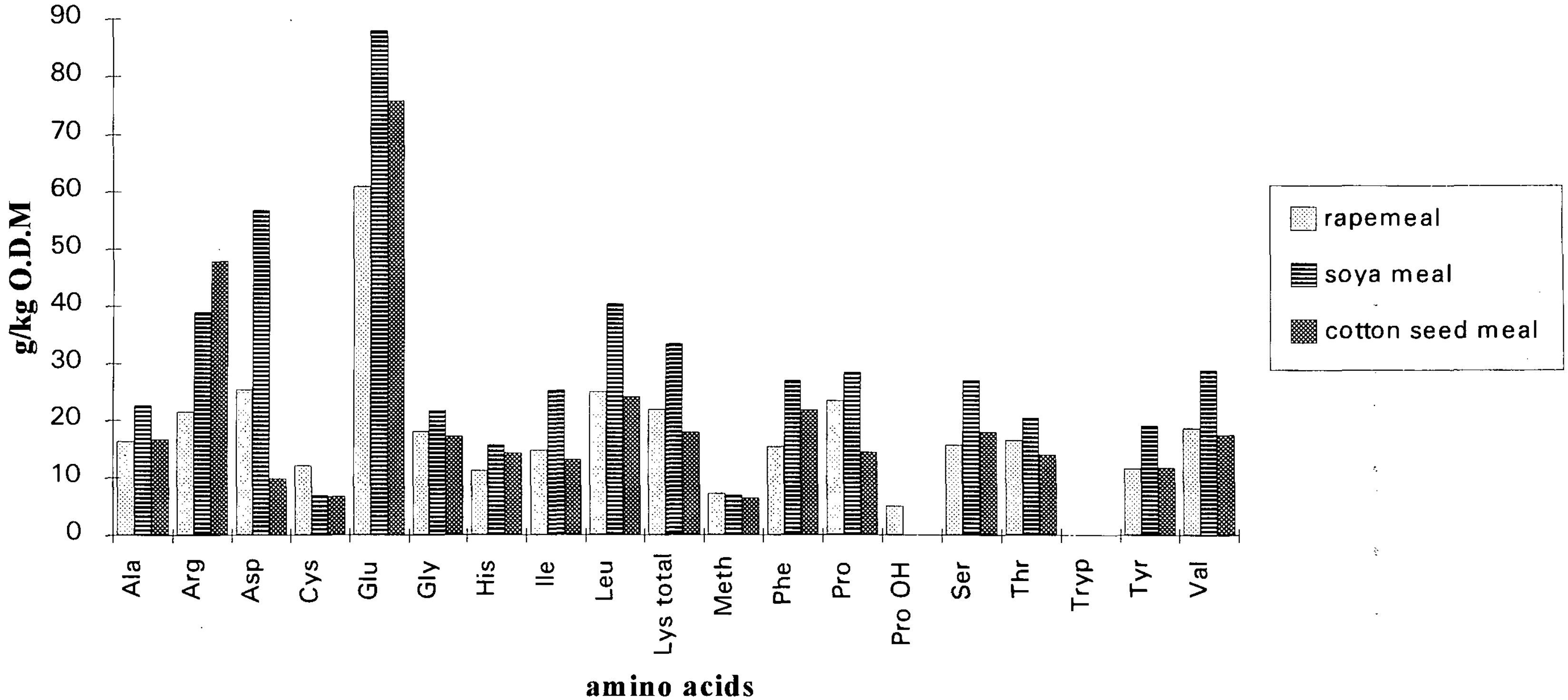
Non-essential	Essential
Glycine (gly)	Threonine (thr)
Serine (ser)	Lysine (lys)
Proline (pro)	Arginine (arg)
Cysteine (cys)	Histidine (his)
Aspartate (asp)	Valine (val)
Glutamate (glu)	Leucine (leu)
Asparagine (asp)	Isoleucine (ile)
Glutamine (gln)	Phenylalanine(phe)
Alanine (ala)	Tryptophan (trp)
Tyrosine (tyr)	Methionine (met)

Table 3.4 Amino acid profile of rapeseed meal (Givens and Moss, 1990)

Amino acid	g/kg Oven Dried Matter				
	mean	SD	Min	Max	n
Ala	16.4	0.45	15.6	16.8	8
Arg	21.5	2.0	19.0	24.2	8
Asp	25.4	1.6	23.5	27.4	8
Cys	12.1	4.4	8.2	18.9	8
Glu	60.9	3.0	56.1	64.8	8
Gly	18.1	0.98	16.3	19.3	8
His	11.2	0.78	9.6	12.2	8
Ile	14.8	2.5	11.3	17.9	8
Leu	25.1	1.5	22.6	27.5	8
Lys total	21.9	0.97	20.5	23.3	8
Meth	7.2	0.78	6.3	8.6	8
Phe	15.4	1.4	13.0	17.3	8
Pro	23.4	1.8	21.4	24.6	3
Pro.OH	5.0	1.4	3.8	6.5	3
Ser	15.7	0.62	14.8	16.6	8
Thr	16.5	0.98	14.9	17.8	8
Tryp					
Tyr	11.6	0.89	10.3	13	8
Val	18.7	2.2	15.9	22.0	8

The amino acid profile of rapemeal is plotted along side that of soybean meal and cotton meal in Figure 3.2.

Table 3.2 Amino acid composition of oilseed meals



Source: Givens and Moss, 1990.

3.5 Carbohydrate and fibre

Nearly half of the dry matter of rapeseed meal is carbohydrate. In a review Bell (1995) stated that rapeseed meal may contain up to 3% starch, 10% sucrose and 5% cellulose (Table 3.5), and that starch occurs at relatively high levels in immature seed but declines as the seed matures.

Table 3.5 Carbohydrate components and component carbohydrates of the non-starch polysaccharide fraction of moisture free oilseed rape meal.

Component	Percentage
Cellulose	4.9
Oligosaccharides[1]	2.5
Sucrose	7.7
Starch	2.5
Non-starch polysaccharides	17.9
Soluble	1.5
Insoluble	16.4
Non-starch polysaccharide components	
Rhamnose	0.2
Fucose	0.2
Arabinose	4.5
Xylose	1.6
Mannose	0.4
Galactose	1.7
Glucose[2]	5.0
Uronic acids	4.3

[1]Excludes sucrose, includes raffinose and stachyose [2]Includes glucose from celluloseSource: Bell, 1995.

Table 3.6 shows the starch, cellulose and lignin content of rapeseed meal in comparison to soya, sunflower and cottonseed meals. The levels of starch, cellulose and lignin presented in Table 3.6 (Givens and Moss, 1990) vary from those given by Bell (1995). However, the data presented by Givens and Moss are averages of a number of different samples, and the minimum and maximum values recorded fall into quite a wide range. For example, the levels of cellulose recorded in rapemeal vary from 7 - 22.9% of dry matter. Bell (1995) stated that variation in chemical composition of rapeseed meal occurs as a result of species of *Brassica*, cultivar, processing conditions in the crushing plant, soil type, weather and other environmental factors, and that these factors and their effects are poorly understood.

Table 3.6 Starch, cellulose and lignin content of oilseed meals

	% of dry matter		
	starch	**cellulose**	**lignin**
rapemeal	3.98	14	5.3
soya meal	2.39	4.5	1.36
sunflower	0.28	24.9	7.48
cottonseed	1.65	16.7	6.16

3.6 Glucosinolates

3.6.1 Occurrence

Glucosinlolates are sulphur containing compounds, that are responsible for the pungency of Brassicas, e.g. mustard, horseradish and radish, when crushed. Over 90 different glucosinolates are known. They have a uniform structure and vary in the nature of their side chain (R) (Fig. 3.3). There are three main types of glucosinolates: aliphatic, indole and aromatic.

```
        S - glucose
       /
R - C
      \\
        N - OSO3-
```

Figure 3.3 General structure of glucosinolates

Within the Cruciferae, glucosinolates have been found in virtually every species examined (Kjaer, 1973). Glucosinolates are present in all parts of the plant (Josefsson, 1967) but are found in high concentrations in the meal fraction of the seed. Large differences in the quantity and type of individual glucosinolates in different plant parts of various species has been reported by numerous workers (Josefsson, 1967; Kjaer, 1960).

3.6.2 Breakdown of glucosinolates

A characteristic feature of glucosinolates is that they co-exist in the plant with an enzyme called myrosinase. Following breakdown of the plant material in the presence of moisture, hydrolysis of the glucosinolates results in the production of an acid sulphate ion, free glucose and an aglucone intermediate. The aglucone is unstable and undergoes spontaneous degradation (Ettlinger and Lundeen, 1957) to yield a range of products (McGregor *et al.*, 1983). The structure of the parent glucosinolate and the conditions of hydrolysis influence the type of breakdown products formed.

The majority of glucosinolates produce stable isothiocyanates, which are the typical mustard oils (Benn, 1977), when hydrolysed at a neutral pH (Kjaer, 1960). Glucosinolates which contain a beta-hydroxy group in their side chain form an isothiocyanate which spontaneously cyclises to yield an oxazolidinethione (Tookey *et al.*, 1980), for example, the glucosinolate 2-hydroxy-but-3-enyl (progoitrin) breaks down to form an oxazolidinethione also known as goitrin. Hydrolysis of 3-indole-methyl glucosinolate (glucobrassicin) and N-methyl-3-indole-methyl glucosinolate (neoglucobrassicin) at neutral or alkaline conditions produce unstable isothiocyanates which breakdown to thiocyanates (McGregor, 1978). Nitriles may be formed when the hydrolysis takes place in weakly acidic conditions (Daxenbichler *et al.*, 1966; VanEtten *et al.*, 1966), or when ferrous ions are present (Tookey and Wolff, 1970).

3.6.3 Biocidal properties of glucosinolates

The breakdown products of glucosinolates are thought to be involved in the resistance of *Brassica* species to a number of fungal pathogens (Greenhalgh and Mitchell, 1976; Anon, 1984). The toxicity of isothiocyanates to fungi has been demonstrated in laboratory conditions (Drobinca *et al.*, 1967; Greenhalgh and Mitchell, 1976). However, not all glucosinolate products are fungitoxic. This is illustrated by the work of Mithen *et al.* (1986), who found that the breakdown products of the indole glucosinolates, 3-indole-methyl and 1-methoxy-3-indole-methyl, as well as prop-2-enyl and but-3-enyl were toxic towards *Leptosphearia maculans* (Phoma/stem canker), whereas the breakdown products of 2-hydroxy-but-3-enyl were not fungi-toxic. In addition, breakdown products may vary in their degree of fungitoxicity. Peterka and Schlosser (1989) found that the derivatives of but-3-enyl, prop-2-enyl and 2-phenyl-ethyl had strong anti-fungal effects with respect to *L. maculans*, whereas 2-hydroxy-but-3-enyl and 3-indole-methyl had a very small inhibitory effect. In further work, Mithen *et al.* (1987) also showed that the extent of fungal colonisation of *L.maculans* on leaves of Brassica species was inversely correlated to the amount of aliphatic glucosinolates (which often form isothiocyanates) in the plants, and accumulation of glucosinolates in tissue infected with *Alternaria brassicae* has been observed (Doughty *et al.*, 1991).

In addition to the anti-fungal effects described above, anti-microbial effects of glucosinolates have been recorded and again isothiocyanates seem to be important (Drobnica *et al.*, 1967). The presence of glucosinolates has also been shown to deter feeding by insects which are not pests of the Cruciferae (Nault and Styer, 1972), and several studies have shown that glucosinolates accumulate in plant tissue in response to attack by pests (Lammerink *et al.*, 1984; Koristas *et al.*, 1989; Birch *et al.*, 1990). This significance of this work has as yet been fully elusidated.

3.7 Minerals and trace elements

Table 3.7 shows the quantities of minerals found in rapeseed and soya meal.

	g/kg oven dried matter	
Minerals	**rapeseed meal**	**soya meal**
Ca	8.4	3.9
Mg	4.4	3.0
Na	0.41	0.16
K	14.3	25.0
Cl	0.10	0.10
P total	11.3	7.4
P inorganic	0.72	0.66
Fe	0.24	0.18
S	16.9	4.6

source: Givens and Moss (1990)

It can be seen that the rapeseed meal tested contained higher levels of most minerals (with the exception of K) than soya meal.

Table 3.8 shows the quantities of some trace elements found in rapemeal and soya meal. It can be seen that there is some variation in the levels of various trace elements found in rapemeal as compared to soyameal. The soya samples tested were found to be higher in Co, Mo, Cu and Se, whereas rapemeal had higher levels of Mn and Zn.

Table 3.8 Quantities of trace elements found in rapeseed and soya meal

Element	mg/kg oven dried matter rapemeal	soya meal
Co	0.16	0.24
Mn	54.5	37.6
Mo	1.0	4.0
Zn	81.5	49.0
Cu	6.1	15.8
Se	0.14	0.3

source: Givens and Moss (1990)

3.8 Other components

Rapeseed meal contains about 1.5% **tannins** (polyphenolic compounds) and a variety of **phenolic compounds**, the most abundant of which is sinapic acid (Bell, 1995). Eighty percent of the total phenolics occur in an esterified form, in the embryo fraction of the meal; 15% occur as free phenolic acids and 5% occur in the form of insoluble bound phenolics. Levels of sinapine in rapeseed meal are reported to be in the range of 0.7 - 3.0%, 90% of which occurs in the embryo. Sinapine has a bitter taste and may be important with respect to palatability, although glucosinolates have been found to have a greater effect (Lee et al., 1984, quoted in Bell, 1995). High levels of sinapine in meal fed to hens may also cause tainting in eggs under certain conditions (Bell, 1995).

Levels of **saponins** in rapeseed meal have been found to range from 0.62 - 2.85 % (March and Sadiq, 1974, quoted in Bell, 1995). It has been suggested that saponins may have potential uses as a molluscide or foaming agent (Fleming and Galwey, 1995), but further work would be required to determine whether the levels occurring in rapemeal could be extracted economically.

Rapeseed meal contains 2 - 5% **phytic acid** ($C_6H_{18}O_{24}P_6$) (Nwokolo and Bragg, 1977 quoted in Bell, 1995), and this compound may account for 60 - 90% of the total phosphorus. With respect to feed use, mineral availability is adversely affected by ingestion of phytates by non-ruminant animals, however Bell (1995) states that despite substantial literature on the nature and nutritional implications of phytates, no clear understanding of the effect has emerged.

CHAPTER 4 CURRENT USE OF RAPEMEAL

Rapeseed meal is currently utilised as a source of protein for inclusion in animal feeds and, as such, competes directly with soya meal. The amount of rapeseed meal used in the animal feed is restricted due to the presence of a number of anti-nutritive compounds, of which glucosinolates are the most important (Hill, 1979; Thomke, 1981; Fenwick, 1982). Glucosinolates cause a range of deleterious effects when fed to animals (Fenwick *et al.*, 1983), and the EU has encouraged the production of low glucosinolate meal. Under EU regulations, in order to obtain area payment supports, farmers must sow purchased oilseed rape varieties which are registered as containing less than 20μM glucosinolates g^{-1} seed (about 5 g/kg seed). The development by plant breeders of double low rapeseed varieties has been a major achievement in improvement of the feeding value of rapeseed meal. High glucosinolate cultivars can have glucosinolates contents of about 100 - 120 μM/g (Acamovic, in press).

Rapeseed meal has an amino acid balance which is well matched to that required by the growing pig (Partridge *et al.*,1987), but a major problem which has been encountered is palatability. Glucosinolates were identified as the most likely causative factors (Lee *et al.*, 1980) due to the pungent nature of their breakdown products (Fenwick, 1982). Better palatability has been noted for low glucosinolate meal compared to high glucosinolate meal (McKinnon and Bowland, 1979; Lee and Hill 1983). As a consequence of these anti-nutritive effects, the amount which can be fed to pigs for optimum performance is restricted.

