IENICA

REPORT FROM THE STATE OF BELGIUM
FORMING PART OF THE IENICA PROJECT

IENICA is a project funded under the FAIR Programme by DG XII of the European Commission

Prepared by
ir Frédéric FRANCIS under the supervision of
Professor André FALISSE
Faculty of Agricultural Sciences
Crops Production Unit
Passage des Déportés 2
B-5030 Gembloux Belgium
Phone : 0032 81 622140 Fax : 0032 81 622407

Methodology for the report preparation

This report aims to gather a maximum of information about the so called "non food" crops and issues for agricultural products in Belgium. The country is divided into two regions and a lot of sectors, agriculture included, are organised at two power levels: federal and "regional" (Flemish or Walloon, if not taking account of Brussel's region).

Up to now, no public or private organisation had collected these industrial activities. In 1996, a research-development project "Chimie Verte" (Green Chemistry) was preparing a report for the Walloon Authorities on that theme.

First steps have been to identify research and industrial groups involved in the non-food sector.

Contacts have been made with representatives of most of them, by phone, fax and often interviews. Quantitative data was rarely available to characterise Belgian activities or issues for all defined products. In this case, this report can display some lack regarding products which are non developed in Belgium.

Most useful organisations were :

- National Institute of Statistics (I.N.S.),
- Agricultural Economy Centre (Centre d'Economie .Agricole), Agricultural Research Centre at Gent (C.L.O.) and Gembloux (C.R.A.) (all of Federal Ministry of Agriculture),
- Flemish Regional Ministry of Agriculture
- Walloon Regional Ministry of Agriculture, Environment and Natural Resources
- Belgian Biomass Association (Belbiom),
- Chimie Verte (Fac.Sc.Agron. Gembloux),
- V.I.T.O. (Vlaamse Instituut voor Technologische Onderzoek),
- V.I.B. (Vlaamse Instituut voor Biotechnologie),
- Sorghal, VALONAL, APPO, several associations,
- European Commission and reports of various research and development actions supported by the European Union.

Most of the private companies which have contributed to provide information are listed in the annex.

The most successful medias have been phone calls, fax and e-mail. The use of Internet has given poor results. Literature reviews have given a lot of basic information on various non-food uses and on industrial processes. Agricultural magazines, agrotechnology and professional periodicals, commercial leaflets have provided various and sometimes contradictory data.

Executive Summary

The report has been divided into four parts – oil, fibre, carbohydrates and other compounds- but several proposals applying to all parts can be formulated as an introduction.

European Union must be considered simultaneously as a producer of raw agricultural materials, as a processor of agricultural products widely open to -or constrained by- the world market, as a large but nevertheless limited market, as a territory with natural and man-made environment to be managed if not protected and as a population whose a decreasing proportion is living on agricultural activities that transform atmospheric CO_2 into usable organic matter.
In our review, very *few plant based end-products have appeared as real "new" products*. Nearly all appear as existing end-products wherein vegetable based materials could serve as substitutes for currently used raw material from non agricultural origin: vegetable oils to replace mineral oils in lubricants, agricultural fibres to replace synthetic and forest fibres, bioplastics in place of plastics, …. Those "green" products display about similar qualities, rarely superior, sometimes inferior, to the "conventional" or "synthetic" products but by their origin they contribute to saving limited non renewable resources, they participate to carbon cycle without increasing the disequilibrium due to the wild injection of fossil carbon into atmosphere as CO_2 and many of them display less risks for human health (toxicity) and environment (ecotoxicity).
So it appears that the future development of non food plant-based end-products is little if any linked to superior functional properties but widely depends on the importance given to side-features such as human health, environment, agricultural activities in rural zones, whose value is uneasy to precisely assess. The industry will follow- if not precede- according to the demand - spontaneous or oriented by public regulations- progressively providing "new" green

products and solving all technical problems linked to economical and ecological melioration of the making processes. European Union programs could

- support basic technical research on plant and on industrial processes,
- aim to adopt common legislative measures on environment, health, genetically modified organisms,
- support management of sound data bases,
- help in the definition of industry needs and
- favour dialogue between agriculture, industry and the society as a base for organising the production networks and chains and for taking advantage of agriculture potentialities.

Part 1. Oil crops

1. Current development of oil crops in Belgium is limited to a relatively small production of oilseed rape (5,000 to 10,000 ha; 7,000 to 15,000 t oil) and to a very small acreage of linseed (less than 200 ha). Surfaces devoted to non-food oil crops broadly reflects the set aside rates in the CAP frame. There is no direct link between agricultural production and real industrial needs.
2. Several alternative oil crops have displayed poor agricultural performances due to a lack of adaptation to local ecology and to not sufficient domestication, so that no species could be currently recommended for secure and profitable cropping at farm level. Furthermore industry demand for specific fatty acids or other components is not clearly defined.
3. In Belgium, the development of oil crops for non-food uses (bio-fuels not included) will be slow, linked to the Agenda 2000 and the future CAPs. Legal rules or incentives could increase the use of vegetable oils and favour or impose the use of European vegetable oils.
4. One part of rape oil and all linseed oil is dedicated to non-food uses and enters uses such as paints, detergents, inks, lubricants… . Those sectors have recently given more attention to vegetable oils and seem to be capable of a significant development of the volume they utilise.
5. At the processing level true technical barriers are only few and they could be solved.
6. Future development of non-food vegetable oils is largely linked to environmental awareness and incitements to replace mineral oils.
7. Priorities could be given to vegetable oil products displaying advantages in relation with human health and environment protection. Lost lubricants, lubricants used in the food sector (30.000 t for Belgium, nearly 1.000.000 t for E.U.) and surfactants notably those used in detergents, cosmetics and body-care products appear as priorities, followed by vegetable inks

and surfactants for other uses. Vegetable oil based products could enter as fuel additives, be it in small proportion, contributing in fossil oil resource savings.

8. In an open market, European vegetable oils are in competition with foreign oils. The ability of facing that competition depends on agriculture capability to produce suitable oils at low price i.e. high yields, precise and optimal input use, on-farm and post-harvest effectiveness. European agriculture has the right to take part in - and profit of - quantitative and qualitative advances in plant breeding including those linked to GMO.

Part 2. Fibre crops

1. Fibrous raw materials are from forest and non-forest origins.
2. In Belgium, vegetable fibres and lignocellulosic products other than forest wood are from cereal straw and from flax. It seems that straw must widely remain as a by-product to be recycled by agriculture itself (soil organic matter, animal husbandry). Up to now attempts for developing other agricultural crops (hemp, sorghum, Miscanthus, short rotation coppice) have been unsuccessful. Hemp could most easily enter existing farming systems.
3. Surface devoted to forest in the European Union has increased during this century and forestation is still encouraged at the moment. In Belgium, forest surface has reached about 600.000 ha, one fifth of the territory area. Forest management and wood exploitation have continuously improved and in a lot of applications wood will remain an important competitor to agricultural fibre and lignocellulose.
4. Except in textiles where cotton, wool and artificial fibres successfully compete with flax and hemp very few end-products can be considered as "noble" products. In a lot of materials (paper, cardboard, building materials) substitution is easy from one to another fibre or lignocellulose source. Plant fibres could replace some fossil-originated materials. But due to a low value per unit produced, the production of fibre crops will remain located on marginal lands in competition with forestation or on set aside land.

Part 3. Carbohydrate crops

1. Numerous crops provide carbohydrates in the broad sense, mainly under the form of sugar (beet, chicory) or of starch (cereals, potato).
2. Many of those species are very effective in utilising light, water and minerals resources.
3. Industrial processes allow nearly all transformations from sugar and starch to various polymers, plastics, and basic materials for composite material preparation.

4. In that topic agricultural products may provide a large spectrum of raw material as close as possible adapted to specific end-products. Various carbohydrates coupled with vegetable oils derivatives and with fibres from wood or crops can supply a lot of materials displaying precise functional properties, suitable life-cycles (degradability, aptitude to recycling, properties in relation to environment) including savings in fuels (petrol additive as ETBE) and energy supply.

Part 4. Crops with special uses.

A lot of biomolecules synthesised by plants as secondary metabolites have found uses in the past, are still in use or have been replaced by artificial looking-like molecules. Natural condiments, flavours, dyes, perfumes plus drugs, herbal drinks will still be in demand. Some species could be promoted for various reasons from ecological to functional (drug effectiveness, absence of non-desired side-effects on health and environment). In Belgium, if a set aside is proposed to farmers, where more biodiversity is wished, for instance in natural park areas, or if plant-originated "agrochemicals" are promoted, some crops (dyes, medicinal plants) could be encouraged. They will occupy small surfaces but could provide some revenues if the sector is well organised, i.e. dialogue between producers and processors, volume of the production adapted to the demand, contracts with industries, quality criterions, prices.

Part I Oil Crops

Part I Oil Crops

Opportunities

Crop species and their production methodologies

Crop species grown in Belgium are **oilseed rape** (1.1.1) and **linseed** (1.1.2). In the last two decades unsuccessful attempts have been made for introducing sunflower, soybean (not included in the report) and several minor species (1.1.3).

Oilseed rape

1. The oilseed rape crop had completely disappeared in Belgium after the second World war, due to numerous possibilities of other profitable crops (sugar beet, cereals, potato, fodder crops). Attention to oil and protein crops only appeared around 1980 when sugar beet areas were more strictly limited by quotas systems and as the EEC encouraged the production of these crops by price support. The need for non-cereal crops in the rotations generated a moderate interest for oilseed rape that never exceeded a threshold of 15.000 ha mainly located in regions considered marginal for sugar beet production.
2. Since 1993, the evolution of oilseed rape areas is linked to the set-aside rate, corresponding to the opportunity to produce non-food industrial oilseed rape. Recent reduction of the set-aside rate has lead to a reduction of the oilseed rape surfaces. Nowadays, surfaces of food oilseed rape remain stable around 5.000 ha and non-food surfaces on set-aside land around 1.500 ha only.
3. All varieties are “double zero” (no erucic acid and low glucosinolates (isothiocyanates) contents). The recent hybrid varieties have quickly taken an important market place representing around half the surface in 1998.
4. **Cropping practices**: Winter oilseed rape representing more than 90% of the surface in rape is drilled from mid-August to mid-September after winter barley or winter wheat. Spring OSR is sown in March-April. Usual densities are between 2.5 to 5.0 $kg.ha^{-1}$. Cropping practises are very similar to those in the neighbouring regions of France and Germany.

Nitrogen fertilisation is managed in such a way to provide a minimum of 250-300 kg inorganic N.ha^{-1}, partly from mineralisation of organic matter and from soil reserves and partly from mineral fertilisers. Insects causing problems are *Psylliodes chrysocephala, Melighethes aeneus, Ceutorrhynchus napi and C. assimilis*. Main diseases are *Phoma lingam* and *Sclerotinia sclerotiorum*. On average the crop protection requires one herbicide, one fungicide and two insecticide treatments. **Harvest** occurs between July and mid-August for the winter varieties, with yields between 2.5 to 5.5 t.ha^{-1}. Yields have increased of more than 1 ton in the last twenty years, averaging 4 t.ha^{-1}. Harvest of spring oilseed rape starts in August with a risk of difficulties in late and humid seasons and with yields lower than 4 t.ha^{-1}, averaging about 2,5 t.ha^{-1}.

Table 1 Set aside surfaces and surfaces of oilseed rape and linseed in Belgium

	1994	**1995**	**1996**	**1997**	**1998**
Total set aside area (ha)	26.360	21.940	17.664	11.802	-
Total oilseed rape area (ha)	15.349	12.634	8.579	6.250	
Total oilseed rape area on set-aside (ha) of which Winter varieties Spring varieties	9.438 *8.348* *1.090*	6.967 *6.261* *706*	3.734 *3.504* *230*	1.377 *1281* *87*	1.597 *1565* *32*
Oilseed on set-aside (% of oilseed rape)	36	32	20	13	-
Linseed on set-aside (ha)	654	206	140	35	8

Linseed

In the last decade linseed has been cultivated under the set-aside regime which implies the necessity of a contract between the farmer and the industry. The meal of linseed doesn't enter the quota of 1 million tons of " soya meal equivalent " defined in the GATT as the maximal meal production for the European Community.

The linseed area has decreased in Belgium from 1994 (maximum surface 885 ha of which 654 under set-aside regime). Linseed is known to be a very versatile crop with fluctuating yields (1.5 to 3.5 t.ha^{-1}) due to frequent difficulties for early sowing, to late ripening, to difficult seed

desiccation after rain and to risks of sprouting before harvest. The crop is sown from mid March to end April at a density of 60-75 kg seeds.ha^{-1}. Nutrients needs are limited.
The future of this crop in Belgium is unknown because yields display large inter-annual variations (1.500 to 3.000 kg.ha^{-1}) and its economic effectiveness is low. Farmers would be interested in the development of winter varieties with earlier and easier harvest and higher and more regular yield.

Alternative Oil Crops

Studies in experimental fields were carried on some marginal oil crop plants (A.P.P.O. and F.U.S.A.Gx). Due to their low yield potential or to very high variability from year to year, they constitute only experimental crops. For all of them, there are no registered insecticides or fungicides and chemical weed control is often hazardous. [2,7,21,22].

Crambe abyssinica

Sown at the density of 10kg.ha^{-1}, this spring species is very sensitive to frost. Crop can be harvested about 100 days after sowing with maximum yield of 2.5 to 3 tons of grains per ha and high inter-annual variability. Aside these negative traits, an important brake to its development is the difficulty to extract the oil (35% of the grain with an interesting 55% erucic acid). ***Uses***: lubricants, plastics or nylon.

Camelina sativa

Spring or winter varieties are respectively sown in April or mid-October with a 7-8 kg.ha^{-1} seeds density. Yields obtained have been between 1.5 to 3 t.ha^{-1} for the spring varieties and about 3-4 t.ha^{-1} for winter varieties. The oil (30-40% of the grain) is interesting for its high rate of gondoic acid (until 19%) and anti-oxidising agents. ***Uses***: paints, inks and cosmetics.

Lesquerella grandiflora and L. gordonii

These species are not really adapted to the temperate climate of Belgium. Their seeds contain 25 to 35% of oil with 55% of lesquerolic acid (C20:1-OH). *Uses* : lubricants, nylon and plastics, gums which could be used as thickeners in food or cosmetics.

Limnanthes alba

Good climatic conditions are requested at flowering stage in order to favour insect pollination which is necessary to obtain yields from 0.8 to 1.8 t.ha^{-1}. Seed contains about 30 % oil of which 95 % is constituted by mono-unsaturated long chain fatty acids showing high stability to heat and air.

Dimorphoteca pluvialis

This species suffers from weak resistance to cold. Grain ripening is spread out and seeds shatter which results in low yields at harvest (0.6-0.7 $t.ha^{-1}$).

Calendula officinalis

The main problem is seed shattering at harvest. Yields varied from 1.5 to 2.5 $t.ha^{-1}$ of seeds with oil contents around 20 % with 60% calendic acid and 30% linoleic acid. This oil displays important viscosity with high refraction index. Its easiness of drying is of value in paints.

Carthamus tinctorius

Good pollination by insects is needed to obtain high seed yield up to 3 $t.ha^{-1}$ with a maximum of 50 % oil (linoleic and oleic acids). Red-orange pigment extracted from flowers can be used in textiles or cosmetics.

All these crops are grown for their seeds. Yield is linked to good crop establishment, dry weather at pollination notably for entomogameous crops and dry weather during ripening. They highly suffer from seedset spreading which induces irregular ripening and from seed shattering before harvest.

Crop products

Typical compositions of rapeseed and linseed oils are given in table 2.

Table 2 Composition in fatty acids of rapeseed and linseed oils

Fatty-acid Components		Component in % of total fatty-acids	
		Rapeseed	Linseed
palmitic	C16:0	4-6	4-6
stearic	C18:0	1-3	2-3
oleic	C18:1	55-65	10-22
linoleic	C18:2	20-22	12-18
linolenic	C18:3	6-10	60-70

Rape oil is devoted mainly to food uses and partly to non-food including biofuels; flax oil is restricted to industrial uses. Oils obtained from these crop species display different compositions and technical characteristics useful for several industrial applications such as lubricants, inks, detergents, etc.

Rich in proteins (up to 40 % for oil seed rape) the meals are appreciated in animal feeding. Through genetic elimination of glucosinolates rape meal quality has drastically improved.

Table 3 Linseed oil production in Belgium, in tonnes per year (average 1996-98)

Companies	Oil produced (in $t.y^{-1}$)	Main issues
Scaldis	15.000	Linoleum, detergents
Oliefabriek	25.000	Linoleum, inks
Vandeputte	16.000	Detergents, soaps
Braet NV	12.000	Linoleum, paints, inks, soaps
Total	68.000	

Linseed oil production is about 170.000 tons per year in Europe and could have a potential increase of 10% per year.

Novel technologies being developed and their impact

1. The largest proportion of the research effort on oil crops is devoted to species considered as important crops at the world level, mainly sunflower, soybean and oilseed rape.
2. Researches on oilseed rape are mainly in the fields of genetic amelioration and cultural practices.

