IENICA

SUMMARY REPORT FOR EUROPEAN UNION

PROTEIN CROPS

8.0 PROTEIN CROPS

8.1 Introduction

Plant proteins are an important source of raw material for both food and non-food uses. Proteins are biopolymers of amino acids and are therefore diverse in molecular structure, including highly polar, water-soluble to hydrophobic insoluble molecules. Proteins can vary from being rigid to flexible in structure and have similar mechanical properties when used to produce non-food products as have existing polymers. It is mainly structural or storage proteins such as collagen, keratin and seed proteins which are of interest for commodity applications. In the plant kingdom these are sourced commonly from seeds (eg soybean and pea proteins, wheat gluten) and tubers (eg potato proteins). These proteins are traditionally valued for their functional properties for example the viscoelastic properties of wheat gluten.

The annual production of protein isolates and protein concentrates reaches 1 million metric tonnes world-wide with prices ranging from €1.50/kg to €5/kg. With the exception of the use of cellulose from wood in construction and paper applications biopolymers on the whole play a minor role in the materials market due to dominance by petrochemical-derived materials. They have remained largely undeveloped due to the low cost abundance of mineral oil and to greater developments in its organic and polymer chemistry. Biopolymers still hold the market where their superior performance is critical, for example protein surfactants in foam concrete and gelatin in photographic materials. Protein end products are in the form of fibres, films or adhesives.

In recent years increased knowledge in protein technology, particularly the effect of modifications of protein functionality, has led to improvements in protein performance and many new and interesting applications are penetrating the market. This has been driven partly by environmental concerns and recognition of the need to replace synthetic polymers, and partly by a market push related to overproduction of wheat gluten and whey proteins (approximately 400, 000 tonnes produced annually world-wide)

The production of protein-based plant products for non-food markets can be based upon fractionation of existing crops (wheat, barley) by current or newly developed processes (eg peas, soybean), or by extracting protein from existing low value by-products (eg rapeseed meal). Currently, soybean and wheat proteins represent the most important resource for protein production with some emerging availability of pea proteins and cottonseed proteins and very recently rapeseed proteins.

8.2 Scientific and Technological Aspects

The suitability of plant proteins in non-food applications is determined by three factors:

(a) Competitiveness: competitive products are EVOH, Polyvinylalcohol and styrole-butadiene-latex or acryl-latex with prices in the range of €2/kg to €6-7/kg.

(b) Availability: protein polymers must be available throughout the whole year in standardised quality.

(c) Product properties: the polymer characteristics required in non-food applications are different from those in food applications. Fundamental research on structure-function relationships and chemical modification of plant proteins offers the opportunity to functionalise the polymer properties with regard to specific demands (e.g. molecular weight, molecular weight distribution, charge, structure).

The success of increasing the use of plant proteins into non-food applications is mainly determined through the availability of processes for functionalising proteins by chemical or physico-chemical modification. It is important to note that for non-food applications, protein additives and modifications do not need to be food compatible therefore a much wider use of techniques is available to the chemist to manipulate protein properties, such as solubility, and improve their suitability for a wide range of industrial applications. For example, acylation of gluten improves its suitability as a co-binder in paper coatings, chemical modification of protein hydrolysates improves their surface active properties.

Proteins form stable dispersions which allow them to be used in surface coatings and paints as well as being amenable to thermal processing, including extrusion or injection moulding. Proteins are also preferred for use in certain adhesives due to their high ‘wet tack’ and the stability of the solutions and dispersions they form.

8.3 Markets

It must be noted that in EU15, vegetable protein is not in surplus and that competition between food and non-food markets for purpose grown protein will be inevitable. Although more than 90 % of the annual protein production is marketed into the food industry, some non-food applications show growing potential concerning the utilisation of plant proteins, these are highlighted in table 8.1.

Table 8.1 : Examples of proteins and their technical applications

Protein	**Technical Application**
Soybean protein	Paper coatings, plywood adhesives
Maize zein	Printing inks, floor coatings, grease-proof paper
Keratin	Textiles, cosmetics
Rapeseed meal protein	Adhesives, plastics
Wheat gluten	Adhesives, coatings, cosmetics

8.3.1 Coatings

In paper coating, plant proteins can be used as binder or co-binder in the coating formulation. The functional properties of proteins can be exploited in the printing industry for example to improve the printability of paper. In this particular industry the ability to recycle paper and cardboard is very important hence biodegradable coatings are eminently attractive.

Wheat gluten is being investigated as a replacement for synthetic polymers in coatings, based on its unique properties such as insolubility in water, adhesive/cohesive properties, viscoelastic behaviour and in particular its film and barrier forming properties for water, vapours and gasses.

8.3.2 Plastics

Plant protein based plastics show thermoplastic properties and good biodegradation properties. Thermoplastic processing of proteins is being studied for the production of packaging foils and disposables. Research on protein extracted from rapeseed meal has created prills which can be converted into moulded plastic products.

Bioplastic use is currently small but potentially enormous. However, competition with starch derived plastics must be recognised.

8.3.3 Adhesives

In label adhesives, plant proteins can contribute to the cold water resistance of labelled bottles. Soybean protein is being investigated for use as an alternative to formaldehyde-containing adhesives such as those used in particle boards and plywood. This application alone represents a potential 1.4 million tonnes/year. Isolates from oilseed rape meal protein show high solubility in water making them highly applicable to adhesive formulations.

8.3.4 Cosmetics

Cosmetics are a small market by volume but with high value-added potential. Plant proteins are active ingredients contributing to better component compatibility.

8.3.5 Encapsulation agents

Proteins have promising applications as controlled release encapsulation agents for pharmaceuticals, agrochemicals and flavours.

While vegetable proteins are already used in a number of situations, eg adhesives, while their current usage is small, their potential is significant..

8.4 Limiting Factors

Biopolymer products must not only be technically feasible but also economically competitive. Additionally, the supply of raw materials must be reliable in terms of quality and quantity. However, while competitiveness can be achieved and availability is ensured, plant proteins are currently in most cases purchased as "bulkware" like food products. In general, it is likely that food protein would have the higher value, especially from true protein crops. However, where proteins can be extracted from lower value protein-containing by-products, the economic potential for its exploitation as a non-food feedstock will probably be much greater.