However increases in thyroid size (Rundgren, 1983) and in liver weight (Thomke, 1984) in pigs, associated with feeding rapeseed meal, were limited by feeding meal from low glucosinolate varieties compared to meal from high glucosinolate varieties. Some detrimental effects on reproductive performance in sows have been reported from feeding high glucosinolate meal, but no harmful effects were noted for meal from seed of less than 35μMg^{-1} seed (Edwards and Gill, 1990). Rundgren (1983) and Thomke (1984) reported that feeding 10% of the sow's diet as low glucosinolate meal did not influence reproductive performance. Current recommendations for incorporation rates are that rapemeal should not be included in the diet of weaner pigs, and incorporation should not exceed 35 g/kg for growing pigs and 75 g/kg in finishing pigs. Rapemeal may be included at rates of up to 25 g/kg in sow diets (Acamovic, in press)

Feed intake in poultry is seldom limited by taste or smell (Hill, 1979) so lack of palatability of rapeseed meal is not a problem. Liver haemorrhage, resulting in death, has been noted as a serious consequence of feeding rapeseed meal to poultry (Jackson, 1969; Hill. 1979; Fenwick and Curtis, 1980). This has been ascribed to glucosinolates (Papas *et al.*, 1979). Campbell (1987) found that liver haemorrhage was more likely with a diet containing 24 μMg^{-1} rapeseed meal than a diet containing 5 μMg^{-1} rapeseed meal. For poultry the following inclusion rates of double low rapeseed meal are currently recommended (Acamovic, pers. comm., 1996):

- layers 0 g/kg
- broiler starters and growers 20 - 50 g/kg
- chick starter and growers 50 - 100 g/kg

Ruminants were not thought to be affected by the presence of glucosinolates in feed until 1973 when Iwarsso *et al.* (1973) reported goitrogenic effects in growing bulls fed rapeseed meal. Meal from a low glucosinolate variety was shown to be more palatable resulting in a higher intake for calves than meal from a high glucosinolate variety (Stedman and Hill, 1987). A review by Thomke (1981) indicated that milk yield and feed efficiency in cows were not affected by including up to 10% of high glucosinolate rapeseed meal, and that low glucosinolate rapeseed meal, containing less than

20 μMg^{-1} seed could be included up to 25%. This figure related to glucosinolates measured under the Canadian standards at the time, which did not include all of the glucosinolates found in rapeseed[1]. Therefore, meal from rapeseed containing a total of this level of glucosinolates could be included at a higher percentage.

[1] Only aliphatic glucosinolates were included.

CHAPTER 5 LOW VALUE MARKETS

Potential uses for oilseed rape meal have been identified and placed into three main categories. Those markets for which oilseeed rapemeal would currently have to be sold at below its market price, those markets for which rapemeal is likely to fetch its current market price, and markets which require long term investment in R&D for their development. This chapter assess uses for which rapemeal would currently have to be sold at below market price.

5.1 Animal bedding

For this type of use rapemeal would be competing with sawdust which is available to farmers for £21/tonne or £29/tonne delivered, i.e. well below the market price of rapeseed meal. If rapemeal were to be used for dairy cow or chicken bedding, measures would obviously have to be taken to prevent the animals from eating the meal, in order to satisfy the conditions of the Blair house agreement. One option may be treatment with Bittrex.

Due to the low price which could be achieved for meal in this market, it would not be of interest unless no other higher value uses were possible.

5.2 Fuel use

The potential for rapemeal as a fuel can be considered at two different levels: use for domestic heating or other small scale uses, and larger scale use for electricity production, district heating or combined heat and power production.

5.2.1 Energy content

The energy content of rapemeal is quite similar to wood. Table 5.1 shows the energy value of rapemeal in comparison to other solid fuels. The table indicates that rapemeal has a relatively good energy content. It is lower than coal, but higher than peat or straw. However, although rapemeal is similar in energy content to wood, it is quite different in composition. Wood is a mixture of cellulose, hemicellulose and lignin in a ratio of 50:25:25. In contrast, the major component of rapemeal is protein (approximately 45%) and nitrogen free extract (32.5%). These components are virtually absent from most woods.

Table 5.1 Energy value of rapemeal and other solid fuels

fuel	**energy value (MJ/kg)**
coal[2]	31.4
rapemeal[1]	22.5
wood[1]	20
peat[2]	17.5
straw[2]	13.8

[1]Peterson *et al.* (1990); [2]SAC Farm Management Handbook, 1995/96

5.2.2 Rapemeal as a fuel for domestic stoves

Peterson *et al.* (1988) considered that developments in the home heating industry such as the introduction of pellet burning stoves enhanced prospects for use of non-conventional fuels because of the additional control over the combustion processes that they afford. Unprocessed rapemeal was not suitable for fuel use because incomplete combustion is likely. Pelleted rapemeal, however, is easier to handle and its use in domestic pellet burning stoves has been investigated. The study, conducted in the US, determined the fuel characteristics of rapemeal pellets, a mixture of rapemeal pellets and wood pellets and pellets composed of a blend of rapemeal and wood (Peterson *et al.*, 1990). Table 5.2 shows the properties of the fuel pellets. It can be seen that the rapemeal pellets had the highest heat of combustion of all the pellet types tested, but also had a high ash content, moisture and sulphur content in comparison to the wood pellets tested.

Table 5.2 Fuel properties

Characteristic	Wood pellets	Rapeseed meal pellets	Blended pellets	Pellet mix
Density, kg/m^3	639	664	637	664
Moisture content %	5.5	7.6	6.0	6.8
Heat of combustion kJ/g	19.2	20.8	20.2	20.2
Ash content %	0.2	7.52	3.77	4.59
Sulphur %	0.02	1.18	0.72	0.72
Carbon %	47.55	46.54	46.94	46.94
Hydrogen %	6.75	7.48	7.19	7.19

Source: Peterson *et al.* (1990)

Although the rapemeal pellets had an 8% advantage in energy content over wood pellets their physical characteristics were found to be inferior. Rapemeal pellets produced in an agricultural pelleting facility were noticeably softer than wood based pellets. The pellets could, however, be burnt in a conventional stove and although the particulate emissions recorded for rapemeal pellets were higher than those from wood pellets[2] they were well within the regulations for Oregon state. Problems of the rapemeal pellets included higher and less controllable burn rates, lower combustion efficiency (Table 5.3) and the formation of deposits which interfered with the flow of combustion air. The burning of a mixture of rape pellets and meal pellets was found to be feasible and deposit formations were less of a problem but the best results were obtained with pellets produced from a blend of meal and wood. Emissions from the blended-pellets were low and deposit formations acceptable.

[2]particulate emissions are related to sulphur content. The higher sulphur content of the rapemeal pellets is likely to be responsible for the higher level of particulate emissions.

Table 5.3 Combustion efficiency of rapemeal and wood.

	Combustion efficiency (% CO converted to CO_2)	
	wood	rapemeal
Low feed rate	95	88
Medium feed rate	97	94
High feed rate	94	95

Source: Peterson *et al.* (1990)

5.2.3 Solid fuel for industry

Rapemeal may have potential as a solid fuel for industrial processes. For example cement kilns can potentially burn a wide range of materials in addition to traditional fuels such as coal, oil and gas and therefore, this and any other similar industrial uses could be an outlet for rapeseed meal. Alternative fuels that have been considered to date for use in fuelling cement kilns include liquid and solid wastes. The cost of these fuels is likely to be restricted to the cost of uplifting and transporting the material. Rapemeal may produce lower levels of polluting emissions than some other "waste" fuels and may therefore be valued higher, but at best this may only be a very cheap market for the meal, and at worst may simply be a means of disposal without any market returns.

5.2.4 Large scale fuel use

Although biomass is used to fuel district heating systems in some countries, notably Sweden and Denmark, in the UK the infrastructure for this use has not been developed. It is interesting to note the case of a Swedish municipal utility in Stockholm, which in 1992 decided to switch from coal to a mixture of biomass pellets and low sulphur oil in one of its 4 district heating systems. Biomass pellets were used (rather than, for example, woodchips) because they resemble coal in physical characteristics allowing existing plant infrastructure to be used. The plant originally used wood pellets, but switched to olive stones (imported from Spain and Tunisia) because they were 30 - 40 % cheaper than the wood pellets, even though this use caused some problems in terms of deposits.

5.2.5 Value of rapemeal as a fuel

The monetary value of rapemeal as a fuel can be estimated from prices and energy content of other fuels. Of the fuels listed in Table 5.1, coal has the highest calorific value and the highest retail value. Grade B coal is retailed at around £108/tonne. This is equivalent to 0.344 p/MJ. If the value of oil seed rapemeal is calculated on the basis of 0.344 p/MJ, it would have a retail value of £77.40/tonne. This is, however, an optimistic estimate of its value as a fuel as handling characteristics could be expected to reduce the figure..

The retail value of peat or wood per MJ is lower at around 0.257 p/kg. Calculating the value of rapemeal as a fuel on this basis gives a lower value of £58/tonne. In practice, oilseed rapemeal may be valued at a figure slightly lower than this, giving a retail value well below the current market price for rapemeal (see Table 2.6).

5.2.6 Conclusions for fuel use

Rapemeal has a good energy content in comparison to other solid fuels and can be processed into a fuel that performs well and is easy to handle. However, the price obtained for rapeseed meal as a fuel is likely to be well below the market price for rapemeal. The fuel would have to be available to domestic consumers at a price in the region of £55 - 60/tonne. If the meal was sold directly by the crushers, the price obtained may be close to this but, if an intermediate processor (for pelleting) and distributor was involved, the price obtained for the meal would be significantly lower.

The best option in terms of price per tonne for fuel use would be to market the meal in the domestic heating market but larger quantities of the meal could potentially be used for district heating or power generation. The Swedish example described above (see section 5.3.4) used 30 000 t of wood pellets in a year. Use of an equal quantity of rapemeal pellets could account for around a fifth of the rapemeal produced in the UK from set-aside in 1995.

5.3 Composts

5.3.1 Peat substitutes

The most important ingredient of horticultural composts is peat. Annual consumption in the UK has been estimated at 2 - 3 million m^3. However, environmental concerns with respect to the degradation of peat bog habitats has resulted in the development of alternative "peat free" composts and plant growing media.

The best opportunities for peat free composts may be in the domestic/amateur sector as for commercial production, hydroponic type media have increased in popularity for glass house production, and peat is likely to remain highly desirable for nursery stock as it is reliable and consistent (Doble *et al.*, 1995). Alternative products that have been developed include coir, bark and waste paper based composts as well as products based on blends of hop waste and coir, or coir and straw. Table 5.4 gives the technical properties of a coir product, and some comparable information for oilseed rapemeal. The limited amount of comparable data available for coir and rapemeal indicates that the two materials vary considerably in their composition. The water holding capacity of coir is 4 times that of rapemeal, and coir contains a much higher percentage of cellulose and lignin.

Table 5.4 Technical properties of coir

property	wetted up coir material	rapemeal (where information available)
Water holding capacity (of dry weight)	8 - 9 times	2 times (see)
Air filled porosity (v/v %)	10 - 12	
Electrical Conductivity (mS/cm) Max	250	
Cationic exchange capacity	60 - 130	
Total organic matter (w/w, dry basis %)	94 - 98	
Organic carbon (w/w, dry basis %)	45 - 50	
Cellulose (w/w dry basis %)	20 - 30	5% (Bell, 1995)
Carbon:nitrogen ratio	80:1	
pH	5.4 - 6.8	
Ash (dry basis)	3 - 6	7.3 - 7.7 % (Bell,1995)
Lignin (w/w, dry basis)	65 - 70	5.3 % Givens and Moss (1990)
Colour (w/w dry basis %)	light to dark brown	
Total pore space (v/v %)	94 - 96	
Appearance	Earthen granular and some short fibres	

Source: product information "Pete's Coco Peat", the Netherlands

5.3.2 Market prices for composts

Table 5.5 shows the bulk and retail prices of peat, peat based products and some peat alternatives. There is a large degree of variation in the retail price of composts. Although when first introduced peat-free composts were priced at a premium to the conventional peat-based product, competition within this sector seems to have increased and now peat-free and peat-based products are priced competitively.

Table 5.5 Prices for peat, peat based products and peat free products

Product	price (£/m^3)		
	bulk(delivered)	wholesale	retail
Peat	*12.00 - 15.00		
Coir	*21.00 - 40.00		
Bark	*20.00 - 30.00		
Coir/straw compost	*16.00		
Hop waste/coir compost	*9.50		
Waste paper compost	*8.00		
Peat		*15 - 25	
General purpose composts		*30 - 45	
Peat			*45 - 75
general purpose composts - peat based and peat free			*70 - 100
Coco husk based garden mulch/ organic fertiliser/soil conditioner			115

source: *Doble *et al.*, 1995.

As part of a feasibility study of anaerobic digestion of wastes, Doble *et al* (1995) concluded that the wholesale value of peat free composted material would be approximately £15/m^3, but considered that the value of the product could be enhanced considerably if bagging and marketing operations were added to the project. Interpretation of this value in terms of £/tonne of rapemeal is difficult as some practical work would be required to determine the density of a rapemeal based composted material. However, the information given in table 5.6, for peat classification may give some rough guidance.

Table 5.6 Peat classification

Peat type	Degree of decomposition*	Bulk density (kg/m3)	total water capacity (ml/100g dry matter)
1	H2/3	<75	>750
2	H3/5	<105	>500
3	H6/7	<135	>400

source: Sinclair.
* Von Post scale of 1 - 10: 1 represents mosses.which have not decomposed and have all there structure intact. 10 represents the opposite extreme where all the structure has been broken.

5.3.3 Conclusion for composts

Rapemeal is quite different in composition to other materials used as a base for peat-free composts. Consequently, some practical work would be required to assess its performance on composting.

5.4 Seed coatings and bait pellets

It is logical to consider the potential of a meal derived from seeds as a suitable material for coating other seeds although no specific references on the use of rapemeal have been identified in the literature.

Pelleted seed is commonly utilised for high value row crops such as sugar beet and vegetables. This has the combined advantage of creating a uniform size of seed pellet suitable for precision seeders and providing physical protection of the seed during the critical germination stage. The pellets are also carriers of nutrients and fungicides. A range of clays are used for sugar beet pellets but given the potential of rapemeal as a slow release fertiliser there is a case for examining its suitability.

Carriers are also used for legumes in order to retain the microbial inoculum. MicroBio, Cambridge, use sterilised peat as the carrier for their rhizobium inoculant. Important factors in considering rapemeal as an alternative would be water retention, effect on the inoculum and other soil organisms and the ability to provide a fine powder formulation (Potter, pers. comm., 1995). It is worth noting that meal from existing hexane extraction crushing plants occurs as a fine powder.

Organic carriers with some feed value are also used for products such as slug pellets and rat poisons. However, experience in using oats as a possible rat bait suggests that the EU would regard this as a food use.

5.5 Conclusions

It is not recommended that priority be given, in the near term, to development of the uses described in this chapter. Although some of the markets such as burning are attractive in terms of the quantity of meal that could be disposed of, prices obtained for the meal are likely to be well below the current market price and other uses, for which meal may be competitive at its current market price, have been identified (see chapter 6). However, should the quantities of rapemeal for industrial use exceed those which can be accommodated by higher value markets, it may be necessary to consider some of the uses described in this chapter. Some consideration of the steps that would be required to facilitate this is therefore given below.