Cultural practices innovations aim to lower the costs per unit of seed produced and to reduce the potential hazards of environmental pollution, mainly through effective use of fertilisers and agrochemicals, higher recovery rate of inorganic nitrogen, better and earlier crop installation, improved seed treatments for plant protection.

Breeding main objectives are:

- to increase yields and yield stability by improving agricultural features such as precocity, grouping of flowering and ripening, disease resistance, resistance to shattering, …
- to modify the seed components: increase of protein content for higher fodder value of the meal, increase of oil content or modification of fatty acids balance as already done in the past with the suppression of erucic acid in oilseed rape and the recent breeding of varieties with oleic acid representing up to 80% of the total fatty acids content. These varieties could be soon released on the agricultural market.

In oilseed rape recent development of **hybrid seeds** will continue notably through the utilisation of male sterile lines and allow still higher yields. Bio-technologies are widely involved in the breeding of new varieties. Genetically modified organisms could be more acceptable for non-food species or varieties, but specific questions remain for rape which is very prone to spontaneous crossing with brassica weeds and volunteers.

Industry needs for and uses (current and potential)

Global needs

1. Vegetable oils suffer from the competition with tallow oils and mineral oils as basic commodities for nearly all non-food uses such as lubricants, vegetable inks, paints, coatings, soaps, detergents and various surfactants. In all those applications the potential exists for replacing mineral oils with vegetable oils and up to now that substitution has already started. Vegetable oil is also an intermediary raw material for several uses as linoleum (linseed oil), …
2. Industrial treatment starts with oil extraction by mechanical separation (trituration) of oil and cake (or meal) and/or by chemical treatment using solvents.

Second step can be oil esterification or hydrolysis. Esterification leads to methyl-esters and to glycerol as a by-product. Hydrolysis generates fatty acids and glycerine.

3. Methyl-esters find different destinations. In several EC countries (France, Germany, Austria, Italy) they are partly used as **biofuels** (not included in this report). In Belgium they find place in various applications such as lubricants, surfactants, fatty acids, their derivatives and co-products (fatty alcohols, fatty amines, glycerol, methyl esters, various esters) are basic substances for lipochemistry.

Biolubricants

1. Lubricants are made of oil and various additives such as antioxidants [10]. "Green lubricants" are made of a single vegetable oil (supplemented with additives and refined) or of a mixture of several oils and an ester resulting itself from alcohol/fatty acids reaction.

Increase of the ester rate (until 70%) has been a general trend in recent formulations. Esters have better lubricating properties regarding resistance to oxidation and high temperature. Biolubricants cost 2 to 10 fold the cost of mineral oil lubricants. Lubricants based on vegetable oils are not suitable for 4-strokes engines due to their lower resistance to high temperatures. Main advantage is their level of degradability which is higher than 90% in 21 days and much higher than the one of mineral lubricants.

2. Biolubricants producers wish to obtain vegetable oils with simplified fatty acid composition (e.g. sunflower rich in erucic acid, oilseed rape rich in oleic acid). Depending on the application, some specific properties are needed for the oil. For lubrication important oil

characters are fluidity (linked to the presence of at least one double link in the fatty acid chain), high energetic power (only one double link), mechanical resistance, resistance to oxidation (low rates of linoleic and linolenic acids), therefore the interest for the mono-unsaturated acids as oleic acid (C18:1) that best fits those requirements [5].

3. In Belgium, aside large multinational oil companies, OLEOFINA (part of PETROFINA) produces biolubricants for numerous uses.

4. **Biodegradable lubricants** currently used in Belgium only represent about 100 tons (equivalent to 0.05 % of the about 200.000 t total market of lubricants and 0.3 % of lost lubricants). (Table 4).

5. Vegetable saw chain oil is constituted of 90% of rape oil. Casing oil for concrete work is made of about 10 % of vegetable oil and of esters from vegetable origin.

Table 4 Lost lubricants and accidentally spread oils. Consumption in Belgium [5, 6].

Lost lubricants	**Amounts in tons**
Chain saw oils	1050
Motor oils (2-strokes engines)	1600
Formwork oils	2000
Grease	2875
Anti-dusts oils (cereals, fertilizers)	3440
Pneumatic materials oils	160
Protection oils	1370
Antifreeze for planes	5060
Accidental spreads	
Hydraulic fluids	9650
Shock absorber oil	2000
Total	**29205**

Paints and coatings (varnishes, enamels)

Among the paint industries several companies use significant volumes of vegetable oils. All companies have declared an interest for developing vegetable oils incorporation in the future. Linseed oil is well represented in the composition of a lot of natural paints (until 80% in some applications) [6]. It is used as thinner playing both the roles of solvent and resin. The oil dries

by oxidation as a film covering the painted surface. Natural paints dry more slowly and stay softer; they still include some organic compounds which confer interesting properties.
Alkide resins used in varnishes and paints allow the formation of films of variable drying times. They can be obtained from polyesters resulting of the condensation of polyalcohols and fatty acids of which a large part can be from vegetable origin.
The culture of **plants for stains** extraction could be a new opportunity. Artificial stains are made from anilin, compound suspected in some cancer apparition. European Ministers of Environment have adopted a directive in order to reduce by 50 % the Volatile Organic Compounds emission convinced of contribution to tropospheric ozone degradation and of harmful effects on human health.

Inks

- Printing inks are made of three components: pigment determining the colour, varnish and/or oil for pigment coating and for transfer, and additives whose nature is function of the application (resins, surfactants). Pigment is responsible for the transparency and resistance to light and heat. The cost of colour ink is mainly linked to the cost of pigment. The cost of black ink is mainly due to the oil price, oil entering for about 50% volume in the ink composition. Mineral oils have been traditionally used but recently the requirement for lower VOCs (volatile organic compounds) has focussed interest on oils from soybean, linseed or oilseed rape which have recovered a significant part in the production of vegetable inks. Previous developments of vegetable oil based inks had been restricted due to indications that deinkability and printability of such inks were poor compared to that of mineral oil based inks. Recent researches have resulted in significant improvement of vegetable inks and the new formulations are competitive with similar quality mineral oil inks.
- In 1990, the total production of printing inks for Europe was around 530.000 tons. Coldset (fast rotational printing press) and sheet fed inks represent 130.000 tons and all could be "vegetable inks". In hotset (illustrated magazine), only 20% of the oil could be substituted by vegetable ones. Current consumption of vegetable oil for inks in Europe is estimated at 12.000-15.000 tons and could reach 25,000 tons in 2000 [3].
- In 1996, 2500 tons of vegetable oils have been used by Trenal, a Belgian company specialised in ink preparation. With a production capacity of 20.000 tons per year, it currently produces annually 14.000 tons of inks for a value of 1,5 billion BEF. More than 50% of the total production is made of vegetable oils.

- All Belgian newspapers are printed with natural coloured inks and 70% of them use vegetable black inks.
- Advantages offered by the new vegetable inks are :

- beneficial for the environment due to their high biodegradability and lower volatil organic compounds emissions
- higher stability and easier cleaning of the rotational offsets
- absence of odour and higher resistance to rubbing (no traces on the readers fingers)
- for coloured inks: contrasts without dry-back
- less additives needed for identical densities

- In "sheet fed" inks rape oil and low prices soybean oil replace linseed oil. These oxidative inks from vegetable oils give good results in rapid printing press. In heatset, ink drying is due to the resins polymerisation by evaporation of light mineral oils and vegetable oils are less adapted to this application.

Detergents

Vandeputte, one Belgian leader in biodegradable detergents was only a linseed grinder until 1970 before starting a production of soaps and liquid detergents. Table 5 summarises its activity on the last twenty years and perspectives for the future. The company used to import Canadian linseed grains but from 1995, it also processes seeds from France, England and Germany.

Table 5 Production and objectives for a Belgian company producing vegetable detergents and soaps

Year	***1975***	***1980***	***1985***	***1990***	***1995***	***1996***	***2000 ****
Soap production (in tons)	1514	3653	7300	9800	12500	16000	25000
Oil production (linseed grains,t)	2000	2000	4000	6000	8000	25000	50000
Total sells (millions BEF)	66	96	307	360	425	650	1000
R & D (millions BEF)	-	-	-	0.5	12	15	25

Surfactants

Surfactants are used in many different food and non food applications, the latter including detergents (supra), plastics, paper, construction materials, cosmetics, pharmaceuticals, etc. Surfactants molecules are made of two components, one hydrophilic and the other hydrophobic. Currently the majority of surfactants are made of molecules of fossil origin but vegetable molecules can provide the two components, sugar derivatives and oil resp. for hydrophilic and hydrophobic parts.

Most specific requirements are for the hydrophobic part: in a number of applications short-chain fatty acids are needed (detergents, wetting agents) and they are more commonly found in non-European vegetable oils (palm) or in animal fats. For other applications long chain fatty acids are suitable (softeners, emulsifying agents).

Linoleum

Linoleum is made of natural stuffs: linseed oil, resins, wood, cork powder, calcium, vegetable pigments and hessian (jute). There seems to be a kind of come back for this material and the European market is expected to increase from 36 millions m² in 1995 to 56 in 2003. A significant part of the linseed oil produced in Belgium is exported to Dutch and German linoleum factories.

Additives and solvents for agrochemicals

Several agrochemicals (herbicides, fungicides, insecticides) already include in their formulation vegetable oils or their esters, in order to favour their solubility. Selected additives to treatments allow better performances of the agrochemical (easier penetration into the plant) and reduction of chemical rate. AGRICHEM in Belgium and other foreign companies produce oil and derivatives for such uses. New developments may reasonably be expected for this kind of application.

Pharmaceutics, cosmetics

The cosmetic sector needs special oils (some from minor plant species) and oil derivatives such as emulsifiers and surfactants *(supra)*. It has recently showed interest for all natural compounds, notably glycerol derivatives and surfactants, for their biodegradability, their good dermal properties and their low allergenic qualities.

Potential uses of plant species (not yet commercial)

Realistic expectations don’t see any significant development of new species in Belgium. While no better adaptation of marginal oil crops (confer 1.1.) is available, any change won’t occur soon and oilseed rape will remain the major crop.

Species producing some special oils adapted to pharmaceutical or cosmetic uses could know a limited development in some European regions.

Problems with crops or crop products and solutions

1. Several oil crop species have been experimented in Belgium, including sunflower, soybean and minor species (confer 1.1.3). The main problems to cultivate them are either their potential of production, their harvest difficulties or their poor adaptation to ecological conditions notably the climate. There could be potential production if agricultural amelioration can be brought to these species. Breeding of crop varieties better adapted to the north European climate could be the solution to spread those plants in Belgium and to valorise their existing potentialities linked to specific fatty acid contents.

2. Simultaneously outlets must be found for the non-oil components, commonly a meal rich in proteins that could be valorised in animal feeding if it doesn't contain anti-nutritional compounds.

1. Identification of new outlets for glycerol, by-product of oil esterification, should be welcome.

Markets and potential markets

Currently in the sector of oil crops, oilseed rape appears as the more suitable crop to significantly develop in Belgium. Other species could only develop in a limited extend in order to satisfy very specific markets. Oilseed rape could become a basic commodity for the oleochemistry. Its flexibility, the great capability of genetic variation in the genus and species notably in relation with fatty acids spectrum and the high increases in yields resulting from hybrid seeds and crop husbandry are some of the factors explaining the interest given to rape by multinational plant breeding companies often linked to the oleochemistry sector.

Biolubricants

In Belgium, the annual consumption of lubricants is around 200.000 tons. About 30.000tons (equivalent to 30.000 ha of oilseed rape) are used in lost lubrication, i.e. with high risks of being spread in the environment. The European market is about 5 Mt lubricants of which 15 % are lost lubricants. Mineral oils have low biodegradability (20-30% after 21 days) and present significant risks of water and soil pollution. One litre of traditional oil can pollute one million litres of water inducing toxic effects to plants, animals and humans and high purification costs.

Some distrust is still found in the performances and costs of these lubricants, even if most consumers are ready to test them. For instance the Belgian National Railways Company (S.N.C.B.) concluded that the global cost of lubricants made from vegetable oils is equal to that of mineral products: biolubricants are some more expensive per unit but they can be used in lower amount.

Inks

Information about **vegetable inks** production and utilisation is difficult to pool. If the printing sector does not know sharp changes in volume or in nature of printed materials, and if vegetable oils enter for a maximum ratio in ink composition the demand for vegetable inks could reach a minimum of 200.000 tons.year^{-1} within 10 years demanding about 100.000 tons of oil possibly from oilseed rape. Once again, the importance given to environmental benefits could play a major role.

Cosmetics

This growing market is estimated for Europe at 150,000 t of surfactants plus about 200.000 t oils.

Costs of production at farm and industry levels

At farm level

Table 1 Gross margin of oilseed rape crop, in BEF.ha^{-1}, year 1996-97.

Main product			Compensatory payment BEF.ha^{-1}	Total BEF.ha^{-1}	Specific costs BEF.ha^{-1}.	Gross margin BEF.ha^{-1} (°)
Yield t.ha-1	Price BEF.t^{-1}	Value BEF.ha^{-1}				
3.7	6,600	24,400	17,150	41,570	14,750	26,820

(°) Gross margin is defined here as the difference between Gross Revenue (value of the product plus Compensatory payment) and Specific costs only.

Table 2 Details of specific costs for oilseed rape (in BEF)

Seeds	Fertilisers	Pesticides	Other costs	Total
1,850	6,700	5,700	500	14,750

Table 3 Prices and compensatory payments for oilseed, in BEF.

Years	Oilseed price for food (BEF/kg)	+ oleaginous fund (BEF/ha)	Oilseed price for non-food (BEF/kg)	+ fallow fund (BEF/ha)
1995	6.45	13,927 to 24,338	5.30	10,230 to 18,915
1996	7.60	13,782 to 24,485	5.90	10,230 to 18,915
1997	7.80	14,507 to 25,352	7.85	10,230 to 18,915

Linseed

Linseed grain is paid at the world price, a fund is added function of the geographical region. In 1997, funds varied from 15.621 to 28.882 BEF/ha under general regime and from 10,230 to 18,915 BEF/ha under fallow regime.

Biolubricants: Cost elements

Table 4 Elements of Production Costs of one litre of hydraulic lubricant.

Source	Raw material cost (BEF)	Lubricant price (BEF)	Difference (BEF)
Mineral oil	10	32	22
Non esterified vegetable oil	20	64	44
Synthetic oil from unsaturated esters (vegetable basis)	60	96	36
Synthetic oil from saturated esters (vegetable basis)	90	128	38

The company OLEOFINA is the only producer of bio-lubricants in Belgium. Several other companies (BP, Wolf Oil Corporation) produce this kind of lubricants notably in Germany and sell them in Belgium.

There is no specific Belgian legislation about the lubricants.

About paints

Belgian producers of paints have sold 138.141 tons of paints in 1996 (9.5% reduction on one year) for a total value of more than 19 billions BEF. Average price per kilogram is 138.7 BEF (increase of 6.6% on one year). The Belgian interior market accounts for 48.8% of the production, or a quantity of 67.500 tons, more than half the production being exported.

Environmental opportunities (potential benefits)

Crop

When sown early in summer, winter oilseed rape has demonstrated its high capability to protect the soils from erosion and to absorb high quantities of soil mineral nitrogen, up to 250 kg $N.ha^{-1}$, therefore reducing risks of nitrate leaching to water tables.

Oilseed rape contributes to atmospheric CO2 fixation in quantities proportional to its total dry matter production, estimated at a minimum of 12-15 t.ha-1 for winter oilseed rape.

Products

Although the vegetable oils are more expensive than the mineral ones quantities needed are often inferior, as it is the case in lubricants. Global cost is thus equivalent but there is a benefit for the environment and the user's health. Certain vegetable oils display a fourfold advantage : a higher useful life, a reduced wear, a high biodegradability, no toxic effect for the users health.

Barriers to progress

Scientific and Technical issues

At agricultural level

Efforts notably in breeding are still necessary to better adapt the plant quality to the industrial requirements and to insure high and regular yields without increasing environmental risks. Significant advances are expected from genetically modified organisms, they are already exploited in several non-European regions but European citizen is still reluctant to those techniques.

At industrial level

The substitution from mineral to vegetable oils is already accepted by several industries; by-products valorisation remains an important objective.

Environmental aspects

At the crop level, demonstration is still to be made on the interest for environment of developing oilcrops for industrial purposes, notably on their contribution to greenhouse gas emission, to soil and water conservation.
Biodegradability of end- and by-products is of major interest and for several applications could rapidly become a decisive argument in favour of vegetable oil derivatives.

Legislative issues

- Up to now in Belgium, there is no specifie legislation directly relating to the use of products from vegetable oil origin.
- Crop surfaces are limited in the European Union by the agreements in the frame of World Trade Organisation.

Economic issues

1. Many companies in all sectors are ready to use vegetable oils as raw materials in place of mineral oils if the end-products may offer the same quality/ price ratio.
2. An opportunity to allow a profitable valorisation of industrial crops is to set contract between industries and farmers. The prices of raw materials should be known by the

companies and the farmers from the crop sowing. In fact, industry is often reluctant to fix prices at that time due to the price variations for substitutes on the world market. The capability to produce high quality of a specific raw material could justify such a contract.