5.6 Research and development required to create a possible market

In order to create a market for rapemeal as a domestic fuel, some product development work would be required. Previous research has indicated that pellets composed of a blend of wood and rapemeal perform well, and optimisation and demonstration of this type of pelleted product may be the best route to development of the domestic fuel market. However, the potential market size for this type of speciality product within the UK is not clear and market research would be advisable prior to any further investment in product development. The steps required for the use of rapemeal as a fuel for power generation, however, must come in the form of government support to put in place the infrastructure required for the use of biomass as a fuel.

In order to create a market for rapemeal as an animal bedding, a method would have to be found to prevent the animals from eating the meal. In fact for all markets where meal was sold below the current market price, treatment by the crusher, to ensure that it was not used for feed would almost certainly be required.

CHAPTER 6 POTENTIAL USES FOR THE NEAR TERM

This chapter includes uses which have been developed for rapemeal or for similar materials such as soya meal outwith the UK, and which may therefore require a relatively low level of investment for their development, as well as novel uses for oilseed meal.

6.1 Fertiliser

One of the few commercial applications of rapemeal already established is use as a fertiliser.

6.1.1 Examples of use as fertiliser

- Although this use has generally not been established in Europe, ancient Chinese texts, dating from as early as 3000 BC, mention the potential of rapemeal as a fertiliser (Johnson *et al.*, 1992) and in China today, ploughing in of rapemeal to aid crop growth is a well established and widely adopted practice (Mithen pers. comm 1995). This custom is understood to have been developed as a means of usefully disposing of the meal, as in China the value of rapemeal as a livestock feed may not have initially been recognised (Guttridge pers. comm 1995). A recent report (Shi and Shi, 1995) describes the addition of rapemeal to a number of other substances including cytokinin, sheep faeces, bone meal, calcium superphosphate, urea, boric acid, ammonium phosphate and adhesive, to produce a cheap source of plant nutrients.

- Use as a fertiliser has also been reported in Japan where specific rapemeal based fertilisers are marketed (Gutteridge, Cargill, pers comm. 1995). Quantities in excess of 500,000 tonnes are used annually, with use on tea plantations as a prime market. Shirai *et al.*, 1992 found that growth of young tea plants was improved by treatment with organic fertiliser which included rapemeal, as compared to standard inorganic fertiliser.

- One report points to use of rapemeal in Romania where organic wastes including slaughterhouse waste, crude gelatins, and defatted oilseeds are hydrolysed to produce a concentrate which is added to ammonium phosphate, and applied as fertiliser (Borlan *et al.*, 1993).

- In Canada, an Alberta based company, CIC Organics, manufacture a fertiliser product under the name Soil Doctor (Appendix I), which uses oilseed rapemeal as a base. Soil Doctor is marketed for use on fine turf, for example lawns and golf courses.

6.1.2 Value as fertiliser

The nutrient and monetary values of rapemeal as a fertiliser, on a fresh weight basis, were calculated from information given Table 6.1, and are presented in Table 6.2.

Table 6.1 Mean composition of oilseed rapemeal

Component	mean % of meal
Dry matter	90
Crude Protein	40
Total Phosphorus	1.13
Total Potassium	1.43
Total Sulphur	1.69

Source: Givens and Moss, 1990

Table 6.2 Fertiliser value of oilseed rape meal

Nutrient	content (%)	Value* (£/t)
Nitrogen N	5.76	21.31
Phosphate P_2O_5	2.9	11.02
Potash K_2O	1.9	4.37
Sulphur SO_3	4.7	4.23
Total		45.89

*Calculated from a price of 37p/kg for N, 38p/kg for P_2O_5 and 23p/kg for K_2O (SAC Farm Management Handbook, 1996) and 9p/kg for SO_4.

Chris Dawson and Associates, consultants with extensive experience of the fertiliser industry, considered that these figures confirm the theoretical potential of rapemeal as a speciality fertiliser (pers. comm. 1995), but the value of rapemeal as calculated directly from the nutrient content is less than half the current market price for the meal. A key factor in determining the suitability and value of rapemeal as a source of nutrients, however, is the mobility and availability of the nutrients, and the slow release quality of rapemeal as a fertiliser has been used in the marketing of the Canadian product Soil Doctor. The NPK composition of a typical Soil Doctor formulation is approximately 6:2:6 and in Canada it has a selling price of $410 Cdn/t (approx £200). Sixty-five percent of the product is rapemeal and therefore the cost of the meal component of Soil Doctor (calculated from the Canadian rapemeal market price of $196 Cdn/t, approx. £95.61, as of January 1996) is $127 Cdn/t (approx £61.95). The difference of $283 (approx -£138) is taken up by the cost of additives, processing and packaging but obviously leaves a viable margin to cover marketing costs and profit.

6.1.3 Market opportunities

In principle the rapemeal could fit into one or more of three fertiliser product categories:

(i) Rapemeal as an accredited organic fertiliser

Organic farming in the UK is regulated by a small number of organisations which operate certification schemes, the most important of which is the Soil Association. In order to retain their organic status, farmers may only use products which have been certified by the Soil Association as organic. It has been indicated unofficially that rapemeal would be likely to qualify as an organic fertiliser if it was entered to the certification scheme, despite the fact that inorganic chemicals and pesticides are used in the production of oilseed rape.

(ii) Organically based fertilisers to which mineral components are added

In the UK, a range of granular organic based fertilisers are marketed for use on arable crops and grassland under the HumberPalmers trademark, by Sheppy Fertilisers Limited of Kent (Appendix II). These products are based on lignite with proprietary mineral additives supplementing the nutrient levels. Nitrates are not added to the products.

Although the HumberPalmers fertiliser range are not deemed to be organic by the Soil Association due to the mineral additives, they command a premium price on account of the release efficiency of nutrients compared with that of conventional mineral fertilisers. The company claim that their organic based fertilisers can generate around 25% higher take up of plant food nutrients than mineral fertilisers.

The market for organic based fertilisers is relatively small in the UK, but in some European markets, for example in Italy, it accounts for up to 10% of the agricultural fertiliser market.

Sheppy have examined rapemeal as an alternative base but found that the high carbon content inhibited the release of mineral nutrients to an unsuitable extent (Moon, pers. comm, 1995). Nonetheless there is scope for further evaluation.

(iii) Slow release fertilisers for specialist use.

The Canadian product Soil Doctor (see section 6.1.1) falls into this category. The product is based on a w/w content of approximately 65% Canola[3] meal which is fortified with proprietary components and is marketed for use on fine turf such as lawns and golf courses.

Measurements taken on weight of foliage clippings over the season show an initial disadvantage compared with mineral fertilisers but as the season progresses, it is claimed that Soil Doctor outperforms mineral alternatives. The product is also claimed to perform better than other organically based products which are enhanced with synthetic additives, and is promoted with very positive claims such as:

- slow release properties
- no scorch of grass
- favourable to soil structure
- safe to children and pets
- not harmful towards beneficial soil microorganisms

Agricultural fertilisers contain too much nitrogen for the amenity market as production of maximum grass yields is not an objective of, for example, golf course management

[3]In Canada, double low oilseed rape varieties are marketed under the name "Canola".

and fast growth is undesirable. The primary objective for the application of fertiliser to golf greens, and other amenity grass is to thicken up the swards. Golf course managers, unlike farmers, do not select their fertiliser simply on the basis of price. Products marketed specifically for this sector therefore have lower N contents than agricultural fertilisers and slow release is particularly important where continued use demands constant replenishment of green foliage.

An example of mineral fertilisers which have been marketed for this sector is the Greenmaster Fine Turf Fertiliser range produced by Fisons. Three products in this range include turf tonic (7:0:0), sold as a spring starter and summer tonic feed; zero phosphate (14:0:7), a phosphate free spring and summer feed and "spring and summer" (14:2:4), designed for spring and summer use on fine turf. In comparison a typical nutrient composition for Soil Doctor is 6:2:6. Fisons did produce a series of organic fertilisers, which were based on chicken manures, for a few years but ceased production. The enterprise was unsuccessful largely because of the high price, and poor marketing. Marketing is very important in this sector.

Golf course management

Golf courses are important users of speciality slow release products. A major factor influencing golf course management in recent years has been the increased television coverage. This has focused attention on the appearance of all golf courses, as members of even relatively small golf clubs now expect their course to resemble what they have seen on television (Gray, pers comm, 1996). As a result it has become fashionable to maintain the greenness of golf greens all year round, whereas in the past presentation was not considered so important. This trend, combined with the steadily increasing number of golf courses in the UK, is likely to result in increased demand for products specifically for the amenity market.

There has been an increase in the area of land devoted to golf courses, which is expected to continue, for a number of reasons, some of which are listed below.

- More women are taking up the game than in the past, although many golf clubs still have restrictive rules which limit the number of women playing.
- Retired people represent an increasing proportion of the population, and golf is a game that can be played into old age
- People are retiring earlier and are fitter for longer
- There has been an increase in disposable income

This increase in the popularity of golf is not restricted to the UK but can also be seen in other European Countries. Golf course developments in other countries often look to the UK for management and may subsequently look to the UK for products.

Table 6.3 shows the number of golf courses in the UK in 1992. From these figures it can be calculated that the total number of golf holes in the UK in 1992 was approximately 35 271. It is estimated that the number of golf holes may have increased by 5% since 1992 giving a total of 37 035 holes (Gray, pers. comm., 1996).

There is an established demand for speciality products for greens but there is also increasing interest in management for tees and fairways. Management of fairways, however, may be of less importance to the speciality fertiliser market than the other areas of the course as rates of application are much lower for fairways than for other areas, and agricultural fertilisers are in some cases used due to their lower cost.

Another trend emerging in golf course management is the creation of transitional areas leaving the fairway. The areas of, and rates of fertiliser application to, individual greens, tees, fairways and transition areas varies. However, estimates of typical areas and fertiliser application rates are shown in Table 6.4.

Table 6.3 Number of golf courses listed in "Golf course guide to Britain and Ireland" (D.Steel, 10th edition, 1992)

	Courses					
	All	9 hole	18 hole	27 hole	36 hole	larger
England	1 490	324	1 042	74	42	8
Wales	130	44	82	1	3	0
Scotland	412	115	272	6	13	6
N.Ireland	60	15	40	2	2	1
UK	2 092	498	1 436	83	60	15

Table 6.4 Maximum N requirement for golf greens, tees and transition areas in the UK (based on current areas)

Part of course	Approximate area per green (m^2)	Total UK area (ha)	Rate of N application (kg/ha/year)	Approx N requirement for UK golf courses (kg)
Greens	400	1481.4	160	237 024
Tees	400	1481.4	107	158 510
Transition between green and fairway	500	1851.75	160	296 280

The total N requirement calculated for greens, tees and transition areas of golf courses in the UK is calculated to be 489 858 kg. This quantity of N could be supplied by 12 011 t of rapemeal, or 7 495 t of meal in the form of the product Soil Doctor (Table 6.5).

Table 6.5 Potential market for rapemeal as a golf course fertiliser or component of golf course fertiliser.

	Approximate total UK area (ha)	Maximum N requirement (kg)	Quantity of meal required for N (t)	Quantity of meal used as Soil Doctor (t)
Greens	1481.4	237 024	3 342	2 568
Tees	1481.4.	158 510	2 235	1 718
Transition area (fairways to greens)	1851.8	296 280	4 178	3 210
Total	4814.6	489 858	8 919	6 854

The Soil Doctor product is not aimed solely at golf courses. It is also marketed for use on domestic lawns, and could be used on other amenity grass such as football pitches, tennis courts and bowling greens. The total N requirement of the sector within which soil doctor is marketed may therefore be greater than that indicated in Table 6.5.

6.1.4 R&D for improved performance

Literature reports on research into fertiliser uses are mainly from Japan.

Greater nitrogen availability has been achieved by scientists in Japan by fermenting the oilseed meal in three stages (Murata and Sugimoto, 1993). The first stage is done in the presence of a filamentous fungus and cellulose degrading micro-organisms. Fermentation then continues with micro-organisms such as *Actinomyces* to degrade the proteins, and then the process is terminated by altering the pH. The oilseed meal is degraded down to the amino acids, phytic acid and other nutrients.

Another use of the meal has been as a fermentation promoting agent in the Kyushu area of Japan (Nakayama and Yamashita, 1975). Rice straw is a major source of compost for tobacco cultivation and the addition of meal together with rice bran, lime and chemical fertilisers improves the rate of breakdown and nutrient availability.

One problem of using rapemeal is reported to be the unpleasant odour. A product marketed in Japan containing metal adsorbents is reported to have reduced the problem (Nisshin Oil Mills). The composition was rapemeal: 89%, China clay 10% and iron powder 1% w/w. When added to soil and watered twice a day for 30 days, hardly any odour was detected.

6.1.5 Conclusions

Use of rapemeal as a speciality fertiliser appears to be a promising market in which rapemeal is likely to fetch its market price. The evaluation of rapeseed based slow release fertilisers under UK conditions should be given priority.

6.2 Use as a component of microbial culture media

Microbial culture media are required in relatively small quantities by research scientists and are used in larger quantities in industry for the production of antibiotics, enzymes and chemicals by fermentation.

6.2.1 Types of culture media

Culture media for micro-organisms must provide a balanced mixture of the required nutrients at concentrations that will permit good growth.

In general, culture media are composed of minerals, a carbon source, an energy source, a nitrogen source and any required growth factors. The precise requirements vary depending on the organism to be grown[4]. A growth medium may be composed entirely of chemically defined nutrients, or may contain ingredients of undefined

[4] For example some bacteria, like plants, can use carbon dioxide as a carbon source, and do not require a carbon source in their culture media.

chemical composition. The latter type are termed complex media. Complex media are commonly used in laboratories and for industrial fermentation processes as they support the growth of a wide range of microorganisms and are easy to prepare. An example of a complex culture media commonly used in laboratories is nutrient broth. It is typically composed of meat extract, peptone and sodium chloride - the exact chemical components of the meat extract are not defined. Other culture media may contain, yeast extract, peptone from soya meal, corn steep liquor, defatted soya flour and cotton seed flour. For example, the ingredients of a *Salmonella* enrichment broth are listed below.

***Salmonella* enrichment broth**

Typical composition

	g/litre
peptone from casein	4.0
peptone from soymeal	1.0
magnesium chloride hexahydrate	29.0
sodium chloride	8.0
Di-potassium hydrogen phosphate	0.4
potassium hydrogen phosphate	0.6
Malachite green	0.036

Some examples of products listed by laboratory suppliers, and their retail prices are given in Table 6.2.1. It should be emphasised that these are prices for laboratory chemicals. Soya meal, cottonseed meal and corn steep liquor, are also all quite commonly used as feedstocks for industrial fermentation processes for production of products such as citric acid and some antibiotics and enzymes. The use of soya meal as a feedstock is illustrated by the abstracts listed in Appendix III. Industrial users are likely to purchase substrates such as soya meal at normal market prices, as a cheaper alternative to yeast extract, a traditional source of nutrients for microbial culture media, which may be available in bulk at around £500/tonne. Manufacturers of some products such as certain enzymes may not be interested in this type of feedstock as a base for media if they require specific information about the components of their feedstocks for legislatory reasons (Tough pers. comm., 1996).

Table 6.2.1 Products listed by laboratory suppliers and their prices

Product	**Product description**	**Price**
Corn steep liquor	a viscous concentrate of corn solubles, rich in vitamins, amino acids, minerals and other growth stimulants (50% solids)	500 g £9.00 2.5 kg £35.00
Corn steep solids	spray dried corn solubles	250 g £8.30 500 g £13.70
Cotton seed enzymatic hydrolysate	typical analysis: total N approx 8.7% amino N approx 2.9% AN:TN ratio 0.33	250 g £13.70 500 g £22.60 1 kg £36.70
Cotton seed flour	a finely ground powder that gradually releases vitamins, minerals and proteins to micro-organisms during fermentation	500 g £9.90 2.5 kg £27.90
Soybean flour	a defatted slowly available protein nutrient, approx 52% protein and 1% fat	500 kg 13.80 2.5 kg 38.50
Peptone type I from meat	total N approx 16.0% amino acid approx 3.0%	100 g £11.10 500 g £46.10 1 kg £77.50
Peptone type IV from soybean	total N approx 9.5% Amino N approx 2.0%	100 g £7.90 500 g £25.50 1 kg 42.60
Yeast extract	spray dried, autolyzed, yeast extract	100 g £23.90 250 g £51.10 500 g £72.40 1 kg £129
Yeast extract	granules	500 g £15.60 25 kg £597.20

6.2.2 Research into the use of rapemeal

No rapemeal derived products appear to be marketed as components for culture media but there have been some reports in the literature of studies on the suitability of rapemeal for this use.

Phillipchuck and Jackson (1979) assessed the suitability of rapeseed meal derivatives as a nitrogenous substrate for microbial fermentation. They used the yeast *Candida utilis* ATCC 9950 to compare the suitability of the rapemeal derived media to some commercial media. *Candida utilis* was chosen because of the ease with which the growth response could be detected and measured.

Four different methods, listed below, were used to prepare the rapemeal derivative, but all were protein digests:

- Hydrochloric acid digestion (reflux method) (RSOM-H)
- Hydrochloric acid digestion (autoclave method) (RSOM-HA)
- Pepsin digestion (RSOM-P)
- Trypsin digestion (RSOM-T)

Little difference in the growth response was found between the different preparations of rapemeal, with the exception of the pepsin digest which supported a slower growth rate and lower cell yield than the others. This was attributed to low levels of certain amino acids.

The authors considered that the results of the study demonstrated the ability of rapemeal derived media to support the growth of *Candida utilis*, and concluded that there was no reason why the rapemeal derived media should not be used in commercial fermentations. It was also suggested that less digested products or whole rapemeal may be suitable as a fermentation feedstock. Garg *et al.* (1983) tested the ability of a further 10 yeast species to grow on media containing rapemeal derivative, and found that an acid digest prepared from the rapemeal supported the growth of all the yeast tested.

Rapemeal derivatives have also been tested for their suitability in supporting bacterial growth. Yeoman and Edwards (1992) tested the ability of rapemeal derived extract to support the growth of, and protease production by a number thermophilic organisms[5] which included 35 *Bacilillus* spp, 7 *Streptomyces* spp, 15 *Thermoactinomyces* as well as two fungal species. Heat stable enzymes such as proteases are of commercial interest for many biotechnological applications. Proteolytic enzymes account for a significant proportion of the world enzyme market and are used for a variety of processes that include baking, food and leather industries and commercial detergents. Some results of their study are shown in Table 6.2.2

Table 6.2.2 Growth and protease production of isolates on liquid and solidified rapemeal derived media

	liquid medium[a]			solid medium[b]
Organism	Number of isolates tested	Number which grew	Number producing protease	Number which grew
Bacillus spp.	35	20	20	28
Streptomyces spp.	7	7	7	7
Thermoactinomyces spp.	15	0	0	15
Thermomonospora spp.	1	0	0	1
Fungal spp.	2	2	2	2

[a]The rapemeal extract broth was prepared by boiling the rapemeal in NaOH, straining then centrifuging to remove all suspended particles. [b]The solid medium was prepared as the liquid medium then solidified with agar.

[5]Thermophilic organisms have considerable advantages for industrial fermentation, including high metabolic activity, enhanced product formation rates, limited mesophilic contamination, reduced cooling costs and the production of heat stable proteins.

Table 6.2.2 shows that a large proportion of the isolates grew in the liquid and/or the solid rapemeal derived substrate. It has also been found that species which grew on solid media and not the liquid (Table 6.2.2) also grew on liquid media from which the meal had not been removed (Yeoman and Edwards, 1994). The presence of a solid surface may therefore be necessary for the growth of these species.

Yeoman and Edwards (1992) concluded that rapemeal may be used for the formulation of protein-rich medium suitable for growth of micro-organisms representative of genera used in the biotechnology industry. Their work also confirms the suggestion of Phillipchuck and Jackson (1979), that less digested derivatives, or whole meal may be suitable as a feedstock (see above). It is of particular interest that all of the *streptomyces* tested grew on the rapemeal medium as *streptomyces* are very important organisms for the production of antibiotics.

Rapemeal has also been studied as a nitrogen source for the microbial production of γ -linolenic acid (GLA), a constituent of pharmaceuticals, health foods and cosmetics. The best known source of GLA acid is evening primrose oil and since 1988 the oil of the Evening Primrose has been registered in the UK as a pharmaceutical product, which is used for a number of conditions including the treatment of atopic eczema. In addition. borage and blackcurrant seeds also contain oil rich in GLA, and it can be produced through fermentation using micro-organisms, including strains belonging to the fungal order *Mucorales*. The traditional carbon and nitrogen sources for this process are glucose and yeast extract respectively. They are, however, expensive and contribute about 80% of the cost of the medium. Scientists at the University of Lund, Sweden, have studied the production of GLA using a number of cheaper sources of carbon and nitrogen, including rapemeal (as a nitrogen source) (Lindberg and Hasson, 1991). It was concluded that *Mucor* spp. growing on rapemeal media produced similar quantities of GLA to that obtained from glucose and yeast extract, at a fraction of the cost. The profile of the lipids produced by the fungus was, however, altered and, although the total yield of GLA was maintained, oleic acid became the predominating fatty acid.

Other published references to the use of rapemeal as a culture media include work on the production of L-lysine by the bacterium *Brevibacterium flavum* on hydrolysates of rapemeal (Smekal *et al.*, 1984, listed in Chemical Abstracts) and production of lactic acid using the bacterium *Thermobacterium cereale*, cultured on 10% sucrose and 1% soybean or rapemeal (Maslowski, 1987). Both these projects were carried out in Eastern Europe.

6.2.3 Conclusions

Results of the limited amount of research that has been carried out seems to indicate that rapemeal is suitable for use in this market. In addition the meal is likely to be attractive for this use at its current market price, and there is may be good potential for adding value to the meal through production of laboratory grade products. The steps required to encourage use in this market may be at the level of demonstration and promotion, although work with a wider range of micro-organisms may be beneficial in establishing the rapemeal as a suitable source of nutrients for microbial culture media. Work with a wider range of micro-organisms would also be enable estimates of the potential market size.

6.3. Low matrix wood composites

6.3.1 Structural composites

Considerable research has been performed on the use of agricultural crops and residues as substitutes for wood based panels. The favoured materials being evaluated are:

(i) wheat straw, which is readily available and at low cost but only suitable for coarse, low density boards.

(ii) flax fibre, due to its strength and fibre length.

No reports on the use of rapemeal have been found in the course of this study, but in the US a product based on soybean meal has been recently introduced. The product 'Environ' is a medium density composite which can be worked and shaped in the same way as fine quality timber.

The history of the product is quite unusual. In 1991 an 11 year old schoolgirl experimented with blending adhesives and used-newspaper for a science project. The resultant product showed good strength and waterproof qualities. Soya meal was then evaluated as the adhesive base and from there the system was patented and taken over by a commercial company which is now a dedicated composites company in Minnesota, Phenix composites (the schoolgirl has a stake in the company) (Haumann, 1993)

Phenix Composites, received a grant in 1993 from the United Soybean Board to start the project and money from the Minnesota Soybean Board for market research. More importantly, the company received a $10 million development loan from the Alternative Agricultural Research and Commercialisation Centre (AARC) to build and equip a manufacturing plant in St. Peter, Minnesota.

The Environ composite board is based on 40% high-protein soybean flour, 40% recycled newspapers and 20% colour and other ingredients. Environ has a specific gravity of about 1.20 and is marketed in sheets 2' x 2' with a thickness of 1/8" to 3/4". The particular qualities of Environ are its durability and appearance. The company describe it as looking like natural stone, but it can be cut and fabricated like wood. It is therefore being marketed for interior applications including furniture, shop fixtures, plaques and signs.

The main problem with plant based composites is that they swell in contact with water and subsequently lose their strength. This limits the use of this type of board mainly to indoor uses where it is unlikely to get wet. However, Phenix Composites have also been able to develop a water resistant product and can offer changes in product specification including weight, flexibility, strength and colour.

The quoted price of the product is high at $ 3800/tonne (calculated from the price of sheets). Not allowing for the cost of processing or the other components, this puts the marketed value of the soybean meal component at $ 9500/tonne.

6.3.2 Conclusion

It is not obvious whether the Environ patent extends to other high protein flours but clearly this is an area worthy of study with rapeseed meal.

6.4 Mushroom compost supplementation

6.4.1 Mushroom compost - background

Mushroom compost was traditionally based on horse manure and a mix of other ingredients including straw, but today most growers use compost based on chicken litter, straw and gypsum. Production of the compost is a multi stage procedure. After rough mixing, materials are stacked and watered to soften the straw and make it susceptible to degradation. The mixture is aerated by turning, or forced air ventilation, and a partially degraded and biologically active material is produced. This is then transferred to specially designed rooms or "tunnels" with sophisticated environmental control for phase II. In this phase the compost is allowed to heat to a high enough temperature for pasteurisation to occur, usually around 58 - 60°C for up to 12 hours. Further biological processes are controlled at a lower temperature of around 43 -53°C for about 7 days for the compost to become "conditioned".

6.4.2 Compost supplements

Many attempts have been made to increase mushroom yield by addition of nutrients to compost at various stages of the growing period. Mushrooms require a balanced compost with respect to nitrogen and carbohydrates. Where the compost is not balanced, carbohydrate and protein supplements are quite widely used. The supplements may be applied at different stages in the process. Two key points for supplement addition are spawning[6] and casing[7].

Addition of supplements such as cotton seed meal, brewers grains and poultry manure during composting has also been studied, but supplementation at this stage has been found to be of limited value as the supplements stimulate the compost microbial population rather than the mushroom mycelium.

A number of different protein based supplements are on the market. Some of these are based on soya meal or cottonseed meal, but no information was found, during the course of this study which indicated that rapeseed meal has been used as a mushroom compost supplement. The high cost of proprietary compost supplements has led to trials using untreated and treated soya and cotton seed and sunflower meal (Eicker and Apostolides, 1986; Gerrits, 1986; Randle *et al.*, 1983) as well as other waste materials. Results have shown that mushroom production can be increased significantly by supplementing with these materials, but no reference has been found to the assessment of rapeseed meal as a compost supplement.

[6]Spawning is the stage in the process where the compost is innoculated with the fungi. The compost is innoculated with a culture produced by a small number of highly specialised biotechnology companies.

[7]When the peat has been fully colonised, an extra layer, usually of peat, is added to the surface. This is "casing" - it mimics the function of an autumn leaf fall and provides conditions for transforming the fungi from vegetative to reproductive growth, i.e. it triggers mushroom formation.

6.4.3 Treatment of protein supplements

Delayed release of nutrients is a desirable quality for mushroom compost supplements (Carroll and Schisller, 1976). This has been achieved by treatment of oilseed meal with formaldehyde and heat, to denature the protein. It is interesting to note that some animal feeds are also treated in this way in order to optimise the digestion and uptake of the dietary protein in ruminant animals such as cows. In fact, Randle *et al.* (1983) assessed a soya meal animal feed supplement and indicated that in some circumstances this product produced better results than a similar product manufactured by the same company (BP Nutrition), specifically for use as a mushroom compost supplement.

6.4.4 Market Size

Total UK mushroom production has been estimated as 750 000 t/year. This production utilised approximately 152 500 tonnes of compost (70% moisture).

Supplement may be applied at a rate of up to 5% of the dry weight of compost (Eicker and Apostolides, 1986, Randle *et al.*, 1983)

Assuming an application rate of 4% the total volume of rapemeal which may be utilised in this market would be 1830 t of meal per year.

Irish production is of roughly the same capacity as the UK, therefore taking account of the Irish market (North and South) would double the market size to 3660 t.

6.4.5 Conclusions

Some practical work is required in order to assess whether rapemeal is suitable as a mushroom compost supplement. A potential problem with the use of rapemeal as a mushroom supplement may be the presence of glucosinolates, as these compounds may be toxic to some fungi.

6.5 Use as an absorbent material

6.5.1 Introduction

Markets for absorbent materials include pet litter, use as an absorbent for oil spills and hazardous chemicals. No examples of the use of rapemeal, or similar materials such as soya meal, as absorbents were identified during this study. However, as rapemeal is the material that contains oil within the plant, it seems likely that it will have good oil absorption characteristics. A novel piece of work was therefore carried out for this project to assess the absorbency characteristics of powdered and granular oilseed rapemeal in comparison to commercially available absorbents.

The materials which were tested for comparison to rape meal are described below.

- **Grey Cellulosic**: a waste product from the paper industry
- **Brown Cellulosic**: a waste product from the paper industry which has been treated to enhance its oil absorption properties.
- **Fibrasorb**: dried and shredded peat
- **Polypropylene granules**: small chips of polypropylene
- **Absolyt**: a mineral based product, the origin of which is unknown
- **Uni-safe**: a mineral based product of unknown origin

- **Cat Litter**: the cat litter tested was manufactured from Fuller's earth[8].
- **Oil-Dri**: a mineral based product resembling Fuller's earth.

6.5.2 Absorbency of crude oil

Crude oil was added to a weighed sample of absorbent until the test absorbent became saturated. Results are shown in Figure 6.4.1. It can be seen that of the absorbents

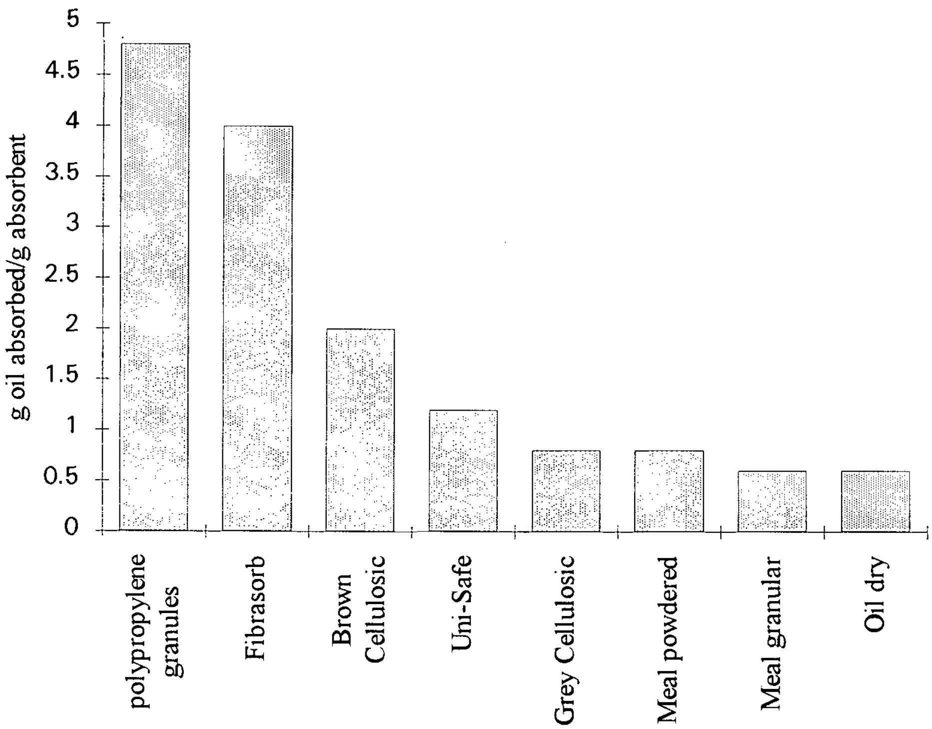


Figure 6.4.1 Quantity of crude oil resulting in saturation of oilseed rapemeal and commercially available absorbents

[8]The term "Fuller's earth" refers to a naturally occurring absorbent clay, commonly calcium montmorillonite, but other clays may also be referred to as Fuller's earth. This material has a wide range of uses including use as a bleaching agent in refining of vegetable oil. However it has been stated that the largest use of fuller's earth granules is as an animal litter (Robertson, 1986)

tested, polypropylene granules gave the best performance in terms of **weight** of oil absorbed by a given **weight** of absorbent, whilst the rapemeal performed relatively poorly in comparison. However, a range of factors must be taken into account in assessing overall performance as an absorbent. The two best performing products in terms of g oil absorbed/g absorbent are both extremely light, low density materials. Therefore a very large **volume** of the absorbent was used, ultimately producing a large volume of waste. The rapemeal, however, although being a poorer absorbent weight for weight, than polypropylene or Fibrasorb, was a heavier product and therefore resulted in a reduced volume of oily waste. The importance of volume and weight in determining the choice of absorbent may vary depending on circumstance, but it is interesting to note that of all the absorbents tested, Oil-Dri is probably the most commonly used in industry. Figure 6.4.1 shows that rapemeal is as good, if not better, an absorbent than Oil-Dri in terms of weight of oil absorbed per g of absorbent. Further work may therefore be justified on the potential of oilseed rape meal as an absorbent for oil spills.