Other items

Vegetable stuffs are not really known for most of the potential consumers (citizen or professional). For promoting green chemistry products the first step is to inform and sensitise those potential users. Once interests and needs will be identified, the demand will follow. For instance several demonstrations have been undertaken in Belgium in order to promote the use of biolubricants and biofuels. Sound information coupled with legislation could quickly enhance their development.

Prioritisation -areas of strength or weakness

Priorities in actions

The industry for primary treatment of oil seeds is well developed in the country. Main companies are linked to multinational groups and are capable of processing imported oilseeds entering the country via sea, road and rail. Advances done by several industries in developing processes for new products based on vegetable oils are significant but the main weakness for Europe is that vegetable oils sources are numerous and that the world market is offering large amounts of various fatty acids at low price.

Other weakness is the European reluctance to GMOs that could more rapidly provide transformed plants showing better agricultural and industrial features.

Priorities in actions could be given to:

- **information** on possible uses of vegetable oils,
- **legislation** relating to environmental and health protection
- **organisation** of sector from agriculture to end-user.

Information on products will commonly be done by industry and based upon the intrinsic properties of the product. Information on the interest of developing industrial crops in Europe is the mission of public services, research institutions and farmers organisations.

Legislation could favour uses of vegetable oils and derivatives as fuel additives and impose uses of vegetable oils notably in the lost lubricants and detergents sectors which are most linked to environmental protection. In the food processing sector all lubricants and detergents could be from vegetable bases.

Up to now, in Belgium, there exists no real **organisation in the vegetable oil sector** from farmer to industry and end-user. It would be useful to favour this kind of organisation. If regional or national initiatives are to be promoted there is a need for a strong organisation at European level taking into account the environmental, agricultural and other common policies. Several elements must be determined in relation with long term agricultural production capabilities (part of agricultural land to be devoted to non-food oil production, farmers revenues, prices).

Priorities in products:

In front of the broad variety of issues it seems useful to focus first on a limited number of products.

Among the industrial productions that could be quickly promoted and developed:

· **fuel additives**: that issues offers potential for large volumes, difficult to assess. Technical problems are solved, legislative aspects appear as the major incentive for launching their use. Priority could be given for captive floats in urban transports.

· **lubricants**, starting with lubricants used in the food industry equipment and with the so-called "lost lubricants" which could represent a significant volume of about 30.000 t for Belgium only;

· **inks**: information directed to the citizen on the interest of vegetable inks in printing; listing of the newspapers and magazines printed with vegetable inks; help to printers for facilitating the conversion to vegetable inks; …

· **surfactants**: broad variety of end-products used in sectors like washing and cleansing, textile, paints and dyes; priorities could be given to the cosmetics and detergents sectors.

Part II Fibre Crops

Part II Fibre Crops

1. Opportunities

1.1. Crop species, their production and products

Fibrous raw materials (FRM) are from forest and non-forest origins. According to several authors, a fibre supply crisis could occur in the next decades due to limitation in forest exploitation and to increase in the demand for industrial wood, fuelwood and paper. Agriculture could contribute to reduce the imbalance by developing annual or fast growing fibre crops mainly devoted to the paper industry.

Table : Average annual production and average market prices of FRM (fibrous raw material) in the E.U. (Koster, R.A.C., 1996).

	Production (1,000 t ODM)	Market Price (ECU/t ODM)
Non wood		
cereal straw	92,650	47
Rapeseed straw	8,500	47
Miscanthus	0 or low	55-100
Non wood with long fibres		
flax	21-25	175-235
linseed straw	255	82
hemp whole stalk	38	70
hemp bast fibre	13	320
kenaf whole stalk	0 or low	53-106
kenaf bast fibre	0 or low	235-470
Wood		
Eucalyptus	2,600,000	107
Poplars	1,728,000	175
short rotation coppice	0 or low	70-90

In Belgium, vegetable fibres and lignocellulosic products other than forest wood are produced by **cereal straw** and **flax**. Several other sources have been proposed in the recent period but have not been developed in the country: annuals such as **sorghum** and **hemp**, herbaceous perennials such as ***Miscanthus*** and some other lignocellulosic perennial plants to be grown in **short rotation coppice** (poplars, willows). These crops mainly produce carbohydrates and give two main basic products: fibres and other lignocellulosic compounds (short fibres, cellulose, hemicellulose, various carbohydrates).

1.1.1. Cereal straw

The straw produced on about 300,000 ha of cereals (nearly half the arable surface) at an average yield of 4.5 $t.ha^{-1}$ is chopped in the soil or harvested for animal husbandry needs (fodder, litter). In the past small amounts of straw have been used by paper industry and for building materials (insulation panels). As a fibre source for the paper industry its use has declined and almost ceased due to environmental and economic reasons but new processes (continuous steam explosion or STEX, twin screw extruder,…) have renewed the interest for this lignocellulosic material.

Studies done some twenty years ago on straw as a biofuel have known very little development. If wheat straw is sometimes regarded as a waste by-product of grain production, it is useful to remember its importance for agriculture itself where future priority will be given:

- to direct recycling of straw by agriculture as the most efficient way to maintain basic soil fertility in relation with soil structure, organic matter cycle, humus quality
- to its utilisation in animal husbandry in relation with the wish to encourage more natural husbandry practices (straw litters) and to reach better C/N ratios in animal effluents used as organic fertilisers.

1.1.2. Flax

Flax is a traditional crop in Northern and Central Belgium and in neighbour regions of France and The Netherlands where its ecological needs are best fulfilled. Area grown in flax strongly decreased since the begin of the century, but during the last 30 years they remained relatively stable at about 10.000 ha in Belgium with some interannual variations. All crops are contracted by farmers to flax traders.

The sowing density is about 140 kg seeds.ha^{-1} corresponding to about 2000 plants per square meter. Yields are about 6.5 t straw per ha.

1.1.3. Miscanthus

Miscanthus fields last decades requiring only basic maintenance from the second year. This plant displays an interesting production potential of about 20-25 tons.ha^{-1}.$year^{-1}$ of dry material from the third year (growing period : from May to October). Fractionating of rhizomes or *in vitro* techniques are used to propagate the crop plants. Optimal density is 40.000 plants/ha. Low amounts of fertilisers and herbicides are needed during the first two years before complete soil coverage by the plants. Yearly harvest is made from February to begin April, a season with unsecure climatic conditions and heavy agricultural work load. Stems are dried (60-70% dry material without leaves). Up to now *Miscanthus* remains an experimental crop in Belgium, no commercial production has been undertaken and there is little perspective for any significant development in the country excepted in the frame of long-term set aside if imposed in the next agricultural policy.

1.1.4. Short rotation coppice

Harvested every five to ten years, SRC can produce 7 to 12 t $DM.ha^{-1}$. $year^{-1}$. Up to now no commercial production has started in Belgium and only very limited surfaces are devoted to small scale demonstrations mainly for harvest equipment and for scientific purposes, e.g. wood gazification as a biofuel, raw material for small scale industrial processes.

1.1.5. Hemp

Hemp is well adapted to local ecological conditions but this crop has been prohibited by law for reasons linked to its possible use as a drug. New varieties with low THC (tetra hydrocannabinol) content could be allowed. The crop which is sown in May and harvested in September could enter the usual crop rotations and produces 7 to 10 $t.ha^{-1}$ of stalks. From 1996, an association has undertaken to redevelop the hemp culture without success up to now. Significant development of hemp production is not likely to occur in the next future.

1.1.6. Sorghum for fibre

Up to now, this species is only grown for research purposes. Potential yield of recent hybrid varieties has been estimated higher than 20 t.ha-1.year-1 of dry matter but the crop is not well adapted to average climatic conditions in the country so that yield regularity remains questionable.

1.2. Implications of novel technologies being developed and their impact

Several European research programmes have dealt with fibre crops covering breeding, cropping techniques and products valorisation. Optimisation of lignin, cellulose and hemicellulose balance in short duration agricultural crops as well as in perennial species is on the way through genetic engineering. It would allow improved pulping characteristics, easier enzymatic attacks of cellulose, reduction of pollution by use of chemical agents less toxic than currently used chlorides and better utilisation in animal feeding.

1.3. Industry

1.3.1. Needs for and uses (current and potential)

Long fibres from flax or hemp must be considered separately from short fibres (including by-products of long fibres crops) and non fibres components (cellulose, other carbohydrates,…). Long fibres are mainly used in threads spinning for ropes and woven textiles preparation.

Flax fibres are mainly used in textiles: more than 55% for clothes, 20% for household linen, 10% for floor surface (linoleum) and 15% for technical tissues (composition of paper pasta, filters for wine or food utilisation). Housing tissues from natural fibres are back fashionable and could continue to represent an important outlet for flax.

Hemp fibres find applications in textiles, in ropes, for technical material (wires, nets). Short fibres enter paper industry (packaging, sheet paper, cardboard) or as construction and insulation materials.

Their **by-products** as well as the products of ***Miscanthus,*** **sorghum, short rotation coppice** have other outlets: they can be integrated in bio-energy systems (same thermal value as wood fibres) or enter the chemistry of cellulosic, hemicellulosic and lignin products for instance pulps for paper and cardboard, building materials (agglomerated panels, insulation material) and various polymers.

1.3.2. Details of processing systems

After harvesting, the flax stems are let on the ground to allow a biological fibres separation by micro-organisms. Fibres included in the phloemic tissues are rapidly isolated, the internal flexible fibres are then mechanically separated from the external rigid straw.

All other crops have specific processes that are still subject to improvement.

New processing systems have improved extrusion of straw pulp, colour removal from straw effluents, enzymatic bleaching, biological delignification, (refer to "Proceedings of the European Conference on Pulp and Paper Research", European Commission, 1996).

1.3.3. Actual or potential technical problems with crops or crop products

At the production level, some technical problems still occur:

- hemp and sorghum harvest: need for improved harvesters,
- *Miscanthus* and SRC: crop install costs, improvement of harvest equipment, post-harvest treatments.

Nowadays, the productivity of crops like hemp or sorghum is not yet sufficient to ensure profitability to the farmers. Miscanthus, sorghum and hemp are not grown on a commercial scale in Belgium and those crops will not develop unless regulations are imposed to farming, e.g. increase of set aside rate.

As perennial crops, Miscanthus and short rotation coppices do not easily enter intensive agricultural systems. They only could find a place on poor agricultural soils and would there compete with forest or with conventional quick-producing systems (poplars crops). Hemp, as an annual like flax, appears more prone to enter existing agricultural systems.

1.4. Markets and potential markets (for the next 5 or 10 years)

1.4.1. Flax

According to the flax traders, in 1998, total stocks for short and long fibres of the Western Europe production is almost 73.800 tons, corresponding to a 33% increase compared to 1997. Long fibres volume in 1997 is around 18.876 tons and represents a total value estimated 889 millions BEF (22 millions EURO). This is an increase of 24% in comparison with 1996. The stability of the sell price is unusual from 1996 (only 3 BEF/kg variation). Forty five percents of the sells were made at 40 to 50 BEF/kg.

Flax cultivated areas in the main three producer countries (The Netherlands, France and Belgium) were in extension up to 70.000 ha in 1995 and decreased to 60.000 ha in 1997. The total flax fibres production in 1997 was 107.000 tons corresponding to a 9% increase in comparison with 1996.

In conclusion, prices are low due to high stocks of raw materials: demand is stagnant. The producers have a lack of profitability and flax areas have decreased (6% in Belgium, 15% in The Netherlands). It is difficult to forecast the market of this crop in the next few years, but in textile applications flax will continue to suffer from the domination by cotton, wool and artificial fibres.

1.4.2. Other fibre and lignocellulosic crops

Up to now, markets for these crop products are limited and can not offer sufficient issues as currently observed for flax. Characteristics of fibres from these species must also be ameliorated to be used in some applications, from paper pulps to new composite materials, as illustrated by several construction materials or substitutes for glass fibre.

1.5. Environmental opportunities (potential benefits)

Fibre crops display several advantages :

- they are renewable and need not too large amounts of inputs, notably from fossil origin (fertilisers, agrochemicals, fuel) if natural drying may be processed

- several species could be grown in set-aside areas only, facilitating control and administration
- they have neutral or positive CO_2 balance
- in some uses they have higher biodegradability than currently utilised mineral-based products.

2. Barriers to progress and issue proposals

2.1. Scientific and Technical issues

At the production level some limitations must be mentioned: the complexity of the process of production in the field, notably harvest itself and after harvest conditioning that are often specific to the crop, the need to develop improved equipment as it exists for flax.

2.2. Environmental aspects

- Plants are the only ligno-cellulosic providers. Their cropping contributes to a reduction of pollution and greenhouse effects by limiting the use of fossil products. Several fibrous plants can be produced with a relatively low consumption of inputs (fertilisers, pesticides) if low yields are acceptable. They can reduce the risks of pollution by efficient use of CO2, water and soil nutrients.
- Products made from plant-derived fibres and ligno-cellulose must demonstrate their high biodegradability.

2.3. Legislative issues

Legislation could play roles in the development of fibre crop production and in the increase of demand for vegetable based end-products:

- fibre crop production: subsidies to farmers; support by prices allowing agricultural profitability
- increase of the demand for products: tax on CO2 emission for non-vegetable derived competing products, including synthetic fibres.

2.4. Economic issues

In the last decades, forest surfaces have increased in the European Union and this trend is expected to continue. Forest area represents 600,000 ha in Belgium. Aside lumber, large amounts of wood fibres are available as by-products. This high production of ligno-cellulosic wastes from wood industry doesn't allow large and profitable valorisation of crop species for their fibres in paper or in building materials. Currently, price competition gives a huge advantage to the wood dusts and doesn't facilitate the integration of new fibre/ ligno-cellulosic crops in Belgian agriculture.

Fibrous agricultural by-products are currently available in large quantities but few are marketed to industry: all productions have no or few specific properties and they often require several steps in their preparation to meet industries standards (drying, cleaning, handling). Their low value per unit of volume or weight results in relatively high transport costs. Same constraints occur regarding the alternative fibrous crops like hemp, fibre sorghum, …

For agriculture, perennial crops like SRC or *Miscanthus* often mean a lack of flexibility regarding rapid adaptation to changing market conditions and farm economy.

Despite the general reduction of crop values in Europe, fibre crops still provide too low revenues at the farm level.

Furthermore, demonstration is not clearly made of energetic and economic advantages offered by those annual and agricultural crops compared to perennials and notably forest.

2.5. Other items

Support to fibre plants could be part of socio-economic help to rural regions in contributing to the maintain of farming and semi-industrial activities. The risk is that fibre crops enter a system of specialised perennial plantation requiring few human presence and activities.

An analysis of global economics including internalisation of environmental and human impacts could help in launching regional development of fibre and lignocellulosic farming and industry.

3. Prioritisation

It seems useful to distinguish here between natural fibres used as textile and the ligno-cellulosic material used for various non-food applications.

Currently the demand for European natural fibres for uses as **textiles** is stagnant or decreasing. That trend could be stopped but it seems difficult to reverse it due to numerous advantages of artificial fibres and to the presence of large quantities of natural fibres on the world market which is an element that must be taken into account by Europe.

It can be foreseen that some new applications could be found for plant fibres and ligno-cellulose in replacement of fossil-originated materials, with environmental advantages like carbon dioxide, biodegradability and absence of toxicity, with social advantages by maintaining agricultural activities in rural regions. Part of the demand increase could be satisfied by agricultural productions aside forest products. But it seems that this production will remain located in marginal lands in competition with aforestation which has already began encouraged by European incentives.

If some developments can be envisaged they would first deal with species that have specific components useful in high value end-products other than paper or low-value materials in order to avoid the competition with forest products and by-products which present relatively low exploitation cost.

Part III Carbohydrate Crops

Part III Carbohydrate Crops

All plants contain carbohydrates and many of them provide large quantities of carbohydrates under the forms of starch or sugars. This chapter deals with those plants significantly grown in Belgium and potentially usable in non-food applications, i.e. wheat and other small grain cereals, maize, potato, sugar beet, chicory, pea. Sweet sorghum is not grown currently but has been added because it has been experimented.

Opportunities

Crop species, their production methodologies and their products

Wheat and small grain cereals

Cereals are grown on 300,000 ha, nearly half the arable land, and current grain production amounts about 2 millions tonnes. Wheat is the major species (180,000 ha, 1.4 millions tonnes) followed by barley (80,000 ha), oat, rye and triticale.
Winter wheat (spring wheat represents less than 10 %) is sown from end September to beginning of December at densities varying from 225 grains.m^{-2} in October to 400 grains.m^2 in December. Harvest is done in August and yields vary between 7 to 10 t.ha^{-1}. The crop needs about 250 kg N. ha^{-1} (on average 3 kg N per 100 kg grain) of which about 160 kg from mineral fertilisers. Weeds are controlled by one or two herbicide treatments and fungal diseases by one or two fungicide applications at springtime.
Out of the wheat harvest, more than 70 % is used for milling (flour for food) and for animal feeding and 25-30% is processed by the starch industry and mainly used as starch or after transformation to various sugars and other derivatives.