6.5.3 Water absorption

The results for water absorption by oilseed rapemeal are shown in Figure 6.4.2. It can be seen that, in terms of weight of water absorbed per gram of absorbent, Uni-safe was the best performing material, absorbing more than 10 times its own weight in water. In comparison, powdered rapemeal was capable of absorbing almost twice its own weight in water, with the granular form being only slightly less efficient. However, both forms of rapemeal performed better than cat litter - a product sold specifically to absorb a water based waste.

Robertson (1986) states that two types of clay material have been used successfully as animal litter granules: sepiolite which is nearly white and has a high absorptive capacity, and calcium montmorillonite, which swells when wetted. The wetted granules are easily recognised and can be removed daily.

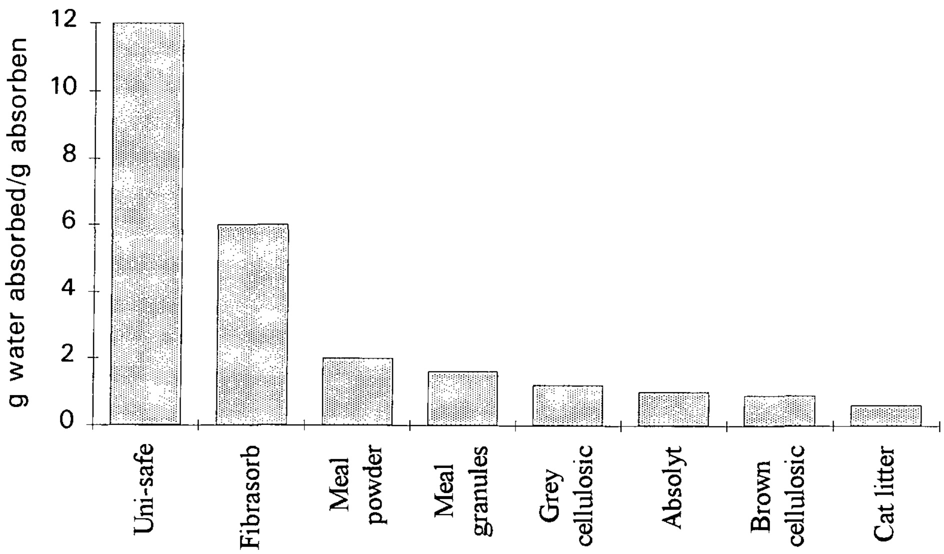


Figure 6.4.2 Absorption of water by oilseed rapemeal and some commercially available absorbents

More recently, alternatives to clay based litters have been introduced to the market. Products based on wood waste and paper are available in supermarkets, appear to be priced similarly, or at a premium to the more traditional clay based products, and are marketed as "environmentally friendly" and "biodegradable". It may be argued that mining for Fuller's earth or other clay raw materials is depleting a natural resource, and once dumped the product takes up space in land fill sites, which are increasingly under pressure. Some examples of cat litter products and their retail prices are given in Table 6.4.1. Direct comparison of all the products is made difficult by the fact that some products indicate the quantity packs in litres, while others state the quantity by weight.

Table 6.4.1 Retail price of cat litter

product	raw material	pence/kg	pence/100 ml	size of bag
Bio cat litter[1]	waste paper		3	12 litres
Tesco Lightweight Cat Litter		55.5	3.1	10 kg
Tesco cat litter Dust free	Wood based	66.3	9.9	5 litres 3kg
Tesco cat litter	Natural Clay	33.2		6 kg
Carstan Ultra absorbent clumping litter[2].			8.7	5 litres
Tesco cat litter	paper based		2.5	
Altons Fussy Puss cat litter States up to 3x more absorbent than ordinary cat litter.[3]	wood based		3.7	15 litre

[1]Bio-catolet (UK) ltd, Rooksley Park, Milton Keynes, MK13 8PH
[2]Pedigree Petwoods, Melton Moabray, Leics LE13 OBR
[3]Altons Ltd, Rose Wharf, Ropery Road, Gainsborough, Liconshire, DN21 2QB

The most desirable properties in an animal litter are (Robertson, 1986):

- easy recognition of the granules that are saturated or fouled by the animal
- the absorptive capacity and the rate of absorption
- odour prevention, or destruction
- resistance to "tracking" by cats - that is granules sticking to the paws by static electricity or by moist adhesiveness.

The preliminary work which has been carried out on the absorptive capacity of oil seed rape meal indicates that from this respect it may be a suitable raw material for the production of cat litter, but further work will be required to assess its suitability with respect to other performance characteristics, and the amount of processing that would required to produce a marketable product.

6.5.4 Concentrated sulphuric acid absorption

Preliminary work has shown that powdered rapemeal is capable of absorbing 4 times its own weight in sulphuric acid and the granular meal can absorb twice its weight in concentrated sulphuric acid. During the absorption process the powdered meal turned from a brown, highly divided solid, into a black, carbonaceous lump. The conversion appeared similar to that observed when concentrated sulphuric acid is added to sugar, i.e. the carbohydrate is effectively dehydrated to form a carbon residue (which was easily handled). The granular meal, however, did not undergo any decomposition and remained as individual pieces throughout the experiment.

6.5.5 Conclusions

- Oilseed rape meal can be used to absorb both oil and aqueous fluids
- Although able to absorb both oil and aqueous fluids, the meal has a greater capacity to absorb aqueous liquids.
- Both a powdered and a granular form of meal were studied with the powdered form proving to be the most effective, probably as a consequence of increased surface area.
- In the absorption of oil, the meal was able to outperform Oil-Dri, a commonly used industrial absorbent.
- During the absorption of water the meal was able to outperform a commercial cat litter (Fuller's earth based)

- When being used to absorb concentrated sulphuric acid, the powdered meal was converted to a black, carbonaceous lump which was easily handled, but the granular form remained unchanged

- The density of the meal appeared similar to Fuller's earth and produced a volume of waste material which was easily delt with

- Oilseed rape appears to have the potential to be a cost effective, multifunctional absorbent which could find usage in a broad range of industrial applications.

CHAPTER 7 POTENTIAL USES FOR THE FAR TERM

This chapter looks at some potential markets for rapemeal which would require longer term investment in research and development before they could be commercially exploited. These uses are largely based on the extraction of the protein from the meal, and its plasticity, strength, solvent and adhesive qualities, but also include other aspects such as the extraction and use of glucosinolates.

7.1 Protein

7.1.1 Background

Plant derived proteins exhibit many of the elasticity qualities associated with high molecular weight polymers and also show bonding properties of potential value when used as adhesives.

Plant proteins most studied for their industrial applications have been soybean protein, wheat gluten and zein from maize. Casein, collagen, gelatin and other naturally occurring proteins have also been used in a number of industrial markets at various times in recent history. However, no tangible information has been identified on uses of rapemeal derived protein. An important need is, therefore, to study the qualities of rapemeal protein in comparison with other crop proteins, with respect to the wide variety of applications that have been considered for them.

7.1.2 Historical development of plant proteins for industrial uses

The first reported non-food uses of plant proteins were with soybeans. The Chinese and Japanese recognised the film forming and bonding qualities of soybean protein from early times but the real interest started at the beginning of the 20th century when research into biopolymers started in earnest (Feillet, 1993).

In 1913, the first patents for soybean derived plastics were published and these were followed by other processes patented by Satow in 1917. A process for the production of glues based on soya meal was patented by Johnson in 1923 and in 1926 marketing of a glue for the Douglas fir plywood industry began in the US. This was the first major industrial use of a plant protein product. The historical development of industrial uses of soybean protein was reviewed at the world conference on oilseed technology and utilisation in 1993 (Myers, 1992).

In the 1930s in the US, the Chemurgic movement got under way. This was an initiative to create industrial raw materials from agricultural products. The industrialist Henry Ford was a leading force in the movement, providing the funding from the Ford Motor Company, and involving many eminent American scientists of the day such as Carver, Christiansen, Edison and Julian. Nearly 200 products from soybeans have been attributed to the efforts of this movement although relatively few made any significant commercial progress.

For the most part, soybean protein products were initially competing with other agriculturally derived proteins such as casein. In the case of adhesives for plywood they quickly took over from starch based glues. However, the arrival of petroleum based polymers and other materials effectively curtailed the commercial development of the more costly soybean products. Soybean based adhesives are, however, still in use. Other current uses are asphalt emulsions, packaging films, leather substitutes, composites and textiles (Tao, 1994)

7.1.3 Extraction and functionality of plant proteins

The characteristics of the proteins derived from plants can be modified to suit particular applications. However the number of processes to which the material is subjected will obviously have a major impact on cost and, therefore, market potential. Soybean protein can be utilised in several forms:

- Soybean flour: Obtained simply by milling the meal after extraction of the oils. Soybean flour contains about 56% protein and 34% carbohydrate.

- Soy protein concentrate: 70% protein.

- Soybean isolate: 90% protein.

Both soybean concentrate and soybean isolate are produced by treatment of the meal with organic and inorganic acids, neutralised with aqueous alkali and then dried. Soy isolates are granular in appearance, water soluble, with a light tan colour and have a bulk density of approx 0.6 g/cm^3. The molecular weight of the proteins range from 8,000 to 600,000.

The ability of proteins to interact with other materials in order to impart desirable properties is referred to as functionality. Desirable functionalities include solubility, water binding, fat binding, emulsification and foaming properties. The functionality of plant proteins can be altered by various physical, enzymatic and chemical processes.

Much of the research into the modification of plant proteins has been aiming at food uses, specifically as a meat substitute. There have, however, been spin off benefits for industrial uses particularly for uses in medical situations and for production of fibres and coating agents (Rhee, 1992).

7.1.4 Markets

7.1.4.1 Biodegradable plastics

<u>History of protein use for plastic production</u>

Proteins have been used for various non-food applications e.g. gelatin and collagen for medical purposes, but their suitability as bioplastics has always been limited. Nonetheless, potential may be indicated by the fact that proteins are polyamides, and

Nylon, one of the leading synthetic polymers used by mankind, is a polyamide. At the other end of the scale spider silk, one of the strongest materials weight for weight in the natural world, is also a protein.

The extrudability of casein, derived from milk, was one of the first practical demonstrations of the potential of proteins as a source of plastics. The early work on plant protein for plastics (Satow, 1913 quoted in Myers, 1992) involved treatment of soybean protein was with acid or alkali followed by cross linking with formaldehyde. The material extruded well and produced high quality moulds from a dye. However, it fractured after only a few weeks and did not show resistance to water. Many attempts to improve the quality of plant protein plastics have been made, including the work of Henry Ford's Chemurgic group. Ford developed a combination product, with phenol-formaldehyde resin, containing 30% soybean protein. The intention was to use the material in motor cars for gear control knobs, distributor heads etc., however the technical barriers - mainly lack of water resistance were never really solved.

Soybean protein plastic, as an extender to phenol-formaldehyde, took on a new interest as oil based chemicals became scarce during the Second World War. Brother and McKinney (1940) tried to improve thermosetting qualities using soybean meal, phenol-formaldehyde resin and wood flour but the rate of curing was too slow to make it viable.

The potential of other plant protein sources for production of plastics and films has also been studied. The first reports of plastic films derived from maize zein were in 1937, however, the production process involved the transformation of protein with plasticizers and solvents, which meant that the costs were high, the protein supply was limited and the properties of the film did not match what the market required (Feil, 1995). The first wheat gluten films were reported in 1969 and peanut proteins, in combination with lipids, were processed into films in 1973.

Other alternatives to petrochemically derived plastics and polymers

Considerable amounts of research and development, over the last 20 years or so, have focused on the use of starch for the production of plastics. Many of the products developed to date have been based on blends of starch and synthetic polyethylene. Marketing of these starch products has been based around their biodegradable character, and products have secured a small portion of the plastics market despite higher costs than petrochemical plastics, although it could be argued that market performance has, to date, been disappointing.

In addition, ICI have developed the biodegradable polymer, Biopol. This is made from polyhydroxy butyrate (PHB) which is produced by a fermentation process. PHB is used for packaging human care products in niche markets where legislation encourages composting such as in Germany.

Current interest in protein for plastic production

Work on the development of combination polymers based on starch and protein polymers which have greater strength than with starch alone is taking place in the US at a number of Universities and research centres. The American Soybean Association (ASA) and the United Soybean Board (USB) are funding much of the work. Iowa State University's Centre for Crops Utilization Research (CCUR) has been trying to make bioplastics with soy protein and corn starch for such applications as eating utensils and golf tees.

Weller and colleagues at the University of Nebraska are active in the field of developing plastic films from agricultural materials. They have succeeded in modifying soybean isolate and combinations of soybean isolate and wheat gluten to produce edible films suitable for food protection. It has been suggested that the use of such plastics in fast food establishments could mean that the used utensils could be further recycled and processed into animal feed.

Obstacles to development

Protein derived plastics generally have the advantage of being edible and biodegradable but they can only be used where water is not present because of their hydrophilic properties. However, this problem has also been encountered in the development of starch based plastics.

The market potential for biodegradable plastics is dependent on the legislation applicable in the region, but it is growing. The potential market for biodegradable plastics in Europe was estimated at 1.1 million tonnes in a study conducted by the EU DG XII in 1994. Compostable bags, non returnable products, rigid packaging, bottles, snack packages and agricultural uses would make up 90% of the market (Fritz *et al.*, 1994). A theoretical replacement potential has been calculated at 240,000 - 500,000 tonnes per year for Germany alone (Feil, 1995).

The main obstacle to the development of protein based plastics is their relative cost. Feillet presented some comparisons in 1993:

Material	**Cost (ecu/kg)**
Starch	0.4 - 0.6
Wheat gluten	0.9 - 1.6
Soybean isolates	3.5 - 4.0
Maize zein	15.0
PHB	15.0
Polyethylene	0.7 - 0.9

Even if the technical barriers are overcome, the place for protein polymers is likely to be in small markets where specific qualities are needed. This is the case with PHB and with collagen and gelatin used in medical situations such as carriers for slow release of pharmaceuticals.

Research effort into biodegradable plastics is quite active and examination of protein polymers derived from rapeseed used alone, or in combination with other polymers, should be considered as a longer term target.