Pea (Pisum sativum)

Pea accumulates sugars and starch (more than 50 %) and protein (about 25 %) reserves in its seeds.
Pea is mainly grown as a vegetable for harvest at non-mature stages to be consumed fresh or after freezing or canning (more than 10.000 ha). About 5.000 ha are harvested as dry seed mainly used as animal feedstuff partly replacing imported soybean meal.
Soil-borne diseases such as *Pythium sp* and *Aphanomyces sp* and other fungal diseases such as *Ascochyta sp* and *Botrytis sp* can induce large losses of yield and/or grain quality when no fungicide treatment is applied. Aphids after flowering and pigeons at sowing or before harvest can damage the crop.
Pea is sown from early March to mid-April at about 200 kg.ha^{-1} seeds and harvested in the first fortnight of August with yields between 3500 to 6800 kg.ha^{-1} of seeds at 85 % D.M.

Potato

Some early potato is planted around mid-March to be harvested in mid-June for direct consumption. A larger proportion is planted in April and harvested in September-October yielding between 30 to 50 $t.ha^{-1}$ tubers at 20 to 24 % dry matter. The variety 'Bintje' represents about 80% of the potato total volume produced in Belgium; it displays a high sensitivity to both *Phytophtora infestans* and the common scab. Production is for direct consumption and for food after processing as chips, dehydrated potato, ….In Belgium a very little part of the harvest goes to the starch industry and no agricultural production is specifically carried on with that objective i.e. there are no industrial varieties rich in starch, no potato starch factory, no market organisation.

Maize

More than ninety percent of the 200,000 ha maize is harvested at immature stages in October for whole plant (yields around 15 $t.ha^{-1}$ dry matter) or cob silage. About 5,000 to 15,000 ha drilled in early varieties are harvested as grain (at about 70 % dry matter) which needs to be dried to 85 % D.M. and with yields of about 8 to 12 t D.M. ha^{-1}. Seed rate aims to install about 100.000 $plants.ha^{-1}$, weed control is based upon treatments with triazines (rates limited for environmental reasons) often associated to other herbicides. Nitrogen needs of about 250 kg N are partly provided by organic fertilisers (animal manures) and partly by mineral fertilisers.

Sugar beet

About 100.000 ha are drilled from end March to mid April and harvested from end September to November, with yields between 55 to 70 $t.ha^{-1}$ of roots at 16 to 17 % saccharose. Leaves and tops are chopped into the soil. Intensive production requires high quality seeds, fertilisers, herbicides and insecticides and specific equipment for harvesting. The crop is limited to regions characterised by deep loamy soils with high chemical fertility and good water retention.

Chicory

Chicory is a biannual plant drilled in the second fortnight of April or in early May with a 300-600 g seeds. ha^{-1} density in order to obtain around 150.000 plants/ha. After the 180 to 200 days growing period roots are harvested from October to November. Yields are about 40 $t.ha^{-1}$ of roots. Crop requirements are similar in nature but somewhat lower than those for sugar beet.

Chicory stores carbohydrate reserves in its root under the form of inulin (15-20% of the root fresh weight). Inulin is a fructose polymer (from 2 to 70 molecules, 10-14 for chicory) often ending by a glucose.

Potential crop: Sorghum

Some attempts have been made for introducing sorghum crop in Belgium. Fibre (see Part two), and sweet varieties have been tested in experimental fields. Sorghum is sown in May at 200.000 grains/ha or about 6 $kg.ha^{-1}$. The crop is very sensitive to weed competition and a preemergence treatment with triazine is recommended (similar to maize culture). Stems harvested in October to mid-November yield between 50 to 85 tons/ha of fresh material with 10-12 % sugar. Sweet sorghum can also be involved in the paper industry for the industrial valorisation of the fibrous waste (called bagasse) remaining after sugar extraction. Differential characters of the fibres lead to a difficult integration of the bagasse in the classical paper pasta. A potential market exists for small production units. A process was set up by Sorghal (Belgian research association) in order to use different straws.

Industrial processes

Although cultivated mainly as food or fodder crops, most of these species give products that are also processed in order to separate their components, notably starch (potato, wheat, maize, pea) or sugars (beet, chicory) from other components (mainly proteins in pea and cereals, oil and protein in maize). Non-food uses exist or are in development for the components notably the carbohydrates. From their carbohydrate compounds including starch, many other products can be obtained by physical, chemical or biological treatments.

Wheat

Grinding and separation of bran (20%) and flour (80%) is followed by gluten extraction (7-8 %). Gluten can be solubilised by enzymatic hydrolyse. Sieving separates fibres from gums. After evaporation leading to the "wheat soluble" occurs the refining to obtain the "starch milk". Gluten and myo-fibrillar proteins display worthy film properties. Gluten is a competitive raw material (25-55 BEF.kg^{-1}) compared to synthetic polymers (25-35 BEF.kg^{-1}). Starch finds numerous food and non-food uses and as a basic commodity for preparing various sugars and derivatives.

Maize

A soaking gives either the corn steep which will be mixed to give the corn gluten feed and the draff or will be pre-ground and followed by the germ separation (more or less 7 % of the grain). Germ contains about 50 % oil which is extracted, the rest being filtercake. Both grinding and sieving of the non-germ part will lead to the draff or maize gluten. After supplementary centrifuge separation, the refining allows to obtain the starch milk.

Potato

Raw material is first grated and sieved to obtain the pulp. After protein coagulation an evaporation gives the "potato soluble". Refining allows preparation of starch milk, prime stuff for preparation of all the sugar compounds. **Error! Reference source not found.** lists reactions and their results: these are very similar whatever the origin of the starch milk (potato, wheat, maize).

Table 25 Reactions and resulting products in starch industrial processing (Source : Roquette)

Reactions	Resulting products	Secondary Reactions	Resulting products	End products
Hydrolyse	hydrolysate	hydrogenation	Liquid sorbitol	
		enzymatic reaction + hydrogenation	Xylitol	
		isomerisation + chromatography	Fructose syrups	mannitol or fructose
		crystallisation	Dextrose	liquid sorbitol
		fermentation	Na erythorbate Gluconic acid Lactic acid	 glucono-delta lactone gluconates & lactates
	glucose syrups	oxidation	Oxide glucose	

			syrups	
		hydrogenation	Maltitol syrups	maltitol
		heating	Staining caramel	
		atomisation	Malto-dextrins	
Pregelatination	pregelatined starches			
Drying	dry starch	extrusion	Extruded starches	
		Dextrinification	Dextrins	
chemical modification	Modified starches	Transformations	Cationic and anionic starches	
		Depolymeration	HES	

Pea
Pea seed can be easily split up into its different components: proteins (22 to 27 %), starch (about 50 %), other carbohydrates, fibres, minerals. Including no fatty stuffs, the seed must not be treated by a solvent as required by many other pulses. Easy splitting up occurs in water: the ground seed is thinly spread in water. In a first separation, non-soluble stuffs (starch and fibres) are decanted from the soluble ones (proteins, simple sugars and minerals). The non-soluble part is sieved to separate starch granules from cells walls residues (internal fibres). The soluble part is concentrated and purified by ultra-filtration which allows separating the soluble compounds according to their molecular weights. Small molecules are taken off by water fluxes through the membrane. Under their native aspect, pea reserve proteins are high molecular weight polymers and are fixed on the ultra-filter membrane. The company Warcoing S.A. has developed original processes for pea cracking and its components valorisation. Several vegetable proteins are studied. Most interesting are the high molecular weight molecules and non- or weakly water soluble proteins.

Sugar beet
In Belgium sugar factories are not linked to distilleries and no or very little alcohol is produced from sugar beet. One factory (Citrique Belge, s.a.) is specialised in the production of citric acid and other acids from beet sugar and molasses.

Chicory
Roots supply to the factory is very similar to sugar beet roots supply. Some difference occurs in the storage: the respiration of 1 ton chicory at 10°C produces about 250 l of CO_2 per day and up to 360 l CO2 per day in difficult harvesting conditions vs. 120 l for sugar beet. This loss can reduce the inulin rate by 0.05 to 0.1 % per day. For this reason, silos are smaller than for sugar beet and storage duration will be as short as possible.
In Belgium, inulin is produced at the Oreye refinery, part of the Sudzucker group and at the Warcoing sugar factory.
Inulin is extracted from chicory in a similar way as saccharose from sugar beet: roots are washed, cut and inulin is extracted by diffusion in hot water. A calco-carbonic purification separates main product (inulin) from secondary stuffs (pulps and foam). From this first step, several processes are used depending on the final product. Semi-epurated juice can be:

- ❖ sent to an ions exchanger and dried by atomisation to obtain inulin
- ❖ partially hydrolysed by enzymatic way and sent to ions exchanger to give oligo-fructoses in liquid state which can be powdered after evaporation and drying atomisation

❖ hydrolysed by chemical or enzymatic way, passed on ions exchangers to give fructose syrup.

Oligo-fructoses are obtained by partial hydrolyse. Inulin molecules do not include more than 2-7 fructose units (called Polymerisation Degree, P.D.). These compounds are called fructanes.

A second purification is made on ions exchangers (anionic and cationic) regenerated by sulfuric acid and ammoniac replacing traditional chlorhydric acid and sodium hydroxide. After evaporation, impurities are precipitated as potassium and ammonium sulfates recycled as soil fertilisers. This purification process is a kind of closed cycle which allows water recycling for inulin extraction reducing pollution or water purification costs. Inulin and its derivatives mainly enter food uses as various diet sugars.

Non-food uses ask for inulin transformation either by fermentation or enzymatic treatment or chemical modification : ethanol, acetone-butanol, polymers, surfactants, plastics, stains, ...

Inulin hydrogenolyse gives glycerol.

Fructose dehydrogenation produces the 5-hydroxymethylfurfural (HMF) interesting for furanic oligomers used as sun protectants, anti-fungal or anti-microbial compounds. HMF re-hydration leads to levulinic acid formation, useable as herbicide, as motor additive precursor and allows to obtain polyesters and polyamides.

Isolated by chemical oxidation, dicarboxy inulin can replace polyphosphates in detergents.

Sweet Sorghum

Technical problems must be solved in the sorghum crop : research of new varieties, harvest machine adaptation, optimisation of juice extraction, ...

The technology consists in several diffusers combined with grinders. A solid residue, called bagasse is produced with 50% dry material rate. Sweet juice concentration is usually made by vapour treatment. Fermentation occurs in liquid medium. Solid fermentation are carried out in laboratories, with the production of a non useful co-product called vinasse. Advances are made to decrease the energy consumption and new dehydration methods are now operational. Bagasse combustion produces electricity and vapour. Bagasse can also enter paper pulp elaboration.

New technologies and their impact

Plant breeding and improvement of cultivation techniques aim to increase yields, to augment yield stability, to improve quality and to reduce the costs of production.

In cereals - notably wheat- attention is paid to starch and protein quality. Due to the nature of European agriculture high yield is a must. In the last decades yields have increased at an annual rate of about 0.15 $t.ha^{-1}$ and simultaneously the milling quality has significantly improved for a majority of varieties. This trend could continue in the future through conventional breeding, biotechnologies and development of the recent new "hybrids" cereals, notably wheat. If the demand is clearly expressed, cereal breeding is able to take into account specific quality requirements for non-food uses notably starch and gluten contents and qualities.

In sugar beet, general trend in the last decades have been to increase yields of extractable sugar mainly through total sugar content of the root, a genetic property, and through better cultivation methods which allow high levels of sugar extractability (management of nitrogen, potash and sodium nutrition). Transgenic sugar beets showing improved agricultural properties are examined for an agreement in order to be proposed to farmers.

At industrial level the starch separation and transformation processes are well mastered. The main challenges remain in finding new products that could replace existing synthetic compounds and in finding applications for end-products, including by-products such as gluten, solubles and brans.

Industry needs for non-food uses

European production of starch has developed in the last two decades, mainly due to the increase of cereal production and the stagnation of the demand in the food and feed sectors. In Belgium the company Amylum has played a major role in improving the wheat starch processing.
Aside the food industry, major starch consumers are the paper and cardboard sector (more than 30 % of non-food uses), the chemical sectors, including pharmacy, detergents and bioplastics (30%) and the fermentation (30 %), textiles and others sectors consuming the remaining 10 %.

Paper and relating products

Despite a decreasing part of the market**, paper and cardboard industry remains an important non-food outlet for starches.** The starch consumption by this sector is about 1,5 millions tons in the European Union. Native or modified starches are used in several proportions (2 to 4%) depending on paper utilisation (writing, printing, packaging).
Starch and sugar compounds can be introduced in the paper pulp at three levels :

1. to ensure the internal cohesion of the paper by forming cellulose-starch-cellulose binding (15% of total paper starch) . When recycled paper pulps are added, larger quantities of starch are needed to compensate for fibre quality losses.
2. to enforce the surface fibres cohesion (75% of paper starch) in order to avoid paper deterioration under writing friction
3. to settle a coating on the paper in order to hide the surface irregularities and to obtain an artificial micro-porosity needed for writing.

Some starch derivatives as **dextrines** are used to produce paper bags or corrugated paperboards. Other derivatives confer high absorbent properties to various paper products such as disposable towels and nappies.
The market of starch products for the paper industry is expected to only slightly increase in the near future.

Adhesives

Besides the paper industry, native or modified starches can be used for their adhesive properties in several fields (wallpapers glues, posters, labels and sticks, glues and adhesives).

Detergents

About 10 millions tonnes detergents are consumed annually in the European Union. Biodegradable starch and sugar derivatives could enter their composition in high proportions. For washing powders this proportion is estimated higher than 50 %, mainly by replacing the currently used polyphosphates (cfr Part One, Oil crops). Modified starches and derivatives of gluconic and citric acids act as sequestering agents, sugars as whiteners agents, glucose derivatives as hydrophilic part of the surfactant molecule (see Oil crops).
This market has sharply increased in the last ten years and the progression is expected to continue in the next decade.

Resins and plastics

Starch can be used as a simple laminating agent in PVC, PVA or polyethylene but it is more expensive than the mineral stuffs. Sorbitol can enter polyurethane composition as laminating agent, humidity absorber or as a basic matter for rigid polyurethane foams.

Biopolymers

Types of bio-polymers

1. Mixture of petrochemical synthetic polymers (polyethylene, polystyrene) and agricultural polymers

This method allows a better microbial degradation of the synthetic polymers due to an incorporation of compounds which can be assimilated by micro-organisms. Starch is the main raw material used in a native or modified shape (sililation, gelatination) or in association with synthetic copolymers (ethylene/acrylic acid, polyvinyl alcohol or polystyrene chain grafted on amylose, amylopectin chains). Some bio-plastics could be called bio-fragmentable more appropriately than biodegradable. The starch presence confers some opacity and a sensitivity to water and humidity limiting their applications.

*2. **The bacterial polyesters** (polyhydroxybutyrate PHB, polyhydroxyalcanoate PHA, polyhydroxyalcanoate valerate PHV, polylactic acids PLA).*

They result from agricultural substrates fermentation (fatty material, golden syrup). They are totally biodegradable and limited to short life-cycle products. Their high cost of production limits their use to high range products. This market is expected to sharply grow in the short term in relation with new regulations on packaging biodegradability and specific needs for noble products.

PHB, PHA : They show properties similar to thermoplastics (PVC, PET,...). Nowadays their cost is higher (around 450 BEF.kg^{-1}, 11 Euro.kg^{-1}) in comparison to the petrochemical plastics (25-40 BEF.kg^{-1}, 0.6 to 1 Euro.kg^{-1}) . Monsanto Belgium commercialises bio-polymers (PHB, PHA) made in England. The commercial product called BIOPOL costs 500 BEF.kg^{-1} (12.5 Euro). Monsanto believes in being able to reduce the price down to 100 BEF.kg^{-1} (2.5 Euro).

Genetically modified oilseed rape could exhibit high content of PHB in the seed and could be cultivated in the next ten years

PLA: Polylactic acids are obtained by polymerisation of lactic acid from sugar substrates fermentation (from wheat or maize starch or beet sugar). In 1999 the company Bioprocess Technology will start a PLA production from lactic acid obtained through beet sugar fermentation.

Utilisation

Biopolymers could find issues in replacing synthetic plastics in the packaging sector. Small plastic bags, dishes and various elements used in packaging of a lot of goods, notably food, can be made in bio-polymers. Utilisation of biopolymers in rubbish bags allows composting after grinding.

A Walloon company will start the production of biopolymers from sugar beet in 1999. UNISAC, located in Tournai and FARDEM located in Flanders produce and sell fully bio-degradable bags for organic wastes, the latter uses sugar from beet (10.000 t.year^{-1} corresponding to 60.000 t of sugar beet).

Pharmaceuticals and Fermentation industry

Pharmaceutical industry uses glucose hydrolysates or their derivatives as fermentation substrate in order to produce several active compounds (vitamins, antibiotics, hormones).