7.1.4.2 Soluble and edible coatings

It has been reported that soybean protein is used for edible films for food wrapping in the far east (Weller and Gennadios, 1991), and soluble sachets for soup and similar products for cooking are used in Japan. The suitability of wheat gluten for the production of food coatings or soluble sachets has also been examined at CIRAD in France. The oxygen permeability of the film is reported to be good but the resistance to water may be insufficient during storage (Lachowski, 1993). In Europe, other forms of soluble packaging are used to separate the components of pizzas and pastries before cooking. There is also an established market for coating fresh fruit, such as bananas and pomme fruit, to enhance shelf life and reduce losses during shipments. So far products used are soluble sucrose esters, such as the product SemperFresh which is marketed worldwide.

Soluble films are also being used in the agrochemical industry. Liquid formulations are packaged in soluble sachets which dissolve quickly in the spray tank, providing a safer method of handling. Polyethylene glycol is the material currently used in this market.

Conclusion

Although work has been carried out on the development of products based on soya protein and gluten, no comparable work appears to have been carried out with oilseed rapemeal. As soluble and edible coatings appear to be products for which there is and existing and increasing demand, the suitability of rapemeal protein for the production of edible and soluble films should be investigated. Although, by definition, the films have to be edible, their purpose is as a physical protection not as a source of nutrition. It should, therefore, be possible to argue that the use still meets the non-food industrial criteria.

7.1.4.3 Adhesives for bonding wood

Background

The use of proteins in the production of adhesives is not new. Blood, collagen, casein from milk, and extracts from fish skins have all been utilised to make adhesives for bonding wood. Caseins were quickly developed as adhesives from their first use in 1880 because of their strong bonding power to wood; protein based adhesives are particularly effective in bonding wood because they cross link with the proteins in the wood. However, today little casein is used due to its high cost and low durability compared to newer adhesives.

The main protein based adhesive in the US has been derived from soy protein. The abundance of supply and the relatively low cost was a driving force for development in the 1930s. Generally soybean flour rather than soybean isolate is used for production of adhesive. The flour is dry blended with various fillers, extenders, and anti-foams and the soy protein content can range from 30 to 70% depending on the use for which the adhesive is produced.

Markets

At its peak, in 1956, use of soybean flour for adhesive in the US was 45,000 tonnes per year but today, although still in use, annual consumption has declined to just 80-90 tonnes. Soybean glue has advantages in terms of bonding strength and relatively rapid setting in the cold but its main disadvantage is the lack of water resistance, and for this reason most plywoods are now bonded with phenol formaldehyde resins. Another factor that has contributed to a decline in use of soy protein adhesive is that processing of soybean flour involves a strong alkali (pH 11) treatment, which is no longer favoured by the manufacturers.

Attempts to find alternative wood adhesive markets are ongoing, but have not been very successful to date, for example discolouration of the glue with time rules out its use in the furniture industry. However, in the US a trend towards the use of younger wood to produce composite boards rather than plywood is encouraging a re-examination of soybean adhesives, as an alternative to relatively high cost urea formaldehydes. Work is also being carried out, at Iowa State's Department of Food Science and Human Nutrition and at Iowa State's Centre for Crops Utilization Research (CCUR), to determine the different binding characteristics of soy flour, soy concentrate and soy isolate. Soy is also being blended with blood, casein and phenol formaldehyde to see the effect on adhesive strength and water resistance.

Conclusions

Myers (1992) considered that the potential for soybean based adhesives will be largely determined by their relative price in comparison with other protein sources or synthetics. Although their disadvantages are well known, they may be partly overcome by protein modification or formulation. The properties of rapemeal should be investigated in order to establish whether it has a potential place in the market.

7.1.4.4 Coatings for paper

Coatings are used on paper to fill in the irregularities of the surface and to give the required finish, gloss and smoothness appropriate for accepting print and for enhancing appearance.

In Europe, starch is used both as a coating agent and a bonding agent in the pulping process. In the US soybean protein coating agents are widely used. This use represents by far the largest industrial market for soybean protein with an annual consumption of 22-45,000 tonnes (Myers, 1992).

The American market evolved with the development of machine coating processes in the late 1930s (Skidmore, 1962). Protein coatings were favoured in the US compared to starches due to their better water resistance. Initially, casein was used but gradually soybean isolate took over (Burnett, 1951). Soybean protein is mainly used in the form of a co-binder with latexes and starches at quite low inclusion rates: 1-5%. The properties that the soybean coating brings are quite specific but involve the density of the coating, viscosity and lubricity of the binder and features which effect the brightness of the paper (Coco *et al.*,1990).

The soybean isolate used for paper coatings is obtained from aqueous extraction of defatted soybean flakes. The protein is then modified by controlled heating followed by chemical reaction and pH. The processes used to enhance the functionality of the soybean protein have been regularly upgraded to maintain its marketing advantage of viscosity, water retention and print retention qualities. There are still, however, some difficulties to overcome. The protein binder solutions, as well as the coating compositions containing the binders have proved to be unstable at room temperature, making it impractical to prepare large quantities for long paper runs. In addition, soy protein binders do not always provide the same gloss and brightness achieved with casein or synthetic binders. When used to coat wallpapers the soy proteins show good ability in keeping pigments in suspension over long periods of time but difficulty has been found in reproducing the quality.

Conclusion

Examination of the potential of proteins derived from rapemeal for this use should be undertaken.

7.1.4.5 Textile and Fibre Applications

Background

Naturally occurring fibres can be categorised into four main markets:

- Wood fibre and wood fibre substitutes
- Lower grade textile plant fibres
- Wool fibres
- High grade textile plant fibres

Wool and silk are proteins, and consequently, early research into the production of synthetic fabrics looked at the concept of mimicking these natural fibres by reconstituting proteins from other sources. Commercial development of this work came about in Japan and the US in the 1930s using casein, maize, zein, peanut and soybean proteins. The generic term for the reconstituted proteins was Azlon. In Japan, in 1939, soybean fibre production, under the name Silkool, is reported to have developed into a market of up to 400 - 500 tonnes. However, soy-protein fibre never reached a commercial stage in the US, despite the relatively high protein content of soya, and relatively low price compared to the other fibres produced from Casein (lanital), zein (vicara) and peanut (ardil) which were introduced.

Process

The process for production of fibre involves treating protein isolate with alkaline solution, filtering, precipitation with acid washing and drying. The material is then dissolved in strong alkali to form a 12% 'stringy' solution, filtered, concentrated under vacuum and wet spun to produce fibres.

The production of rayon from cellulose through the viscose process is well established and commercially successful. Theoretically, fibre obtained from protein should have a quality advantage over rayon, in terms of the strength and resilience that is found in wool. However, this has never been obtained because of the loss of structure resulting from protein denaturation, the relatively long protein chains and bulky side chains which limit chain interaction, and the lack of stability in the coil configuration.

Current research

A new approach to the use of soy-protein for fibre production is being developed in the US The work is using soy protein fibre as the core fibre around which a poly vinyl alcohol polymer is wrapped, like a sheath. The incorporation of PVA is expected to result in a fibre with good wet strength and better dry strength than soy protein fibre alone. The work aims to produce a silk-like fibre directed at the clothing market. It may be commercially available in eight to ten years.

Work is also being carried out in the US to improve the technology used in the 1930s when soy protein was first used to make textile fibre. The major problem to overcome is the lack of strength of the fibres when they become wet. Some progress is being made by using cross-linking agents to block the ions, which also results in a more flexible fibre (Haumann, 1993).

Conclusion

For rapemeal derived protein, studies on the qualities in comparison with the other plant proteins could be justified.

7.1.4.6 Other applications

Other uses for which plant proteins have been considered were reviewed by the Arthur D Little organisation for the USDA in 1951 and by Myers (1992). Some of these are listed below, but are not viewed as high priority for development. If, however, other markets were established for extracted rapemeal protein, research into the suitability of some of the markets listed below may be justified.

- The paint industry used soybean flour in the post-war period. Soy isolate and flour was used in water thinned paints - up to 1000 tonnes in 1949; in cold water paste and powder paints, the material was used for its adhesive, film forming and water proofing properties. Casein was preferred in resin based paints due to better physical characteristics. Currently, these markets have all been replaced by synthetics.

- Soy isolate was also used in printing inks. It was also reported to be used in size for treating paper and fibres.

- In the second world war, in the US, hydrolysed soybean isolate was used to make fire fighting foam of particular use on ships.

- New technology is showing how certain proteins such as casein may be modified as phosphopeptide inhibitors of tartar formation on teeth, films strengthened by chromate for holographic recordings, metal ion carriers used in graph polymerisation of leathers and enhanced adhesive properties of biologically applicable cements.

- Agricultural engineering researchers at Purdue University in Indiana are developing a variety of soy based plastics for potential use in pharmaceuticals and as bio-lubricants.

- The use of synthetic polymers to deliver drugs has attracted much attention in recent years. Attaching drugs to macromolecules could alter the rate of excretion from the body, providing longer periods of release. The use of naturally occurring polymers such as starch or proteins such as collagen have also been of interest, because they are natural products of living organisms, they are readily available, relatively inexpensive and they can be chemically modified. To date most work on natural polymers as matrices have centred on, for example, collagen, gelatin, albumin, starch and cellulose. No work has been identified using proteins from soya meal or rapemeal. Similarly there is little information available about the fractions that could be modified physically or chemically for pharmaceutical use.

7.2 Glucosinolates

7.2.1 Utilisation of biocidal properties

Work has been carried out to determine whether increasing glucosinolate levels in foliage of oilseed rape plants can enhance plant protection, and also to examine the potential for increasing the proportion of the most fungitoxic glucosinolates by agronomic means. In a glasshouse trial it was found that increasing the concentration of glucosinolates was associated with a delay in the appearance of the disease *Alternaria brassicicola* and also reduced the level of infection (Luong *et al.*, 1993). It was not, however, possible to change the proportions of glucosinolates. Field trials were carried out over a number of seasons to assess the variation in light leaf spot (Pyrenopeziza brassicae) susceptibility resulting from changes in the glucosinolate content of the plant. Changes in glucosinolate content were achieved through adjusted sulphur nutrition. The results showed that increasing the glucosinolate content of the plant reduced disease infection early in the season, but the effect was not maintained throughout the season and by harvest no yield advantage was noticeable. Only slight changes in the proportion of individual glucosinolates were noted with different agronomic treatments. Increasing the glucosinolate levels within the foliage had only a limited plant protectant effect in the field and could not substitute for fungicide application in terms of disease control (Booth and Walker, *in press*). It was therefore concluded that if the biocide potential of glucosinolates is to be exploited, an alternative method of utilisation must be employed.

7.2.2 The Biorefinery technique

The development of the Biorefinery technique to process rapeseed may offer such an alternative. In this process rapeseed is broken down by enzymes, instead of solvent extraction or physical means, to its constituent fractions of hulls, oil, protein and syrup. The glucosinolates are contained in the syrup, from which they can be easily extracted. A European Union funded project is underway to investigate the properties and uses of products from the biorefinery process. Part of this will be to evaluate the biocidal properties of glucosinolate products as fungicides, pesticides and nematocides by external application to plants which will allow control of the glucosinolate type and also the timing of availability. The effect of glucosinolates on a greater range of crops is enabled including plants which do not contain glucosinolates, where there may be greater potential for biocidal activity.

Although this approach may offer better potential for utilisation of the biocidal activities, it has several problems. The glucosinolate products may be toxic to the plant and work is underway to investigate this. Safety and ecological data relating to this application is presently limited and this area would have to be exhaustively investigated before commercialisation. Formulation of the product must also be resolved.

In the long term, oilseed rape may be used to provide a source of glucosinolates for the production of natural, biodegradable pesticides. After glucosinolate extraction, the meal would have an improved nutritional value (see Chapter 3) and would be a more attractive animal feed. However, this would add to the current problems of the Blair House restriction (see Chapter 1).

7.2.3 Production of Progoitrin

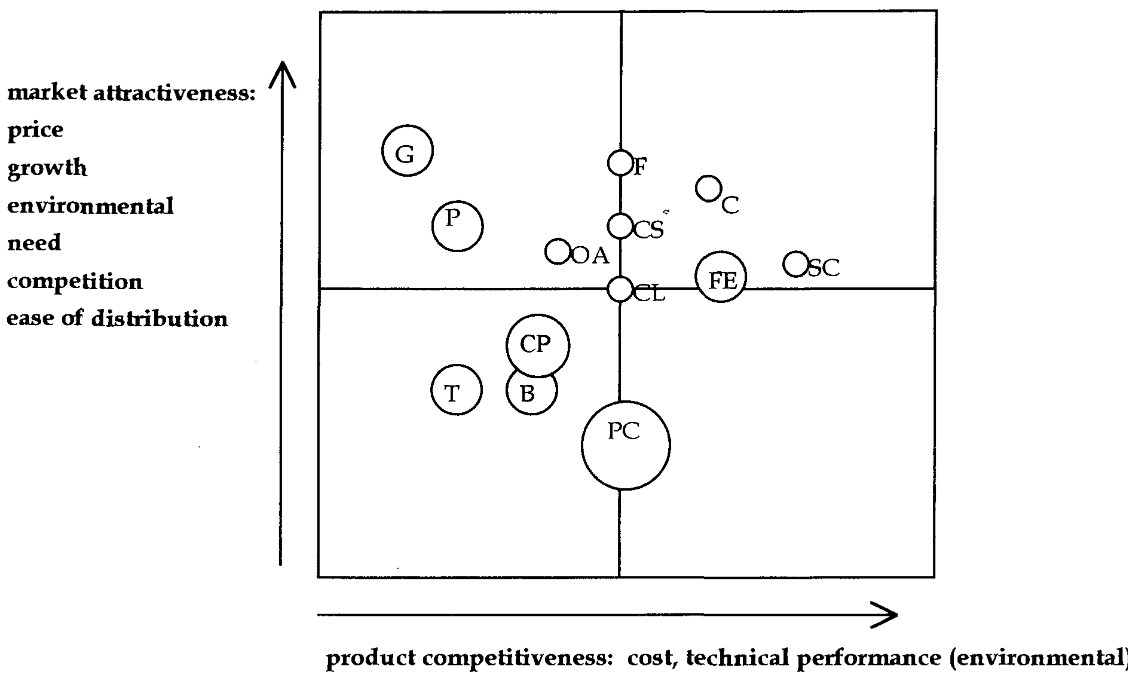
Progoitrin is a glucosinolate found in the meal of oilseed rape. Workers at the University of Orleans and CETIOM (Dreux *et al.*, 1993) have extracted large amounts of this and other glucosinolates and have considered the possibilities of using them in therapeutics, phytoprotection, polymers, tensides and liquid crystals. The teams have developed medium sized extraction methods obtaining yields of 10g of pure progoitrin from 3 kg of dehulled rapeseed meal.

CHAPTER 8 CONCLUSIONS

As a commodity, rapemeal has been underutilised and underinvestigated. Within the UK, use of rapemeal has been restricted to the animal feed sector, and alternative markets for rapemeal do not appear to have been previously researched. This may be because in the past there has been a sufficient market for the meal as an animal feed and consequently no incentive to look at other possible outlets.

In contrast, there has been a great deal of research into different markets for soya meal (largely through the efforts and funding of the American Soybean Association), and there seem to be quite a large number of commercially viable uses in addition to animal feed, not only for soya meal but also for other similar protein substances such as cotton seed meal. As rapemeal is currently available at a lower cost than soya meal, if it performs as well as soya in some of these markets there will be a number of options for its use, for which the full current market price may be obtained. Consequently, no premium would be required for the industrial oil in order to maintain the overall profitability of the rapeseed. Of the "near term" markets which could be quantified at this stage, there is no one single market, which if developed, could alone account for more than 5% of the meal produced from UK set-aside (1995 figures). Markets which could potentially use large quantities of the meal tend to be those for which the price obtained is likely to be well below the current market price. However, it is important to remember that it is not the entire industrial cropping area for which alternative markets need to be found, only the quantity produced above the restrictions of the Blair House agreement, and at this stage it is not clear how areas would be allocated within the EU were an overshoot to occur.