Starches and their derivatives are also used as vehicle, binding or coating agents in drug preparation.
Sorbitol is known to mainly produce vitamin C. Cyclodextrins stabilise aromas as chelating agent or move bitterness from citrus fruits. They also trap cholesterol and enter the preparation of lightened butter. Grafted starches are super absorbent products that can be used as talc substitutes or in nappies and various hygiene products.
Inulin from chicory is used as a substrate for pharmaceuticals preparation as it displays beneficial effects on kidney functions, due notably to its rapid excretion.

Other uses for starch and carbohydrates

Formulation agents for fertilisers and various agrochemicals: binder in solid fertilisers, seed coating, additive for slow release of agrochemicals
Paints: starch derivatives as thickeners
Glues and adhesives notably for corrugated paperboard
Surfactants: aside oil as hydrophobic part, starch and sugar derivatives can constitute the hydrophilic part of surfactant molecules (cfr Oil crops)
Several **traditional uses** exist such as weaving agents in natural **textile** manufacture, demoulding agent in **metallurgy**, anti-freeze agent for concrete in **building**, …

Economical aspects

Current areas and yields

Table 26 Surfaces of protein peas and beans in Belgium

Years	Dry peas (ha)	Beans (ha)	Total (ha)
1994	3.702	1.812	5.514
1995	2.446	686	3.132
1996	1.690	512	2.212
1997			3.150
1998			3.170

Markets and potential markets (for the next 5 or 10 years)

Biopolymers
Composting of organic domestic wastes could be a solution to reduce the volume of rubbish in dump. The utilisation of bio-polymers "plastic bags" allows not to pour the dust. These bags made in Germany from potato or maize starch are now widely distributed throughout Belgium.
A lot of uses in food packaging

Costs of production at farm and industry levels

Potato

The gross margin varied from 10.000 BEF (in 1992) to 150.000 BEF (in 1989) for the last ten years. The profitability of this crop must be considered over several years to be realistic. Potatoes were sold between 0.50 BEF and 10 $BEF.kg^{-1}$ during the same period, thus a 20fold ratio for the incomes. These extreme values can be corrected by mean values for 2/3 of the farmers who sold their harvest between 3.25 BEF and 7.50 $BEF.kg^{-1}$.

Sugar beet

For the last ten years the gross margin varied from 50.000 BEF (in 1987) to 90.000 BEF (in 1993 and 1997). There is no large difference in the profitability of this crop from year to year. Sugar beets were paid between 1500 BEF. t^{-1} and 2000 BEF. t^{-1} during the same period.

Table 27 Gross value of several crops (1996-97)

Crop plant	Main product			Compensatory payment BEF.ha^{-1}	Secondary products BEF.ha^{-1}	Total BEF.ha^{-1}
	Quantity (t.ha^{-1})	Price BEF.t^{-1}	Value BEF.ha^{-1}			
Wheat	9.2	5300	48760	12050	5800	66610
Maize	9.1	4300	39130	12050	0	51180
Pea						68350
Sugar beet	60.3	1900	114570	-	400	114970
Chicory	44.8	1800	80640	-		80640
Potato	38.2	2100	80220	-	700	80920

Table 28 Specific costs for some carbohydrate crops (in BEF)

Crops	Specific costs					
	Seeds	Fertilisers	Agrochemicals	Other costs	Total	Gross margins
Wheat	2700	4100	5650	1100	13550	53060
Maize	5500	5000	2750	1550	14800	36380
Pea	8900	1650	3950	700	15200	53150
Sugar beet	7600	7950	8950	2300	26800	88170
Chicory	3350	5400	9950	1600	20300	60340
Potato	18350	7450	13350	1600	40750	40170

Table 29 Prices for protein pea at farm level

Years	Peas price (BEF.kg^{-1})	General regime (BEF.ha^{-1})	Simplified regime (BEF.ha^{-1})
1994	5.20-5.40	11.666 to 21.570	6.282 to 11.614
1995	5.10	11.666 to 21.570	8.077 to 14.933
1996	5.90	11.666 to 21.570	8.077 to 14.933
1997	5.75	11.666 to 21.570	8.077 to 14.993
1998	4.20	11.666 to 21.570	8.077 to 14.993

Table 30 Costs (in BEF. hl^{-1}) for ethanol from sugar beet.

Raw material	1.050
Energy	172
Variable costs	295
Material depreciation	467
Financial costs	495
Others costs	100
Energetic development of the co-products	0
Total cost for 1 hectolitre ethanol	2.579

Raw materials costs per hectolitre of anhydrous ethanol varies from 420 to 1785 BEF (10 to 43 Euro) for sugar beet and from 850 to 1785 FB (20 to 43 Euro) for sorghum. The production costs are 1.050 FB/hl and 850 FB/hl respectively for sugar beet and sorghum.
Bio-ethanol production is possible in Belgium but must be improved for its profitability.

Non starch co-products values

Gluten is also a competitive raw material (27-51 BEF.kg^{-1}). Homogenous, transparent, resistant and non-soluble films have been obtained by dispersion of gluten proteins in a solvent medium followed by spreading and drying.

Environmental opportunities (potential benefits)

Positive effects on the environment are to be found mainly in:

- products biodegradability that could facilitate recycling of large volumes of residual materials including packaging goods, composite materials for construction, car industry, equipment industry, …
- better CO2 balance
- scarcer use of limited resources: demonstration of the interest of agricultural products is still to be made in comparison with mineral derivatives products

Barriers to progress, strengths and weaknesses

Technical issues

Improvements in the industrial processes could ensure a higher utilisation of these crop species.
Industry requires large supply of raw material offering homogeneous quality standards.
Industry must specify more precisely its quality requirements in order to facilitate plant selection and to better manage crop production, harvest, storage and raw material quality control.

Environmental aspects

For several products such as plastics, biodegradability of starch and carbohydrates products is an advantage that must be better demonstrated and exploited.
Currently, plastics represent 10% (in weight) and 25-30% (in volume) of the total domestic wastes. Volume is the most important aspect for the rubbish. Biodegradable plastics with a short life cycle could be a good way for reducing this volume and would facilitate the development of composting.

Legislative issues

- Ethanol used as a biofuel or as a fuel component remains the most important potential issue for carbohydrates originated from agriculture. Without European adaptations in taxation rules the development of this outlet will be stopped.
- Bio-ethanol transformed into ETBE is considered as an oxygenated product replacing lead in order to increase the petrol octane index. An European directive (85/536/CEE) allows to add 5% volume of ethanol in petrol without any special specification.
- The use of biodegradable plastics is mainly linked to legislative encouragement. As long as fossil carbon materials will be cheaper than bio-polymers, the latter will not display a significant increase in the packaging sector. A taxation could be set up on those non-biodegradable goods that could be substituted by bio-degradable equivalents.
- Rules in the waste management sector are changing and some packages will be forbidden for dumping in 2010. A percentage of single use packages will have to be collected and treated.
- Legislation has been recently adopted in Belgium: from March 1997, every company is responsible for recycling at least 40% or valorising at least 60% of the 'single use' packages utilised for its products. In 1999, recycling and valorisation rates will have to reach 50% and 80% respectively.

Economic issues

Aside the legislative aspects in relation with environment, wastes management and human health protection, the other way to enhance the use of the various products generated from starch and vegetable carbohydrates is to reduce the production costs of end-products. It could be made both by increasing yields of agricultural products of good quality which meets specific industrial needs, by optimising industrial processes and by organising the chain from the production to the industry in order to make up large volumes of homogeneous quality products.
European agricultural products are in competition with world production. Furthermore Europe is limited by quotas in its production of sugars from starch and by trade competition and former agreements in its valorisation of several by-products such as gluten.

Prioritisation

In Belgium, strengths are to be found at several levels:

- agricultural production: agrosystems productivity including natural fertility and technical skill of farmers offers the perspective for supplying raw material at low prices approaching world prices.
- first transformation: agro-industry expertise is good in processing raw material production notably starch from cereals and sugars from beet and chicory. These processes could still be ameliorated in relation with energy consumption, de-pollution costs of residuals (water, by-products) and more effective valorisation of by-products.
- processing of end products and setting-up of new uses: a lot of research-development actions have been launched in the last twenty years.

Starch industry is a multinational sector, all processes may be transferred throughout the world. European starch industry is waiting for agricultural raw products at low prices, close to the world prices.

Up to now few opportunities occurred for installing a dialogue between agriculture and industrial sectors in order to better organise the market. Challenge is severe for Europe. Non-food uses of agricultural raw products will depend on the new agricultural policies as influenced by Agenda 2000 and on legislation mainly in relation with environment and health. **Priorities among the numerous products** could be chosen and clearly indicated: for instance, due to their impact on environment, **biodegradable detergents** made from vegetable oil and starch and biodegradable **food packaging and related products** could be first promoted.

Starch or sugar derived **ETBE** used as an additive to 4-strokes engine petrol would display significant environmental advantages.

Crops with Special Uses

Crops with Special Uses

This chapter deals with aromatic (broad sense), perfume, colorants and medicinal plants

Opportunities

Crop species, their production methodologies and their products

A great diversity of species have medicinal and aromatic properties. Few of them are currently grown in Belgium. Several producers were located in the western part of the country (Tournai, Ath and Lessines regions), the production ceased more than twenty years ago excepted some angelica for aromatic use. North of Antwerp, close to the Dutch border, some farmers have occasionally grown species like *Carum carvi* or *Cuminum cyminum* (cumin). Current registered surfaces are shown in

Table 47 Surfaces in medicinal plants in Belgium

Crop species		Surfaces (ha)	
	in 1996	***in 1997***	***in1998***
Angelica archangelica	***14.7***	***14.8***	***16***
Silybum marianum (syn. Carduus marianus)	***Non available***	***n.a.***	***124.5***

For several years cuts of ornamental *Taxus baccata* have been gathered at private's owners by a company specialised in taxol and derivatives extraction. In 1998 a company has proposed contracts to farmers for growing *Silybum marianum* and intends to double the surface in 1999.

Industry

Needs for and uses (current and potential)

Medicinal plants

They are used by different types of medicine and therapy methods, notably:

- *Allopathic medicine*: aside numerous synthetic molecules, conventional medicine uses some molecules insulated from plants. In neighbouring countries several plants such as poppy (*Papaver sp)* for alcaloids (morphine and thebaïne), foxglove (*Digitalis purpurea*) for digitaline, may be grown under specific regulations.
- *Homeopathic medicine*: therapy by use of very small quantities of elements present in minerals, plants or animals.
- *Herbal medicine*: curative or preventive therapy using plants parts without insulating one single type of molecules; a large variety of plants are grown according to terms defined in national or European pharmacopoeias. This medicine seems to know a kind of come-back.
- *Aromatherapy*: therapy by use of essential oils in external application or by ingestion.
- *Veterinary medicine*: several traditional uses of medicinal plants in conventional veterinary medicine, some uses in organic agriculture. This market could grow in relation with the evolution to more natural animal production systems and the willingness to reduce antibiotics and synthetic drugs use.

Crop protection

Crop protection utilises a lot of chemicals partly originating from plant or living organisms such as fungi, bacterias or imitated from natural compounds: pyrethrine has helped as a model for numerous pyrethrinoïds with insecticide properties; a more recent example is given by the strobilurine family of artificial fungicides copied from natural substances produced by specific fungis. Organic agriculture and related ecological agricultures should need more "natural agrochemicals".

Aromatics and condiments

The market of aromatics and condiments is mainly linked to food industry uses. Excepted some carvi, cumin and angelic already mentioned, no commercial production is made in Belgium.

Stains and dyes

The culture of **plants for stain** extraction could be a new opportunity. Many artificial stains are made from aniline, a volatile compound suspected in some cancer apparition. Furthermore, European Ministers of Environment have adopted a directive in order to reduce by 50 % the Volatile Organic Compounds emission convinced of contribution to troposphere ozone degradation and of harmful effects on human health.

Several wear manufacturers have developed fashion lines based upon natural materials from fibres to stains, buttons and accessories.

Perfumes, flavours for non-food uses

Currently, no production is done for these uses in Belgium.

Actual or potential technical problems with crops or crop products and solutions

A lot of species need better adaptation to modern agriculture and improvement of products quality: Plant breeding, crop mechanisation and post-harvest technology are the main potential sources of advances. Through classical and/or new plant breeding techniques advances could rapidly be obtained for several species, notably by inducing precise metabolites synthesis.

The diversity of plants and products makes it impossible to describe all the specific objectives; for instance, codeine can be produced by several *Papaver sp* which don't produce the non desired morphine; genes responsible for specific metabolites synthesis have been insulated and transferred to other species: transgenic oilseed rapes can synthesise several alcaloïds.

Markets and potential markets (for the next 5 or 10 years)

In the European Union current development of the demand for natural products in the food and non-food sectors is partly satisfied by imported products. For many products traceability will become a must and could be easily guaranteed by better streamline organisation from grower to end-product.

The demand is partly linked to fashion (cosmetics, perfumes), to legislation related to food additives, to environment protection. In an open market supply is far to be strictly from European origin.

Costs of production at farm and industry levels

Cost of production at farm level widely depends on the plant species. Assessment of average costs and margins are given hereafter. Gross margins of the crop is much variable according to fluctuant market conditions.

Year 1996-1997 (BEF/ha)

Crop plants	Gross production	Specific costs	Gross margin
Medicinal and aromatic plants	84,490	19,950	64,540

Environmental opportunities (potential benefits)

In relation to environment the development of crops with special uses displays some advantages:

- biodiversity: the diversity of plants that could be involved in various molecules production suggests that agricultural ecosystems would be richer and more various; those possibilities could be encouraged in areas of special ecological interest, in the frame of agro-environmental measures and as crops for set aside land.
- decrease of pollution risks: substitution of artificial dyes by natural dyes for use in paper, paints, inks and textiles could result in a decrease in pollution both at the colorant production stage and at product end of life stage (garbage, recycling).

Barriers to progress

Scientific, technical and economic issues

The diversity of species, the small dimension of the various markets, their current organisation don't facilitate prioritisation: efforts in research are dispersed, markets are prone to economic speculation and quasi monopolistic situations.

Legislative aspects

In Belgium, the production of several species is regulated or is forbidden: *Papaver somniferum, Digitalis sp, Cannabis sativa.*

Official acknowledgement of alternative medicines could increase the interest for some plant species.

Legislation on the production and use of artificial colorants, perfumes and flavours such as the one about the limitation of volatile organic compounds emission could favour the development of various crops.

3. Prioritisation

Inventories of natural products vs artificial products characteristics linked to human health and environment hazards could help in determining priorities amongst species, supporting their improvement and encouraging substitution of hazardous artificial compounds by natural ones if less hazardous. Aside compounds entering foodstuffs as additives, attention could be paid first to the various stains and dyes, detergent flavours and to plant-based agrochemicals. According to the evolution in dietetics and health sciences some medicinal plants could be first promoted.

IENICA

Interactive European Network for Industrial Crops and their Applications

Annexes to the

REPORT FROM THE STATE OF BELGIUM

FORMING PART OF THE IENICA PROJECT

IENICA is a project funded under the FAIR Programme
by DG XII of the European Commission

Prepared by

ir Frédéric FRANCIS under the supervision of
Professor André FALISSE

Faculty of Agricultural Sciences
Crops Production Unit
Passage des Déportés 2
B-5030 Gembloux Belgium
Phone : 0032 81 622140 Fax : 0032 81 622407

Annex 1: Crops – areas – productions – yields

Annex 2 List of key contacts 12

ANNEX 1: Crops – surfaces – productions – yields

Areas per crop (in ha)

Years	1980	1989	1990	1991	1992	1993	1994	1995	1996
Winter Wheat	168980	198978	202528	195760	198070	190181	187836	192476	193666
Spring Wheat	10180	3806	2522	3790	3206	6475	7382	4352	2727
Total Wheat	179160	202784	205050	199550	201276	196656	195218	196828	196393
Rye	10175	3133	2954	2516	2053	2310	2568	2677	1844
Spelt	8374	8093	8031	7441	7269	6946	7668	12265	8137
Total baking cereals	197709	214010	216035	209507	210598	205912	205454	211770	206374
Malting barley	..	..	..	943	696	1059	773	446	1105
Winter bareley	129801	96202	85889	70004	65792	56966	48896	47532	44481
Spring barley	22931	11523	7168	5920	6088	8164	8085	5706	4882
Total Barley	152732	107725	93057	76867	72576	66189	57754	53684	50468
Oats	28284	12737	8842	8250	8408	11452	9646	6293	5387
Summer mixtures	5745	1705	1391	1551	1316	1355	1501	1242	1400
Maize	6220	6902	7329	9700	10126	18500	7316	6235	6109
Triticale	..	6520	7901	9098	7648	8853	8944	9438	9003
Total Secundary Cereals	192981	135589	118520	105466	100074	106349	85161	76892	72367
Total Cereals	390690	349599	334555	314973	310672	312261	290615	288662	278741
Dry peas	701	1868	2168	4287	3310	5101	3702	2068	1690
Dry french beans	717	759	675	788	513	407	331	384	781
Beans	..	..	580	621	522	1540	1812	639	512
Mixtures	319	483	113	145	142	90	153	72	109
Total Dry Pulses	1737	3110	3536	5841	4487	7138	5998	3163	3092
Sugar beet	117165	105800	107837	102580	101269	99087	95178	98810	97990
Chicory	815	784	1642	3153	5246	4150	5969	7697	12039
Linseed	7257	11486	11722	9675	7142	9218	11107	11011	11260
Tobacco	436	439	444	453	430	418	390	373	384
Hop	795	393	363	391	399	411	377	372	348
Winter oilseed rape	288	3638	5240	7013	5625	3967	5534	5274	4497
Spring oilseed rape	38	69	64	139	247	397	578	393	376
Others	178	321	335	344	405	456	284	281	753
Total Industrial crops	126972	122930	127647	123748	120763	118104	119417	124211	127647
Early varieties	3121	3805	7526	7725	8263	5922	7021	9593	10740
Mid-early varieties	19029	23416	34806	36488	42439	35724	37962	39252	42039
Late varieties	15982	14308	5939	6640	7487	6474	6608	7001	8624
Total potatoes	38132	41529	48271	50853	58189	48120	51591	55846	61403
Temporary to cut	28357	18976	16908	21170	22753	24138	36673	28547	28712
Permanent to cut	170147	103400	91325	84027	80306	68961	50980	60276	51619
Temporary grazed	7715	3898	23094	30697	41310	39050	117258	56290	35675
Permanent grazed	496233	348258	314946	299620	270256	270533	191112	250972	251822
Mixed	..	163010	186853	194034	202402	215602	224089	224257	251288
Total grasslands	702452	637542	633126	629548	617027	618284	620112	620342	619116
Fodder beet	17276	11934	11587	11159	10973	10469	9952	9094	9333
Fodder roots	308	581	416	501	397	425	612	514	952
Total	17584	12515	12003	11660	11370	10894	10564	9608	10285
Clover	1904	815	1310	1236	1069	1116	1004	766	493
Alfalfa	2969	1000	985	1227	1367	1246	1194	1161	1173
Milky maize	89912	122438	122865	133134	138387	143088	142914	144264	166257
Others	3605	13301	16406	17554	18422	19511	36037	38484	30149
Total green fodders	98390	137554	141566	153151	159245	164961	181149	184675	198072

In Greenhouse	1980	1989	1990	1991	1992	1993	1994	1995	1996
Tomato (Hot glass)	451,60	576,50	606,52	593,88	591,29	587,44	550,79	550,99	461,54
Tomato (Cold glass)	258,96	141,80	107,20	105,75	108,39	82,34	83,39	63,90	46,12
Cauliflower	..	..	..	..	..	..	..	..	2,43
cucumbers	39,54	70,77	71,69	94,95	94,89	83,71	76,96	82,98	80,90
Gherkins	23,97	8,77	8,07	16,67	13,14	7,39	17,07	10,02	4,28
Melons	8,05	..	..	..	..	..	..	..	..
Others	118,15	123,78	161,88	205,12	203,70	244,97	267,41	308,25	380,93
Total	900,27	921,62	955,36	1016,37	1011,41	1005,85	995,62	1016,14	976,20
Mushrooms	16,91	19,14	19,77	20,21	20,58	21,23	23,56	20,78	21,30

In fields									
High trees orchards	2216	933	845	827	751	763	701	707	676
Short trees orchards	9014	10765	11465	12075	12831	13281	13676	13801	14158
Strawberries	542	493	612	612	660	694	815	878	979
Berries / Raspberries	119	82	85	91	130	127	117	117	114
Total in fields	11891	12273	13007	13605	14372	14865	15309	15503	15927

Peaches	0,76	..	..	..	..	..	..	..	..
Strawberries	102,33	119,62	111,77	101,49	121,70	134,13	143,46	148,13	141,33
Grapes	153,62	51,53	48,43	42,06	38,42	35,46	33,01	30,55	27,32
Others	..	4,92	3,18	3,80	4,48	4,92	5,54	6,58	8,67
Total inside crops	256,71	176,07	163,38	147,35	164,6	174,51	182,01	185,26	177,32

Green peas	5452	10462	9139	9232	8724	7465	7075	6630	7885
French beans	893	3104	2470	2569	2838	2741	3277	3204	3455
Carrots	1054	1458	1392	1390	1301	1255	1413	1597	1525
White celery	94	134	132	145	158	113	129	120	153
Spinash	239	932	859	1007	1194	1109	1331	1360	1489
Chervil	23	25	30	38	31	30	31	13	15
Onions	18	57	131	79	90	84	63	112	60
Cauliflower	..	..	1199	1398	1639	1467	1583	1633	1819
Brussels sprouts	..	..	1227	1348	1775	1636	1571	1587	1590
Celery	..	..	517	528	483	430	417	484	571
Parsnips	..	..	1257	930	962	824	588	503	640
Endive	..	..	5	15	15	30	24	17	15
Total	7773	16172	18358	18679	19210	17184	17502	17260	19217

To be consumed fresh	1980	1989	1990	1991	1992	1993	1994	1995	1996
Green peas	107	170	666	861	1280	1182	1524	1983	735
French beans	300	764	1844	2192	1669	1397	1497	1542	874
Carrots	278	466	464	491	426	408	496	375	436
White celery	26	32	22	24	23	37	31	27	47
Spinash	74	98	82	79	90	146	118	114	139
Chervil	11	6	6	6	6	14	5	7	5
onions	290	278	299	250	251	224	305	292	286
Chicory (Witloof)	3379	4107	4200	4273	3857	3757	3661	3420	3300
Tomato	48	38	14	24	16	12	22	9	58
Cauliflower	792	2014	775	771	780	806	851	789	831
Asparagus	100	87	90	81	94	94	107	118	117
Lettuce	322	365	346	354	309	337	265	273	250
Red cabbage	176	252	242	348	401	301	269	311	441
White cabbage	117	105	93	118	161	165	129	162	175
Brussels sprouts	..	1443	218	184	189	204	197	168	201
Green cabbage	117	153	153	203	159	212	197	186	181
Leeks	553	1038	1165	1399	1499	1704	1853	1931	2088
Shallot	23	13	12	12	18	16	15	21	29
Green celery	112	64	53	47	54	58	73	66	72
Celery	..	529	88	93	90	107	116	111	163
Parsnips	1980	1951	54	28	25	45	48	43	44
Endive	39	54	51	42	42	48	54	59	43
Gherkins	309	265	225	269	214	154	172	154	77
Parsley	..	..	45	38	58	76	50	53	66
Radish	18	16	10	9	8	9	8	5	5
Rhubarb	27	19	26	25	40	26	33	35	36
Others vegetables	1055	481	348	545	435	498	714	736	777
Total fresh	10253	14808	11591	12766	12194	12037	12810	12990	11476
Total in fields	18026	30980	29949	31445	31404	29221	30312	30250	30693

Commercial production (in tonnes)

Year	1980	1989	1990	1991	1992	1993	1994	1995
Grains								
Winter Wheat	814484	1386877	1255674	1342913	1313204	1392125	1346784	1432406
Spring Wheat	38277	15224	10592	18303	15709	35548	38313	20807
Total Wheat	852761	1402101	1266266	1361216	1328913	1427673	1385097	1453213
Rye	38156	12532	12614	10594	9074	10349	11736	9126
Spelt	26211	41841	36300	37352	35545	35425	39874	70082
Total baking cereals	1917128	1456474	1315180	1409162	1373532	1473447	1436707	1532421
Malting barley	..	..	..	5394	3800	6015	4731	2325
Winter bareley	735972	608959	508463	465527	421728	348632	307556	330538
Spring barley	71086	38026	25876	24096	24108	35922	33957	23737
Total Barley	807058	646985	534339	495017	449636	390569	346244	356600
Oats	108893	44707	34042	36133	35734	54168	42442	28300
Summer mixtures	21486	5814	5188	6562	5409	6192	6454	5332
Maize	39062	53698	55700	72752	89109	163910	58528	47112
Triticale	..	34621	42033	48403	42293	50993	50891	55382
Total 2nd Cereals	976499	785825	671302	658867	622181	665832	504559	492726
Total Cereals	1893627	2242299	1986482	2068029	1995713	2139279	1941266	2025147
Straw								
Wheat	711611	947300	963011	945763	904613	807334	869885	925877
Spelt	45279	13973	13293	10921	8540	9956	11017	11230
Barley	579742	437009	383309	322061	291701	242789	219645	205449
Oats	96731	37574	29798	30936	30437	41914	35208	23240
Others	46279	69114	76027	83095	70232	75867	81011	109144
Total	1479642	1504970	1465438	1392776	1305523	1177860	1216766	1274940
Dry peas	2166	7995	11469	17621	13968	23618	14956	9126
Dry french beans	1628	2649	1829	1914	1734	1188	741	947
Beans	..	..	2517	2408	2271	6730	6306	2238
Mixtures	922	1719	384	507	561	354	529	256
Total Dry vegetables	4716	12363	16199	22450	18534	31890	22532	12567
Sugar beet	5314597	6061282	6418458	5675748	5956643	6264280	5393737	6080570
Chicory	32144	30294	64925	117969	212148	176832	229568	299289
Linseed	5588	8155	8792	7450	5428	7467	8997	16483
Flax	43760	60072	65057	58050	43495	54478	64087	71715
Tobacco	1059	1541	1492	1065	1509	1563	1459	1251
Hop	1431	621	621	711	798	769	686	1008
Winter rape	795	11714	15930	21459	17249	12337	18096	18301
Spring rape	96	173	146	319	543	1056	1058	797
early varieties	74339	103894	230756	186189	227381	186002	177747	340879
mid-early varieties	722199	934817	1387391	1568745	2093819	1905706	1410287	
late varieties	619259	564164	218971	247284	315577	285633	232337	1967067
Total potatoes	1415797	1602875	1837118	2002218	2636777	2377341	1820371	2307946

Grasslands								
Year	1980	1989	1990	1991	1992	1993	1994	1995
Ray-grass 1 cut	185455	114236		..	..	..	..	..
2 cut	123353	76473		..	..	..	..	..
Others 1 cut	47910	22180	190962	240963	286653	318842	557679	415164
2 cut	24611	13370	103818	162904	203789	223665	377225	491252
Permanent to cut								
1 cut	896675	1361355	1302312	1078593	1283847	1250984	1065830	1333445
2 cut	552978	855176	764515	806377	962242	915854	793978	1555889
Total	1830982	2442790	2361607	2288837	2736531	2709345	2794712	3795750

Clover 1 cut	9330	3855	6471	5255	5174	4910	4990	7228
2 cut	6264	2249	3773	3499	4126	3515	2279	
Total clover	15594	6104	10244	8754	9300	8425	7269	7228
Alfalfa 1 cut	16775	5330	5634	5804	7464	6317	6006	
2 cut	11817	3540	3576	4013	5673	4859	4191	14272
Total alfalfa	28592	8870	9210	9817	13137	11176	10197	14272
Milky maize	3600076	5883146	5145586	6009663	7219650	7504966	6858443	6156466
Leaves								
sugar beet	3823094	2976000	2853000	3656000	4040000	3458000	2557000	2198000
fodder beet	458505	258000	236000	306000	336000	281000	206000	156000

Vegetables

Year	1980	1989	1990	1991	1992	1993	1994	1995	1996
Green peas	26000	49200	63500	61712	66000	68078	66297	60840	
French beans	15200	41850	28200	34160	62000	70710	66592	52885	
Carrots	68200	70900	64400	70135	83100	100068	80925	71802	
Cauliflower	..	..	..	..	..	..	60010	53025	
Leeks	..	..	..	..	..	..	161070	141070	
White celery	12800	7500	6300	5045	9400	12850	11597	14195	
Spinash	10500	22600	20300	25518	31800	40612	30639	33309	
Chervil	660	110	120	291	280	502	1127	718	
Onions	500	100	80	148	180	277	277	30	
Parsnips	35440	23760	17520	17995	12900	14421	13149	9814	
Others	..	..	..	..	..	..	..	..	
Total	169300	216020	200420	215004	265660	307518	491683	437688	

Green peas	416	270	480	355	3400	3254	3301	4529	4177
French beans	3800	6200	5000	6328	11600	8742	7252	5133	4268
Carrots	15800	22000	26000	35425	34600	33290	35445	31824	41620
White celery	8400	3300	3500	2775	2700	2540	6097	2967	3300
Spinash	2600	1870	2300	2471	2600	2472	2165	1971	2236
Chervil	360	85	80	150	150	162	242	306	358
Onions	18200	18700	17400	17730	16600	15381	13593	11778	9077
Witloof	84000	89500	104000	107960	101600	97160	96680	93547	78180
Tomatoes	2300	..	..	..	..	..	..	..	..
Cauliflower	38500	68800	69100	87219	95700	117371	44331	39229	31329
Asparagus	560	1080	1500	1345	1500	1847	1660	1824	1522
Lettuce	38400	40500	39800	30922	28300	22956	17910	19442	10760
Red cabbage	20300	29150	24000	25660	32200	33715	27115	23095	28445
White cabbage	10000	12750	10700	10972	13200	15916	15726	13104	16759
Brussels sprouts	11700	40560	34600	29162	39700	50959	46006	40682	38306
Green cabbage	12000	8800	8300	7318	8100	9570	7462	6026	5090
Leeks	69000	155000	146000	137332	163800	237830	97114	99080	97890
Shallot	660	350	400	360	400	442	545	569	536
Green celery	4200	1370	1500	1470	1900	1954	2666	3615	3523
Celery	8800	24400	20800	28820	26600	23505	21516	24174	23880
Parsnips	8860	5940	4380	4499	3200	4807	4383	3271	2698
Endive	7600	6650	5900	5760	5400	6430	6123	7105	8185
Gherkins	15600	42000	25800	40375	38000	17325	20301	16675	6395
Radish	400	320	400	396	300	289	291	181	226
Rhubarb	2100	2200	2100	2226	2400	2510	2165	2400	2960
Corn salad	440	420	330	257	250	225	129	120	115
Others	8510	10630	5320	19191	19700	30981	32116	33413	34849
Total	393506	592845	559690	606478	653900	741633	512334	486060	456684
Total field	562806	808865	760110	821482	919560	1049151	1004017	923748	857627
Inside crops									
Tomatoes	90700	225220	268400	313960	329500	346779	309334	342890	285520
Cucumber	9600	13900	19000	23388	26800	30453	27189	27290	26160
Gherkins	7100	4600	3100	3045	2300	1028	948	480	120
Melon	960	..	..	..	..	..	..	..	..
Lettuce	42000	47200	46800	54146	55200	59607	60772	65599	66286
Cauliflower	375	190	220	190	180	172	217	263	242
Celery	2600	3400	3600	3147	3000	2877	2384	2405	2110
Paprika	200	..	6200	8970	11300	12230	11382	11148	12660
Corn salad	600	1820	1700	1654	1700	1659	1779	2159	2349
Others	2375	5560	2570	2375	2600	5143	6492	6541	9951
Total inside	156510	301890	351590	410875	432580	459948	420497	458775	405398
Mushrooms	13600	17527	19549	20592	20593	22611	22600	22136	30792

Lists of current industrial crops (areas in ha, yield in tonnes/ha, production in tonnes)

Crop species and their respective areas

Crop species	**National areas (ha)**	Regional areas (ha)	
		Walloon region	**Flemish region**
Maize for grain- wet	16,081	1,009	15,072
- dried harvested	6,109	1,043	5,066
Winter Wheat	193,666	124,702	68,954
Spring Wheat	2,726	1,509	1,217
Spelt	8,137	8,046	91
Rye	1,844	232	1,612
Spring Barley	4,882	3,679	1,203
Winter Barley	44,481	31,091	13,390
Oats	5,387	1,844	1,543
Triticale	9,003	6,253	2,750
Potatoes (total)	61,403	20,805	40,598
Early	10,740	951	9,789
Bintje variety	42,039	15,500	26,539
other varieties	8,624	4,354	4,270
Sugar beet	97,990	62,294	35,696
Chicory for inulin	10,754	2,808	7,946
Linseed	299	204	95
Flax	10,962	7,186	3,776
Spring Oilseed rape	376	340	36
Winter Oilseed rape	4,497	4,368	129
Dry peas	1,690	1,416	274
Medicinal and aromatic plants	583	383	200

From Institut national de statistique, recensement agricole 1997

Crop species and their respective yields

Crop yields in t/ha

Crop species	Harvested products	National means	Regional means	
			Flemish region	Walloon region
Maize grain - wet	Grain	10.14	10.29	8.82
- dried	Grain	7.61	7.88	5.94
Spring Wheat	Grain	6.57	6.93	6.16
	Straw	4.06	4.44	3.62
Winter Wheat	Grain	9.13	9.33	9.02
	Straw	4.68	4.78	4.62
Epeautre	Grain	6.25	6.48	6.25
	Straw	4.84	5.01	4.84
Rye	Grain	5.28	5.31	5.14
	Straw	4.31	4.59	3.24
Spring Barley	Grain	4.82	5.75	4.39
	Straw	3.10	3.25	3.03
Winter Barley	Grain	7.77	7.75	7.79
	Straw	4.27	4.25	4.28
Oats	Grain	4.98	5.73	4.60
	Straw	3.69	3.96	3.56
Triticale	Grain	7.53	7.83	6.85
	Straw	5.30	5.47	4.90
Potatoes for Plant	Tuber	21.24	22.08	20.69
Early		30.07	30.05	30.22
Bintje variety		42.72	44.17	40.05
other varieties		40.11	41.23	38.77
Sugar beet	Roots	54.53	58.66	52.04
Chicory for inulin	Roots	34.13	37.06	33.18
Linseed	Grain	1.66	2.18	1.56
Flax	Straw	6.50	7.08	6.22
Spring Oilseed rape	Grain	1.62	2.53	1.53
Winter	Grain	3.67	3.23	3.69
Dry peas	Grain	5.10	5.43	5.06

From Institut national de statistique, recensement agricole 1997

Annex 2: Lists of key contacts

Academic research groups and organisations

Walloon Region

APPO (Oilseeds and Protein crops Promotion Association)

The APPO takes care of oil and proteins crop plants information's to the farmers in collaboration with federal and regional ministry of agriculture and the industrial companies involved in this field.