Figure 8.1 illustrates the interaction of a number of factors relating to the potential for the possible uses for rapemeal identified in this study. The best options have both a high market attractiveness (in terms of factors such as the price obtained for the meal, potential for growth of the market, environmental factors and ease of distribution) and a high product competitivity (in terms of cost of the product in comparison to other competing product and performance in relation to other products), and fall into the top right hand corner of the chart. Market size is indicated by the size of the circle. Options which fall into the bottom left hand corner have a poor market attractiveness and low product competitiveness, and are therefore least attractive for development.



G = glucosinolates
T = textile
PC = paper coating
OA = oil absorbent
SC = seed coating
C = composites
FE = fertiliser

P = protein, plastic etc
B = burning
CL = cat litter
CS = compost supplement
F = fermentation feedstock
CP = compost

Figure 8.1 Market attractiveness of options for oilseed rapemeal use

The options which fall into the top left hand corner, for example, the extraction of protein for the production of biodegradable plastics may be seen to have a good market attractiveness on the basis of increasing demand for environmentally friendly products, but poor competitiveness as products developed to date perform poorly compared to petrochemical based products and have a higher cost. Figure 8.2 illustrates the market attractivess of the options in relation to the level of investment required for their commercialisation.

In the longer term, development of markets for protein extracted from the meal may allow the development of a multi-use approach. If the protein is extracted for the production of, for example, textiles or plastics, it may be possible to utilise the remaining material in some of the categories listed above as "low value", such as fuel use. If the fibre is considered as a by product of (higher value) protein extraction, it may become economically viable to utilise it in this way. It may even be possible to use the remaining fibre in some of the higher value markets such as absorbents. It is, therefore, recommended that further work be carried out on the characteristics and performance of the material remaining after protein is extracted from the meal, as development of this approach could have a major impact on the economics of rapemeal utilisation.

Steps required for development of uses

There are some potential uses for which development requires extensive academic/industrial research. Development of other areas which deserve focused effort may be achieved through pilot scale demonstration and evaluation i.e. uses in the first two categories agreed above - "disposal" uses and markets for which soya meal is already used. In addition, some other uses may require a relatively small amount of research and development to define their potential. A range of uses from low-tech to high-tech could be evaluated quickly using this approach, allowing priorities to be defined in a relatively short time, especially with respect to low-tech uses. The value of this approach has already been demonstrated by the fact that the very limited practical observations which were carried out indicated that the meal has a very promising potential.

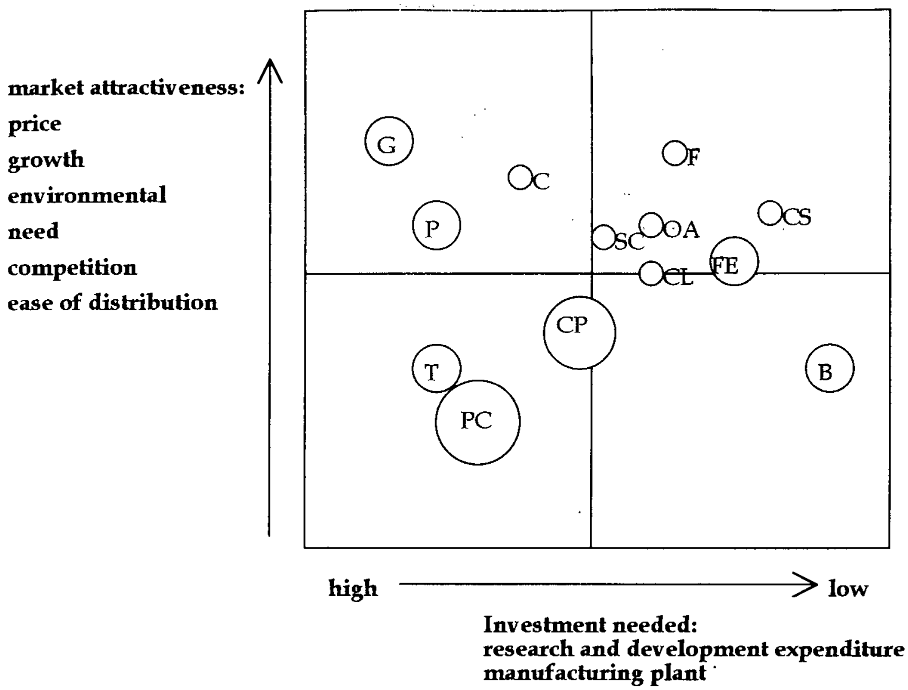


Figure 8.2 Market attractiveness of and investment required for development of options for oilseed rapemeal use

G = glucosinolates
T = textile
PC = paper coating
OA = oil absorbent
SC = seed coating
C = composites
FE = fertiliser
P = protein, plastic etc
B = burning
CL = cat litter
CS = compost supplement
F = fermentation feedstock
CP = compost

It is therefore recommended that the next stage for the development of industrial uses of oilseed rapemeal should be a co-ordinated series of "look see" studies, e.g. 6 month trials, in order to evaluate the potential for use of rapemeal in those markets classed as "near term" before , allocating any major projects. Where the results of these studies confirm the suitability of rapeseed for a particular market, the results could be used in order to promote the potential of rapemeal to possible industrial users.

There are some policy issues that have to be addressed. Firstly, the Blair House limits to the area of rapeseed grown on set-aside were put in place to protect the interests of the US soya industry. However, in a number of potential non-food and non-feed markets identified in this report, rapemeal would be competing with soya. If rapemeal performs as well in these markets as soya, it would have a clear competitive advantage due to its lower market price, and the US may initiate further action to protect the interest of soya growers and processors. Secondly, the definition of "non-food" needs to be clarified. for example, a mushroom compost supplement is not food, but is used in the production of food, and some fermentation feedstocks are used in the production of products that are used in the food industry. Clarification of these points would increase industry confidence of the potential for rapemeal in these markets.

This report has shown that a number of significant non-feed markets could be developed for rapeseed meal and that this could be achieved with minimal investment in research and time. Although some of these markets may not represent a huge volume, cumulatively they could represent a significant tonnage so easing pressure on the Blair House restrictions. Furthermore, some of these markets together with those requiring longer term research to reach commercial fruition, justify further research irrespective of Blair House considerations as they appear to offer a real opportunity for wealth creation.

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Appendix 1

"SOIL DOCTOR"

CANOLA
ORGANIC
FERTILIZER

FEEDING TURF NATURALLY

- ***Increases microbial activity*:**
  The protein in "Soil Doctor" feeds and increases the microbial population in the soil allowing more nutrients to be made available to turf.
- ***Slowly available :***
  The nutrients in "Soil Doctor" are water insoluble and are released by microbial activity in the soil over time.
- ***Humus is a sponge:***
  "Soil Doctor" increases the humus in the soil profile improving water retention and slowing down evaporation.
- *Low salts*:
  Synthetic, chemical fertilizers are high in chemical salts which not only burn turf but can reduce the numbers of soil microbes essential to soil and plant life.

IMPROVES RESISTANCE.

- ***Organic:***
  "Soil Doctor" is rich in bio-degradable organic matter and nutrients.
- ***Improves resistance*:**
  Plants are less vulnerable to disease and drought stress.
- ***Thatch reduction:***
  "Soil Doctor" helps to reduce thatch destroying the habitat of surface and sub surface insects and reduces the need for pesticide applications.

NO LEACHING INTO THE WATER TABLE.

- ***No Contamination:***
  "Soil Doctor" contains water insoluble nitrogen which releases into the soil ecosystem only as the microbial population requires it avoiding the pollution of ground water.

SAFE AND EASY TO USE.

- ***Safe:***
  "Soil Doctor." is safe with children or pets.Enjoy your lawn after application.
- ***Superior Homogeneity:***
  Each of the granules in the "Soil Doctor" product contains all nutrients assuring even distribution during application.
- ***Long Lasting:***
  The nutrients in "Soil Doctor" release slowly so that plants can use them all.

ANOTHER ORGANIC SOLUTION

COMPARATIVE ANALYSIS OF ORGANIC FERTILIZERS

SAMPLE	CANOLA FERTILIZER	POULTRY MANURE FERTILIZER	SEWAGE FERTILIZER
ARSENIC ug/gm	<0.02	24.6	7.33
NITROGEN %	6.20	3.37	6.70
P2O5 %	2.00	5.32	<O.10
K2O %	1.54	3.34	0.58
SULPHUR ug/gm	0.93	1.34	0.82
BORON "	90.00	2540.00	3720.00
ALUMINUM "	13.00	50.60	146.00
BERILLIUM "	<0.10	0.40	0.30
CADMIUM "	<0.30	0.90	7.10
CALCIUM "	8020.00	50700.00	11400.00
CHROMIUM "	4.40	69.90	4190.00
COPPER "	7.30	613.00	208.00
IRON "	152.00	15000.00	48500.00
LEAD "	<2.00	8.00	130.00
MAGNESIUM "	5860.00	8200.00	4030.00
MANGANESE"	57.00	648.00	92.60
SODIUM "	141.00	3900.00	1000.00
VANADIUM "	0.70	8.70	<0.30
COBOLT "	2.00	47.00	11.00

A GOOD SOIL IS A LIVING SOIL

Our soil is the home of numerous beneficial microorganisms. The numbers, kinds and activities of these organisms are influenced by the food material available, the organic content of the soil and other factors like: ph, moisture, temperature.

Soil fumigants and some fungicides may kill large numbers of all soil organisms. After the initial kill, organisms not killed or certain species which quickly become re-established become dominant and the normal healthy and diverse populations of beneficial soil microorganisms is put out of balance. Canola based organic redresses these imbalances helping to re-create a healthy, active and productive soil ecosystem .

KINDS OF SOIL ORGANISMS

Yeast and yeast like fungi are present on living grass leaf surfaces.

Bacteria are the most numerous and are present on living root surfaces where they feed on organic food. Some utilize the more resistant soil materials formed through microbial activity.

Some actinomycetes produce antibiotics and many synthesize substances which impart a rich sweet smell to healthy soil.

Soil fungi are larger than the bacteria or actinomycetes and in most soils constitute a greater total live weight.

Algae are the dominant photosynthetic microflora of the soil. They thrive primarily on or near the surface and are important in the colonization of new surfaces and soil formation.

IMPORTANT ACTIVITIES OF SOIL ORGANISMS.

Decomposition of organic residues with release of nutrients like Nitrogen and Phosphorous

Improved soil physical properties, better water infiltration and improved aeration.

Antagonistic action against plant pathogens.

Production of beneficial soil humus through decomposition of organic residues.

Improved plant nutrition through symbiotic relationships between fungi and plant roots.

CANOLA BASED FERTILIZER.

STATEMENTS FROM UNIVERSITY TESTS 1991-1995.

- Data indicates that the Canola based product was the top performer of all organic sources applied.
- The Canola based product showed less tendency to increase conductivity and decrease pH. The product was superior in both these categories to other fertilizer products.
- Results from clipping weight tables show the Canola based product provided one of the most consistent growth responses including the synthetics. Indication is that an even response occurs over a long period of time. The products also produced the highest ratings in density.
- The Canola based product indicated that it could be used affectively to meet turf requirements, to maintain a high level of quality and to supply the nutrients for vigorous plant growth. In addition, it appears that this organic source is capable of stimulating bacterial populations in the soil, contributing to improved nutrient transformation.
- The effect of Canola based product on cumulative clipping weights would indicate the product is more efficient in converting its nitrogen into vegetative growth.
- The Canola based product had a slow, steady, release with competitive values versus the synthetically enhanced organic products three weeks after application and showed a movement towards superior performance by the mid point of the trial and to its conclusion.
- The turf showed a satisfactory response to Canola based product applications. The impact of the vigorous growth observed on long term stand persistence, deserves further attention.

EFFICIENT! EFFECTIVE! ECOLOGICAL!

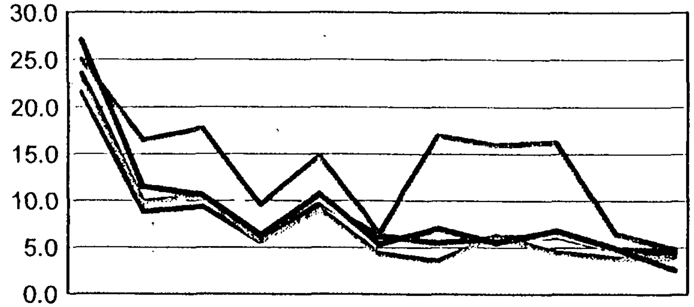
CIC Canola Industries Canada Inc.
Fourth Floor, County Centre, 1101 5 Street
NISKU, ALBERTA, CANADA, T9E 7N3

Tel: (403) 955-8822
Fax: (403) 955-2843

CANOLA BASED ORGANIC

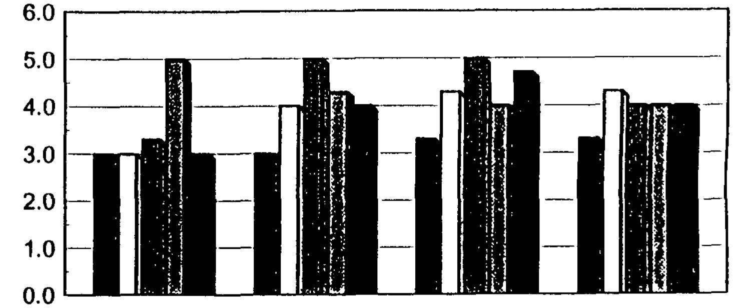
UNIVERSITY TESTS CONFIRM EFFECTIVENESS

Clipping Weights



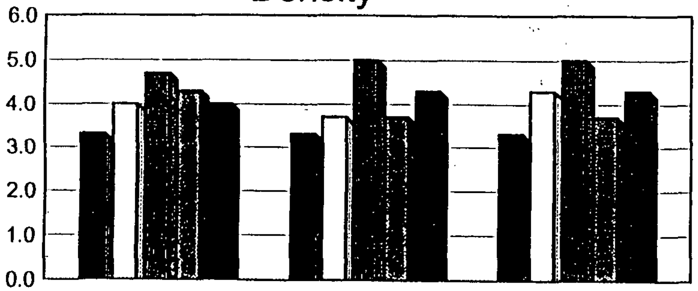
	July 4	July 11	July 18	July 25	Aug 2	Aug 8	Aug 17	Aug 22	Aug 29	Sept 5	Sept 12
Check	21.5	8.8	9.3	5.6	9.7	6.2	5.5	6.0	6.2	4.8	4.4
Vitorganic	22.4	10.2	12.4	8.6	10.1	5.3	6.9	5.5	6.4	4.8	3.2
Canola	25.0	16.4	17.7	9.5	14.7	6.5	16.9	15.9	16.2	6.4	4.8
Sustane	23.5	9.8	10.5	5.6	9.0	4.3	3.5	6.2	4.5	3.8	4.0
Milorganite	27.0	11.5	10.8	6.3	10.7	5.3	7.0	5.5	6.8	4.9	2.6