Demonstration and experiment fields are annually set for different crop species :

- ***proteaginous peas*** : on several varieties available on the market, with different densities, on insecticides, weedkillers and fungicides protection.
- ***oilseed rape*** : on several species (classical or hybrid), nitrogen fertilization, fungicide utilization, density sowing, study the first hybrid resistant to the total weedkiller glufosinate
- experiments on ***linseed*** varieties were also undertaken.
- alternative oilseed plants were studied (***Calendula officinalis, Crambe abyssinica, Lesquerella sp, Brassica juncea, Limnanthes alba, Dimorphoteca pluvialis, Camelina sativa, Carthamus tinctorius, Euphorbia lagasceae and E. lathyris***).

In response to the many questions notably during the growing season, advises are given on oilseed rape, pea, linseed specially on economic, crop husbandry and crop protection aspects. As soon as pests or diseases are detected, information is broadcast and actions are proposed. APPO acts as a crop surveyor advising on fertilisers, agrochemicals, their application dose, proposing solutions on economical threshold and environmental impacts bases.
APPO participates a project aiming to promote Familiarization with and Acceptance of Crops incorporating Transgenic Technology in modern agriculture (FACTT) prepared by Plant

Genetic Systems to study the genetically modified organisms and their acceptation. Assays with oilseed rape
resistant to glufosinate were held. Annual meeting are organised between the European partner.

Proposals in the frame of "Agenda 2000" are unfavourable in relation with the profitability of arable crops including oil and protein crops. APPO takes part actively in the discussions on these European proposals at the national level.

Contact :

Faculté Universitaire des Sciences Agronomiques
Unité de Phytotechnie des Régions Tempérées
Association pour la promotion des protéagineux et des oléagineux (APPO)
Passage des Déportés 2, 5030 Gembloux
Tél : 32 81 62 21 37 ; Fax : 32 81 62 24 07 ; E-mail : appo@fsagx.ac.be

Gidéol

Contract from the 18/08/1994 to the 18/08/19996

The aim is to develop the issues from oilseeds plants (biofuel). A pilot unit, located at Feschaux (near Dinant), was set to produce biofuel. Oils and grinding from oilseed rape and linseed were sold. It was an association between some companies and Valonal.
Several studies were lead on oilseed rape trituration and the properties of the grinding. Preliminary contacts were held to set a research project with Petrofina on the vegetable oil issues as lubricants. The settlement of several pilot utilisation's of biofuel was made in different cities (Charleroi, Philippeville). The non technical barriers of the biofuel non-development were identified in collaboration with the BELBIOM in an ALTENER program. A project to reduce the taxes on this kind of fuel was send to the belgian minister of finance. The conclusion was a failure of the biofuels as long as the taxes will stay at the actual level.

Valonal

Contract from the 15 / 12 /1997 to the 15/ 12 / 1999 (renewable)

The former association GIDEOL was renamed Valonal. Its aims are :

1. Encouragement to the utilisation of biodegradable lubricants, vegetable inks and adding for phytosanitary products :

- Micro and macro economic evaluation of the products (production costs, sell price, potential market)
- Functionnal qualities evaluation of the products
- Environmental evaluation of the products
- Research of the most appropriated applications of the products (particular market niches, involved material,...)
- Identification of the industrial and commercial partners concerned by the products
- Products promotion to industrial and commercial selected partners
- Organisation of the necessary demonstration

2. Information and sensitisation actions for new utilisation's of the vegetable resources

3. Management and diffusion of the cultural contracts on agro-industrial set-aside

- Contracts adaptation to the laws evolution and in function to farmers, collectors and transformers demands
- Statistical settlements of the cultural cont0racts (producers number, fields areas,...) and analyse of them.
- Contracts adaptation to cultures specificity and ton their phytotechny evolution

4. Inventory and evaluation of the non-food utilisation's of the crops products

Contact :

Faculté Universitaire des Sciences Agronomiques
Unité d'Hydraulique et Topographie
Valorisation non alimentaire des productions agricoles (Valonal)
Passage des Déportés 2, 5030 Gembloux
Tél : 32 81 62 23 50 ; Fax : 32 81 62 23 16 ; E-mail : valonal@fsagx.ac.be

<u>Green Chemistry</u>

The approach

In 1991, Europe was forced to reduce its food production and to change the CAP framework. The set-aside policy reduced the market not only for the farmers but also for the upstream and downstream agro-industrial sector. At that time, the idea was to use these set-aside to grow industrial crops for non-food purposes. The motor fuels market was the main targeted.
A « marketing push » approach was followed to convince public autorithies to give a fiscal advantage because this production generated more activities in Europe than the production of the same amount of fossil fuels. Then, ; a large debate took place and we gave our contribution to it by a macro-economic study of a motor biofuels production in Belgium. At the end of this study, we were convinced that the consensus would be difficult to build and the chance of success in the short term would be quite low in Belgium without an European decision.

This explain why, at the end of 1992, we proposed to the Walloon government to take over the issue from zero by trying to understand better the reasons of the GATT agreements, of the CAP reform, of the Rio conference and of the obstacles met in the motor biofuels case. We followed a pragmatic approach based on innovation management, industrial analysis and environmental challenge. Here are the five steps that we went through during the last three years.

Target higher added value markets

Several reasons explain this choice ? In Wallonia, the set-aside area was quite limited at this time. Moreover, the oil price is quite low. Finally, the set aside and the low prices of agricultural products were not guaranteed in the long run. The chemical sector in the broad sense, including pharmaceuticals, cosmetics, fine chemicals and polymers, seemed more attractive.

Launch a positive and integrative concept

Rather than using a negative concept like « non-food », we used a positive one, « green chemistry », in order to integrate the objectives of consumers, chemical industry, agriculture and environmental associations. This concept targets a chemistry tat uses minimum ressources and produces minimum wastes, that uses renewable ressources if it is possible, (renewable energy, agricultural products, bio-organic wastes from households and the food industries and that produces more ecocompatible stuffs (non-toxic, quickly biodegraded, ...). This concept is of course linked to sustainable development.

Build a multidisciplinary and international network

In order to be credible, to avoid marginality and to get a critical mass, a broad network has been built at the Walloon, Belgian, European and worldwide levels by presentations at conferences (European Parliament, club of Brussels, World Business Council for Sustainable Development, SRBII, Industrial Crops and Products...) and publications (Green Chemistry Study, Ecodecision, Ecomanager, Orcazette, European Chemical News, Chimica Oggi, L'Usine Nouvelle, Inform, Agro-food High Tech Industry, Agra-Valor, OCL, Biofutur, Industrialb Crops and Products, Athena, newspapers, ...).

Crystallize and cross-fertilise around several products and markets

For the same reasons and to learn experiences from comparisons, we have looked at the same time at different markets : inks and paints, lubricants and hydraulic oils, detergents and cleaning stuffs, plant protection products, packaging and other polymer materials, cosmetics, pharmaceuticals, ...

Go from agriculture towards consumers, industries and environment

So far, the « green chemistry » project is an agricultural initiative. If we want to avoid some reserves - right or not - met in the motor biofuel debate, we must remain as possible and get a consensus as broad as possible.

Contact :

Faculté Universitaire des Sciences Agronomiques

Unité d'Economie Rurale

Groupe Chimie verte

Passage des Déportés 2, 5030 Gembloux

Tél : 32 81 62 23 60 ; Fax : 32 81 61 59 65 ; E-mail : ecru@fsagx.ac.be

Sorghal

Sorghal is a non profit organization founded in 1989 from ISI Huy (High Industrial Institute located in Huy) to promote research on tropical plants able to grow under the European climatic conditions. With the CREW (Research Centre on Walloon Economy) from the Economical Sciences Faculty of Namur, the settlement of a bio-ethanol production line from sugar beet and sorghum juices in Wallonia was studied. Two reports were published. In an other hand, agronomical researches on the viability in our regions of sugar and fibres sorghum were held. The phytotechny of an interesting plant for biomass production (Miscanthus) is also approached in European networks settled by DG VI and DG XII of the European Commission.

All these works were possible thanks to the collaboration of many industrial companies and researches groups (De Smet Extraction, STOLZ, Drouillon Ltd, SAPSA-SES, CARAH, CHPTE, FSA-UCL, ISI Gembloux).

Crop Species	**Sorghum**
Research Title	Feasibility Study : Bio-ethanol production from sugar beet and sorghum in Wallonia
Founding	Walloon Region, 1992
Objectives	Study of the bio-ethanol potential market, the production (agronomical aspects, juice extraction, fermentation, co-products utilization
Research Title	Project of a demonstration unit to produce Bio-ethanol from sugar beet and sorghum in Wallonia
Founding	Walloon Region, 1994
Objectives	Study the technical, material and economic aspects to use sorghum for ethanol production and demonstrate the ability of this process.
Research Title	Sweet Sorghum Network
Founding	AIR-CT-920041, 3 years, from 1993 to 1995

Objectives	Development of agronomical assays on Sorghum to quantify the crop plant potential throughout Europe - (10 European partners)
Crop Species	**Miscanthus**
Research Title	Feasibility Study : Bio-ethanol production from sugar beet and sorghum in Wallonia
Founding	AIR-3-920294, 3 years, from 1993 to 1995 and Concerted action on Miscanthus – FAIR-CT96-1707, for 1 year
Objectives	Quantification of the Miscanthus potential as biomass crop plant, agronomical and transformation aspects (15 European partners)
Research Title	Studies of the industrial valorization opportunities of Miscanthus in Wallonia
Founding	Walloon Region, 1997, 5 months
Objectives	Study of the Belgian Industrial Interest (Walloon in particular) for the ligno-cellulosic plants with annual harvest (as Miscanthus)

Contact :

Sorghal asbl
Institut Supérieur Industriel
Rue Saint Victor, 3
B-4500 Huy
Phone numbers : 32 85 24 00 12 Fax : 32 85 21 15 41 E-mail : sorghal@skynet.be
32 85 21 48 26

Belbiom

The biomass is all the renewable raw materials from animal or plant for non food utilization (green chemistry, paper,...) or for energy (heat, electricity, fuel,...). In Belgium, biomass represent mainly the first renewable energy source even if it covers only one pecent of the total energy consumption. Nowadays, this energy comes almost exclusively from wood and its

derivative products used by the industry to produce stream, heat and/or electricity or by individuals for their own heating.
Further of this utilization, here is a potential origin of important biomass in forestry and woodwastes (packaging, construction ...). The agriculture could provide future energy furniture. The green chemistry undergoes at present a revolution mainly by environmental aspects. New lubricants, detergents, plastics, inks or paints are some examples of new biodegradable stuffs from the biomass.

Energy and materials : find other energy sources to reduce our dependence of fossil fuels, ensure and be aware of our provides, increasing renewable energy in primary energetic consumption
Environment : replace a part of fossil fuels mainly responsible of the CO2 level in the atmosphere, utilization of potentially less pollutant fuel, maintenance of rural areas, valorization of residues.
Employment : create new local jobs, maintain jobs in agriculture and forestry, indirect activities.
Agriculture and forestry : new market opening, alternative proposition to food surplus

The BELBIOM

The Belgian Biomass Association is a non-profit organization which pools Belgian actors involved in biomass. The objective of the Belbiom is to promote the biomass production and valorization in Belgium. To achieve these aims, the Belbiom :

- disseminate the information (by post, seminars, visits)
- purpose measures and solutions to cope with obstacles to biomass development
- get in touch with the political authorities
- participate to international activities (Association Européenne pour la Biomasse, AEBIOM)

Activity from the Belbiom members :

poplar physiology, new industrial crops experiments and development (as Miscanthus, Sorghum), experiments on biofuel and development of these stuffs from oilseed rape on agricultural set-aside, pilot unit on transesterification-biofuel production, studies and prospection of plant chemistry issues, pilot project of decentralised electricity by wood gazification from very short rotation copsewood, ...

Contact :

Belgian Biomass Association
c/o CRA, Département de Génie rural
Chaussée de Namur, 146
B-5030 Gembloux
Phone number : 32 81 612501 and Fax : 32 81 615847

Flemish Region

VITO (Vlaamse Instelling voor Technologisch Onderzoek)

VITO- Flemish Institute for Technological Research, provides the business world and governmental agencies with multi-discipline assistance in applied research and development. VITO is active in the fields of environment, energy and materials. In carrying out assignments (in the framework of regional, national or European research projects), VITO offers: quality, efficiency, compliance with agreed deadlines through goal-oriented, co-operative, effort based on confidentiality

The centre of expertise ENVIRONMENTAL DIAGNOSTICS (DIA) performs frequent control analyses and measurements for the Belgian government in the fields of waste products, soil, air and water, and is recognized as the leading Flemish laboratory for environmental analyses.
A wide range of specialized analyses (atmosphere in the workplace, dioxins, cyanides, etc.) and integrated environmental studies are performed for various industrial clients.

The centre of expertise REMOTE SENSING AND ATMOSPHERIC PROCESSES (TAP) has already gained a lot of experience with national and international projects, executed on behalf of industry and government. We develop processing strategies to improve the interpretation of satellite imagery in the fields of vegetation (carbon fixation & classification) and air pollution.

The models for air monitoring can visualise the environmental impact (concentration of pollutants, deposition, etc.) from industrial, residential and transport emissions. Some of the models are used as policy tools, in which case they are applied for evaluation of emission reduction scenarios.

Measurement of electromagnetic smog. CETAP has the most advanced measuring equipment. CETAP will host the image processing centre and the global imagery archive of the "VEGETATION"-instrument mounted on the SPOT 4 satellite due to be launched march 1998.
BELFOR: Sustainable Development of the Belgian Forests Research during the last decade yielded a generous harvest of information on very specific forest ecosystem cycles.

The centre of expertise ENVIRONMENTAL TOXICOLOGY (TOX) evaluates the impact and risks environmental disturbances have for plants, animals and people. This centre of expertise determines the harmful effects of water, soil and air contamination and is the leading research laboratory in this field in Flanders. Human toxicology research is performed within the framework of international joint ventures concerning test methods and validation studies.

The centre of expertise ENVIRONMENTAL TECHNOLOGY (MIT) offers advice, evaluation and demonstrations involving technologies for the purification of waste water or groundwater and the cleaning of soil and dredged materials, on the request of companies or government organisations. These technologies include biological and physicochemical (including electro-chemical) methods. In-house technology with leading-edge expertise in biotechnological processes geared specifically to the elimination of heavy metals and organic compounds that do not readily decompose, is in development. PRODEM is a promotion, demonstration and advice centre that offers SME's logistic and technological support in the introduction of environmentally friendly and economically feasible technologies.

The centre of expertise RATIONAL USE OF ENERGY (REG) aims at lowering energy consumption and simultaneously reducing environmental impact. A number of projects focusing on heating systems and climate control in buildings by means of cold and heat storage in groundwater, are currently being implemented. This centre of expertise acts as a hub for the dissemination of knowledge and the promotion of co-generation of Combined Heat and Power (CHP), as well as a catalyst and objective assessor for the interest groups involved.

The centre of expertise TRAFFIC AND ENVIRONMENT (V&M) carries out researches into the use of alternative fuels and new traction systems for vehicles is also.
Components such as primary energy sources, batteries and electric motors for hybrid and other traction systems are tested and evaluated on a dynamic test bench in order to assess their technical feasibility.

The centre of expertise PRODUCT AND PROCESS ASSESSMENT (PPE) aims to develop integral evaluation methods for products and processes and strives for implementation of these methods in industry and in government policy. This integrated approach can be driven from the standpoint of environment (LCA, BAT), energy (ESA) or society (TA).
Life Cycle Assessment (LCA) studies the environmental impact of products and services over their entire life cycle, from cradle to grave. EMIS collects a wide range of information concerning energy and environment. The information is processed and presented free on the world wide web.
BAT The Flemish centre for Best Available Techniques collects and evaluates information on BAT for all industrial sectors and disseminates this information to industry and government.
Energy System Analysis (ESA) Focused on a sustainable use of energy and raw materials, projects are mainly related to energy planning and process optimisation.
Technology Assessment (TA) The project group investigates and gives advise on questions related on the interaction between technology and society.

The centre of expertise RAW MATERIALS (GRO) promotes the sustainable use of raw materials and develops economically viable applications for waste products. This centre of expertise plays an active role in recycling projects by devising means of utilising waste products (secondary raw materials) in an economic and beneficial manner. The suitability of secondary raw materials for re-use or incineration with energy recovery is investigated on the basis of environmental hygiene characterization.

The centre of expertise PROCESS TECHNOLOGY (PRO) supports and improves industrial technological processes. Specific expertise is available in the fields of membrane separation processes (liquids and gases), pyro-metallurgical processes (non-iron metal melting) and electrochemical processes (water electrolysis and alkaline batteries). Process optimisation, Membrane filtration, Non-ferro metal melting, Product development, Electrochemical processes, Membranes: Product development

The centre of expertise MATERIAL TECHNOLOGY (MAT) assists companies to put innovative material technologies to appropriate use in production processes. This task is carried out through the provision of practical solutions for a wide range of material problems. This centre of expertise is a partner for industries in the fields of coatings, laser technology, material analyses and the formation of metallic and ceramic powders. In addition to advice and guidance, the division also develops prototypes and runs pilot productions.

VITO a research partner

Efficiency in solving the problem is a key aspect. Both knowledge and technology are, quite literally, transferred. VITO does not provide theoretical solutions - it works in the field on projects that are planned and implemented in line with the client’s budget and deadlines. This research is geared to the client’s needs and includes intermediate adjustment, thus limiting the client’s financial risks.

For companies large and small As a research partner specialised in solving problems, VITO also assists small and medium sized enterprises, or SMEs, with their research and development programmes, the implementation of innovative technologies and the optimisation of environmental investments. These smaller businesses can benefit from VITO’s specialised research services in a way that enables them to keep pace with the rapid technological developments in the industrial world.

Policy-making support

VITO is the leading reference laboratory and main research partner in energy, the environment, raw materials and new materials for government organisations. The objective research performed by VITO leads consistently to scientifically responsible conclusions on which coherent, overall policies can be based. At the same time, these policies ensure the sustainable use of increasingly scarce raw materials and the monitoring and preservation of the environment for future generations.

VITO - Vlaamse Instelling voor Technologisch Onderzoek
Boeretang 200
B-2400 MOL
Tel: +32 (0)14 33 55 11 Fax: +32 (0)14 33 55 99
http://www.vito.be/

VIB (Vlaams Interuniversitair Instituut voor Biotechnologie)

A tradition of innovation

In 1995, the Flemish authorities joined nine renowned Flemish university biotech research teams in one autonomous institute: the VIB. Even though a number of the research teams had already acquired an international reputation in the past, our institute now constitutes an important concentration of top level critical intelligence. Moreover, the synergy between our research teams and their parent universities has been maintained.

At present, the VIB consists of nine scientific departments.

1. Department of Molecular Biology - Frans Van Roy

2 Department of Genetics - Marc Van Montagu

3. Department of Transgene Technology and Gene Therapy - Désiré Collen

4. Department of Human Genetics - Guido David

5. Department of Microbiology - Nicolas Glansdorff

6. Department of Immunology, Parasitology and Ultrastructure - Lode Wyns

7. Department of Cell Growth, Differentiation and Development - Danny Huylebroeck

8. Department of Neurogenetics - Christine Van Broeckhoven

9. Department of Medical Protein Chemistry - Joël Vandekerckhove

VIB - (Vlaams Interuniversitair Instituut voor Biotechnologie)

Rijvisschestraat 118 box 1

B-9052 Zwijnaarde

Tel 32-9-244.66.11 - Fax 32-9-244.66.10 - E-mail : vib@vib.be

Oil and fatty acids

UCL, Dr Rosanna MAGGI
Place Croix de Sud 2/17
B-1348 LOUVAIN-LA-NEUVE
Telephone: 3210473652
Fax: 3210473649
E-mail: maggi@cata.ucl.ac.be

Dr Marc FRANKINET
Dept Production Végétale
Centre de Recherches Agronomiques
Rue du Bordia
B 5030 Gembloux
Tél 32 81 62 50 00
Fax 32 81 61 41 52

Starch – sugars

Prof Dr Robert JEROME
Université de Liege
Sart-Tilmant B6
B-4000 LIEGE
Phone: 3241563565
Fax: 3241563497

Universiteit Gent, Prof Jean Guy SWINGS
Laboratorium voor Microbiologie
KL Ledeganckstraat 35
B - 9000 GENT
Phone: 32 92 645116
Fax: 32 92 645346

Fibres

Laboratorium voor Biochemie
Faculteit der Wetenschappen
Ledesanckstraat, 35
9000 Gent

Telephone: 32 9 264 52 72
Fax: 32 9 264 53 32
E-mail: marc.claeyssens@ruz.ac.be

Universiteit Gent, Prof. M Stevens
Vackgroep Bos- en Waterbeheer- afdelin
Coupure Links 653
9000 GENT

Telephone: +32-9-264.61.25
Fax: +32-9-264.62.33
E-mail: Joris.Vanacker@rug.ac.be

Other uses

Prof. Willem Broekaert
F A Janssens Laboratorium voor Genetica
Katholieke Universiteit Leuven
Willem de Croylaan 42,
B-3001 Heverlee
Tel: +32 16 32 24 03
Fax +32 16 32 29 90

List of involved industries or associations

1.3 Section 1 : Oils

Company name	***Blocks***
Activity	Paints
Address	Route de Liège 39 - 4560 Terwagne Tel : 32 85 411162 - Fax : 32 85 412535
Used stuffs	Linseed oil, arabic gum, sugar, honey

Company name	***Dothée***
Activity	Paints, coatings, varnishes
Address	Rue Charles Lamquet 167 - 5100 Jambes Tel : 32 81 300862 - Fax : 32 81 306233
Used stuffs	Oils from castor beans, linseed, wood

Company name	***Eurodye***
Activity	Lubricants and detergents for textile Jeans discoloration
Address	Chaussée de Charleroi 115 - 1370 Jodoigne Tel : 32 10 813002 - Fax : 32 10 813029
Used stuffs	Casein, lecithin, cellulase, alpha-amylase

Company name	***Fina research***
Activity	Chemistry from fossil fuels (polymers, paints), Oleo-chemistry (detergents, food emulsifier, lubricants,…)
Address	Zone industrielle C - 7181 Seneffe Tel : 32 64 514229 - Fax : 32 544652
Used stuffs	Oilseed rape, oleic sunflower

Company name	***Lubri-Asept & Lubrix***
Activity	Detergents and lubricants
Address	Rue du Prince, 10 - 4800 Verviers Tel : 32 87 315030 - Fax : 32 87 31 13 08
Used stuffs	Oilseed rape oils, tensio-actives from alcohol and fatty acids sulfates

Company name	***Riem Belgium***
Activity	aerosols insecticides cosmetics
Address	Chaussée de Charleroi 19 - 5140 Ligny Tel : 32 71 813434 - Fax : 32 71 818084
Used stuffs	Starches derivated, resins, stearic acid derivated, ethylic alcohol, cellulose, myristate, vegetable extracts

Company name	***Trénal***
Activity	Inks
Address	Rue R. Magritte, 165 - 7860 Lessines Tel : 32 68 334921 - Fax : 32 68 334925
Used stuffs	Soya, oilseed rape and oilseed oils

Company name	***Vandeputte***
Activity	Linseed oil and detergents
Address	Zone industrielle- Rue Robert Spriet, 8 - 7700 Mouscron Tel : 32 56 842223 - Fax : 32 56 840201
Used stuffs	Linseed grains

Association name	***Federation Petroliere Belge***
Activity	Association of mineral oils, oil derivatives and prime stuffs for chemistry
Address	Rue de la Science 4 - 1000 Bruxelles Tel : +32 2 512 30 03 - Fax : +32 2 511 05 95
Used stuffs	Oils, mainly mineral

Company name	***Extraction De Smet n.v***
Activity	Oil extraction
Address	Prins Boudewijnlaan 265 - 2650 Edegem Phone : 32 34 440400 - Fax: 32 34 440444
Used stuffs	Oilseed crops

Company name	***Puratos S.A***
Activity	Cosmetics and food
Address	Industrialaan, 25 - B-1702 Groot-Bygaarden Tel: 32-2-481.43.29 - Fax: 32-2-466.25.81
Used stuffs	Sugar, fatty acids

Company name	***Ecover Belgium S.A.***
Activity	Surfactants, detergents
Address	Industrieweg, 3 - B-2390 Malle Tel: +32 3 3092500 - Fax: +32 3 3117270 E-mail: pmalaise@innet.be
Used stuffs	

Company name	***Agrichem n.v.***
Activity	Additives and oil for pesticides applications
Address	Mons. Eestermansstraat 23 - B-2328 Meerle (Hoogstraten) Tel: +32 3 3150876 - Fax: +32 3 3150904
Used stuffs	Vegetable oils

Company name	***Braet n.v.***
Activity	Linseed oil extraction
Address	13, Kanaalweg - B-8710 Wiels Tel +32 56 66 60 15
Used stuffs	Linseed grains

Company name	***Scaldis***
Activity	Linseed oil extraction
Address	Z.I. - B-8580 Avelgem Tel : +32 55 38 84 12
Used stuffs	Linseed grains

Company name	***Oliefabriek Lichtervelde***
Activity	Linseed oil extraction
Address	8, Kortemarktstraat - B-8810 Lichtervelde Tel : 0032 51 72 24 01
Used stuffs	Linseed grains - Oilseeds

Company name	***Vandemoortele NV***
Activity	Oil extraction Vegetable proteins
Address	Group R&D Center Prins Albertlaan, 79, PB 40 - B-8870 Izegem Tel : +32 51 33 21 33 - Fax : +32 51 33 21 75
Used stuffs	All oilseeds and vegetable oils sources

Association name	***FEVIA Federation de l'Industrie Alimentaire***
Activity	Association of various food industry including sugar, oils, starch, milk, chocolate, …
Address	Avenue de Cortenberg, 172,Bte7, - 1000 Bruxelles Tel : +32 2 743 08 00 - Fax : +32 2 733 94 26 E-mail: info@fevia.be
Used stuffs	Vegetable oils - Sugar and starch - Condiments

Section 2 : Fibres

Company name	***Arjo Wiggins***
Activity	Papers for Special uses (self-copying,…)
Address	Place des Déportés - 1400 Nivelles Tél : 32 67 281211 - Fax : 32 67 281640
Used stuffs	Paper pulp, starches, emulsion products, pork gelatine, vegetable oils, cellulosic speciality

Company name	***SOLVAY S.A***
Activity	Chemicals Pulp and paper industry Plastic composites
Address	Research and Technology Brussels Centre Rue de Ransbeek, 310 - 1120 BRUXELLES Phone: +32-2-264.28.82 - Fax: +32-2-264.29.55
Used stuffs	Fibres, enzymes

Association name	***Federation Textile FEBELTEX***
Activity	association of enterprises involved in textiles, natural and artificial fibres
Address	Rue Montoyer, 24 - 1000 BRUXELLES Phone: +32-2-287 08 11 - Fax: +32-2-230 65 85 E-mail: info@febeltex.be

Used stuffs	Fibres, textiles

Association name	***Union des Producteurs de Fibres-Ciment***
Activity	Construction materials with cement and fibres
Address	Avenue de Tervueren 361 - 1150 Bruxelles Tel : +32 2 778 12 11 - Fax : +32 2 778 12 12
Used stuffs	Various industrial mineral and organic fibres

Association name	***COBELPA***
Activity	Association of enterprises in paper pulp, paper, cardboard.
Address	Chaussée de Waterloo 715 Bte 25 - 1180 Bruxelles Tel : +32 2 344 19 62 - Fax : +32 2 344 86 61
Used stuffs	Various fibers and starch stuffs

Association	***Centre de Promotion du Lin***
Activity	Promotion of Flax Fibers
Address	Rue Montoyer 24 - 1040 Bruxelles
Used stuffs	Flax fibers

Section 3 : Starches & Sugars

Association name	***Confédération Professionnelle du Sucre et de ses dérivés***
Activity	Association of enterprises involved in sugar and derivatives (citric acid, yeast, enzymes;…)
Address	Avenue de Tervueren, 182 - 1150 BRUXELLES Phone: +32-2- 775 80 65 - Fax: +32-2-775 80 75 E-mail: marc.rosiers@subel.be
Used stuffs	Sugar and derivatives

Company name	***Biotop***
Activity	Detergents, cleaning products from vegetable, ecological
Address	Rue Neuve 32 - 4370 Raeren Tel : 32 87 852783
Used stuffs	Tensio-active from sugar derived, vinegar, lemons, linseed foam

Company name	***Bioprocess Technology***
Activity	Lactic acid and derivated resins, coatings, metals treatment, textile industry Ethylic ester production from lactate (solvent),
Address	Place d'Escanaffles 23 – 7760 Escanaffles Tel : 32 69 454921 - Fax : 32 69 454926
Used stuffs	Sugar from sugar beet for fermentation

Company name	***Warcoing s.a.***
Activity	Inulin and fructose syrups
Address	Rue de la Sucrerie, 1 - 7740 Warcoing Tel : 32 69 556921 - Fax : 32 69 558137
Used stuffs	Sugar beet till 1991 Chicory roots from 1992

Company name	***Fardem Belgium***
Activity	Packaging, rubbish bin bags, biodegradable plastics
Address	Toekomstlaan 18 - 2340 Beerse Phone : 32 14 615031 - Fax : 32 14 615039
Used stuffs	Starch, bio-polymers

Company name	***Brussels Biotech sa***
Activity	Bio-polymers, biodegradable plastics
Address	Chaussee de Saint Job 10 - 1180 BRUSSELS Phone: +32 23321400 - Fax: +32 23321611
Used stuffs	Lactic acids or sugar as substrate fermentation

Company name	***Organic Waste Systems NV***
Activity	Recycling, biodegradable plastics
Address	Dok Noord 4 - B - 9000 GENT Phone: 3292330204 - Fax: 3292332825
Used stuffs	Starch, sugars

Company name	***Ace S.A.***
Activity	Recycling, biodegradable plastics
Address	GilletRue Renory, 499 - B-4031 Liege Tel: +32-4-349.86.72 - Fax: +32-4-349.86.50
Used stuffs	Starch, sugars

Company name	***Bioprocess Technology S.A.***
Activity	Recycling, biodegradable plastics
Address	Place D'escanaffles, 23 - B-7760 Escanaffles Tel: +32-69-45.49.21 - Fax: +32-69-45.49.26
Used stuffs	Starch, sugars

Company name	***Provital***
Activity	protein isolate internal and external fibres starches Origin : peas
Address	Route fluviale, 10 - 7740 Warcoing Tel : 32 69 556138 - Fax : 32 69 558629
Used stuffs	dry proteaginous peas – Pea starch

Company name	***Citrique Belge s.a.***
Activity	citric acid and other organic acids derivated from sugar
Address	249, Pastorijstraat - B 3300 Tienen Phone ++32 16806211 - ++ 32 16821121 - Fax ++32 16806611
Used stuffs	sugar, mollasses, …

Company name	***Van den Broeke - Lutosa***
Activity	Transformed products from potato
Address	Zone industrielle du Vieux Pont, 5 - 7900 Leuze en Hainaut Tel : 32 69 668274 - Fax : 32 69 668200
Used stuffs	Starches to produce bio-gaz - Starch, oil, flavours,…

Section 4 : Low tonnage, High value

Company name	***Acos-Visoderm***
Activity	• perfumes • milk and cream of beauty
Address	Rue Grignard, 88 - 6533 Biercée Tél : 32 71 591124 - Fax : 32 71 591011
Used stuffs	Medicinal plants, Alcohol from sugar beet and wheat

Company name	***Meyskens R***
Activity	Seeds and vegetable products transformation for perfumes, medicine drugs and diets
Address	Rue des Marais, 140 - 7380 Quievrain Tel : 32 65 457011 - Fax : 32 65 431319
Used stuffs	Several hundreds of vegetable products

Company name	***Omnichem***
Activity	Tannic acid for brewery and textile, pharmaceutical products, surfactants
Address	Scientific Research Park - 1348 Louvain-la-Neuve Tel : 32 10 483111 - Fax : 32 10 450693
Used stuffs	malt, hop, quinquina bark

Company name	***Ortis Laboratoire***
Activity	Natural pharmaceutical products, food adding, skin milks and creams from plants
Address	Hinter der Heck, 46 - 4750 Butgenbach Tel : 32 80 445786 - Fax : 32 80 444280
Used stuffs	Medicinal plants, fruits and vegetables extracts, honey

Company name	***Perlarom***
Activity	food aroma
Address	Rue Jean Lenoir, 9 - 1348 Louvain-la-Neuve Tel : 32 10 453445 - Fax : 32 10 451046
Used stuffs	Various chemicals, some natural aromas