Uniformity



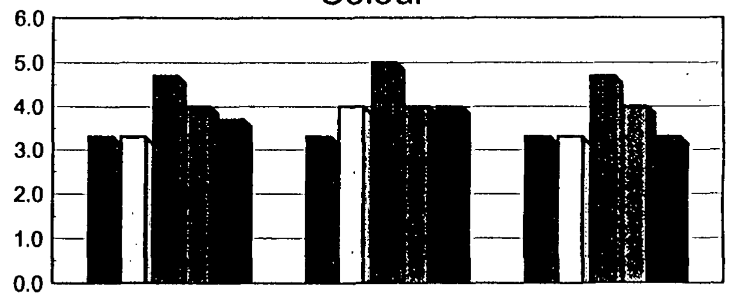
	July 2	July 18	July 31	Sept 6
Check	3.0	3.0	3.3	3.3
Vitorganic	3.0	4.0	4.3	4.3
Canola	3.3	5.0	5.0	4.0
Sustane	5.0	4.3	4.0	4.0
Milorganite	3.0	4.0	4.7	4.0

Density

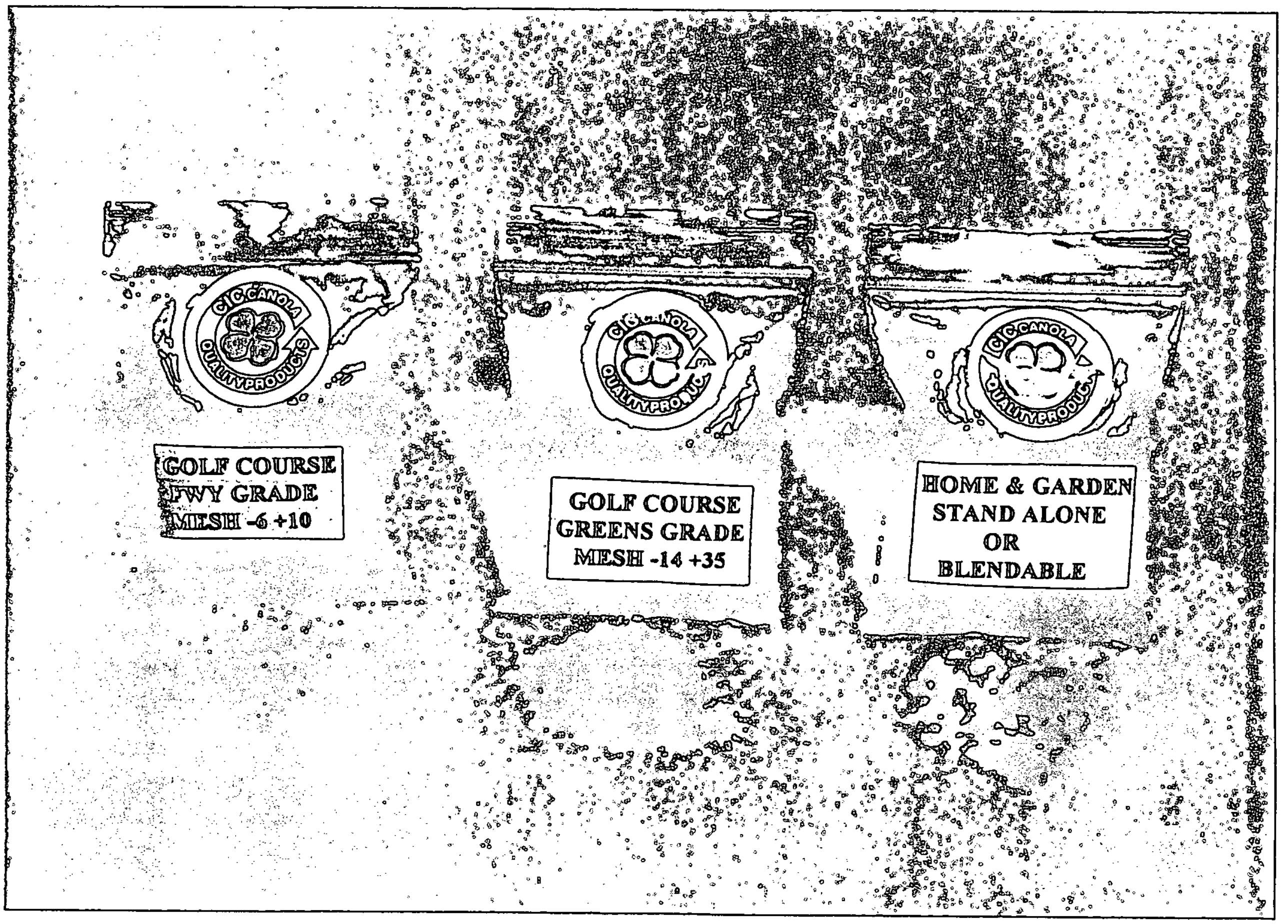


	July 18	July 31	Sept 6
Check	3.3	3.3	3.3
Vitorganic	4.0	3.7	4.3
Canola	4.7	5.0	5.0
Sustane	4.3	3.7	3.7
Milorganite	4.0	4.3	4.3

Colour



	July 18	July 31	Sept 6
Check	3.3	3.3	3.3
Vitorganic	3.3	4.0	3.3
Canola	4.7	5.0	4.7
Sustane	4.0	4.0	4.0
Milorganite	3.7	4.0	3.3


CIC CANOLA
QUALITY PRODUCTS
GOLF COURSE
FWY GRADE
MESH -6 +10
GOLF COURSE
GREENS GRADE
MESH -14 +35
HOME & GARDEN
STAND ALONE
OR
BLENDABLE

Appendix 2

HumberPalmers Standard Grades

GRADE	N	P	K	MgO	SO3
No.1	0	12	18	0	14.0
No.2	2	10	30	0	8.0
No.3	3	15	15	0	15.5
No.4	6	12	22	0	16.0
No.5	7	14	7	0	25.0
No.6	7	5	12(SP)	3.5	35.0
No.7	7.5	7.5	14	0	26.5
No.8	9	4	10	5.0	22.5
No.9	9	12	15	0	19.0
No.10	10	10	10	0	25.5
No.11	10	5	16	0	31.5
No.12	12	6	6	0	37.0
No.14	15	7	7	0	31.5
No.15	16	4	4	0	33.5
No.16	18	2	12	0	26.0
No.17 NITRIPAL (with six trace elements)	18	2	0	4.0	34.0
No.18	20	4	5	2.0	26.0
No.19 NITRAGRO	26	2	0	2.0	30.5
No.20 CONSERVATION	1	12	12(SP)	0	30.5

More Information

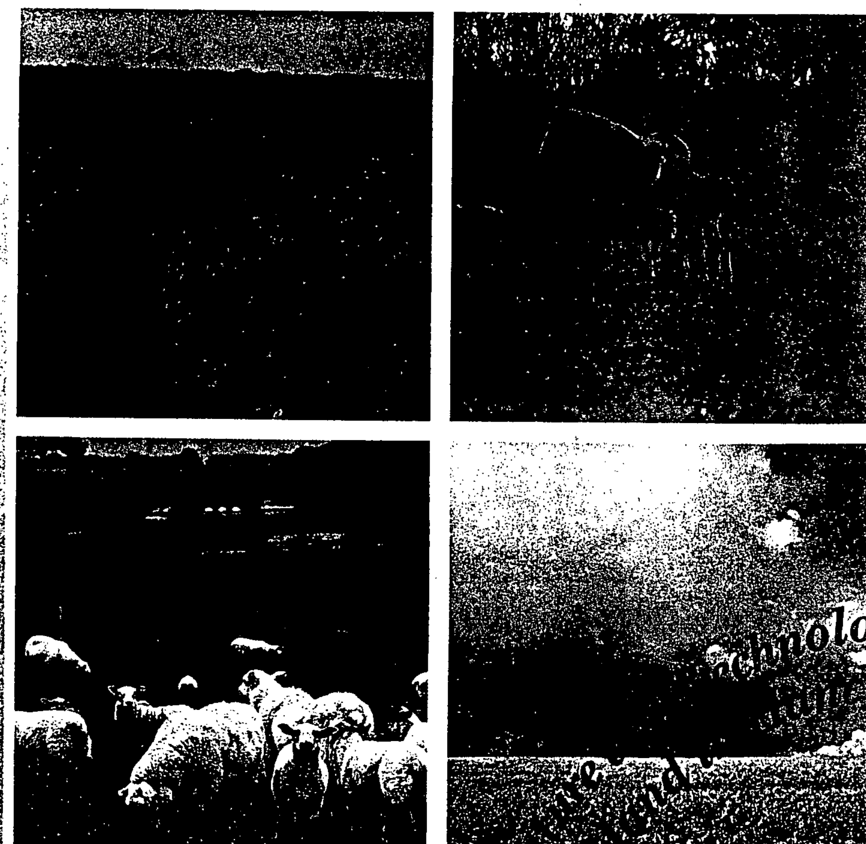
Ask your local salesperson named below for further information.

SHEPPY

Introducing you to

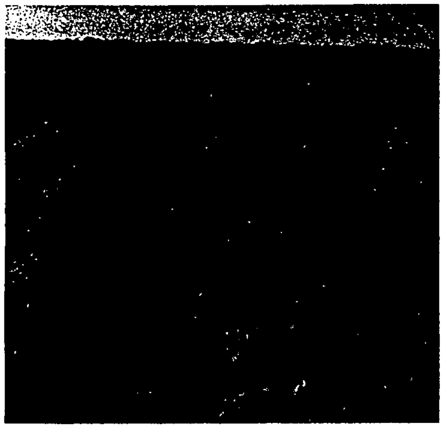
HumberPalmers

Granular Organic Based Fertilisers



What are HumberPalmers
Granular Organic Based Fertilisers?

Our fertilisers are manufactured from a carefully selected organic base, to which we have added mineral ingredients in measured proportions to achieve the formulations detailed in this booklet.

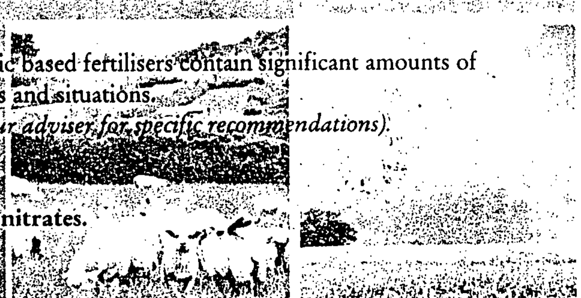


Organic Base - Vegetable Origin

The organic base is a well researched, unique formulation from **vegetable** origins. The organic raw materials are carefully chosen to create **HumberPalmers** high performance and efficiency.

Phased Relea

The organic ba
release of plan
reducing waste
volatilisation.



Sulphur Content

HumberPalmers granular organic based fertilisers contain significant amounts of **Sulphur** - enough for most crops and situations.
(Please don't forget to consult your adviser for specific recommendations).

Nitrate Free

Our fertilisers contain **no added nitrates.**

Trace Elements

A large selection of trace elements are also contained in the organic base and in the carefully selected mineral raw materials. Specific trace element deficiencies however should be treated separately once the specific deficiency has been identified.

Granular

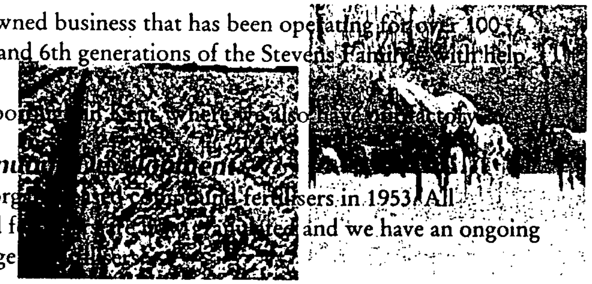
HumberPalmers products are true granules, not a blend, with each granule containing a proportion of each plant food nutrient.

Farmers Contact Line: 0345 573361

About Sheppy

Family Owned

Sheppy Fertilisers is a family owned business that has been operating for over 100 years. It is now run by the 5th and 6th generations of the Stevens Family with help from others!
Our main offices are at Queenbo



First to Granulate - Contin

We were the first to granulate org ... fertilisers in 1953. All **HumberPalmers** organic based f ... and we have an ongoing programme to develop our range

HumberPalmers

In 1989 we purchased the well established Palmer Agricultural business and later the Humber Fertiliser Agricultural business. All Sheppy granular organic based fertilisers are now marketed under the **HumberPalmers** brand.

Largest in the UK

The amalgamation of these three businesses makes us the largest organic based fertiliser company in the UK which means....

nationwide coverage
investment in research and development
comprehensive support services.

...But we're still small enough to care and take notice of what our customers need.

Nature and Technology
Hand In Hand

Sheppy Fertilisers Limited
Rushenden Road
Queenborough
Kent ME11 5HH
Tel: 01795 580181
Fax: 01795 580649

What are the Benefits of Using HumberPalmers Granular Organic Based Fertilisers?

Bigger and Better Crops

Independent research has shown that **HumberPalmers** granular organic based fertilisers help to grow **bigger** and **better** crops across a wide range - from grass to cereals to fruit and vegetable crops.

Phased Release - Waste Reduced

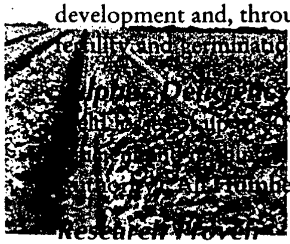
Through the **phased release** of plant food, **waste** as a result of leaching or volatilisation **is reduced.** In other words, the plant gets a far higher proportion of what is applied.

Organo - Mineral Reactions

The granulation process **combines** the highly beneficial complex **organic compounds with** the **mineral nutrients.** This, together with the phased release properties, gives the best agricultural results.

Bacterial Activity Stimulated

Because **HumberPalmers** products are nitrate free and organic based, they **stimulate bacterial activity.** This enhances root development and, through a phased release of plant food, will improve long-term soil [illegible]n.



[illegible] Prevented

[illegible]% have occurred under some conditions when **Sulphur** is [illegible] done to rectify the situation (Source: Home Grown Cereals [illegible] All HumberPalmers products contain significant amounts of Sulphur.

Research Proven

Independent scientific research in ryegrass trials has shown **HumberPalmers** granular organic based fertilisers;

- out-perform the best **mineral** fertilisers by up to **35%** in yield terms on some crops;
- have approximately **25% higher take-up** of plant food nutrients compared with the best mineral fertiliser;
- have a lower plant nitrate content;
- produce bigger and [illegible] crops!

Agronomic Value = Caring For the Environment

By providing you with enhanced agronomic value as shown above, we can also help you in your contribution towards improving the environment.

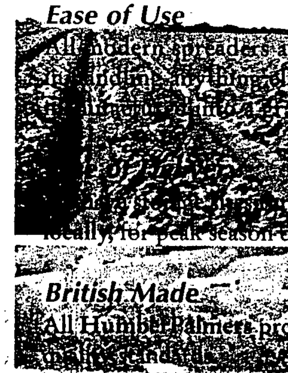
Farmers Contact Line: 0345 573361

Additional Benefits

Ease of Storage

HumberPalmers granular organic based fertilisers are manufactured into a granule for **ease of storage.** They are packed in 500kg IBC's and 50kg sacks on free pallets.

Ease of Use



All modern spreaders are [illegible] to spread prills or granules and have difficulty [illegible] r organic based fertilisers are [illegible]

[illegible]

[illegible] throughout the country which means our products are **available locally** for peak season demand.

British Made

All HumberPalmers products are made in the **United Kingdom** to high [illegible]

Soil Analysis

We offer our customers a free **soil analysis** service to determine the correct analysis to use. This service provides our customers with up to date knowledge of the fertility level of their soils.

Personal Service

Our sales are looked after by a nationwide team of salespeople. We cover most of the country from the Orkney Islands to the Channel Islands, so we give a personal service - something which a lot of major companies no longer do.

Agronomic Advice

If there is any doubt as to which HumberPalmers fertiliser should be used, FACTS qualified advisers are available for either farm visits or telephone enquiries.

Farmers Contact Line: 0345 573361