Processing-bioprocessing of oilseed rape in bioenergy production and value added utilization of remaining seed components

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Abstact

Cruciferous oilseed crops accumulate relatively high concentrations of oil, proteins and dietary fibres (DF) in their seeds, in addition to bioactive components as glucosinolates and myrosinase isoenzymes (thioglucohydrolase; EC 3.2.1.147). When mixed in the presence of moisture, myrosinase isoenzymes and associated components transform glucosinolates into various types of products, which reduces the value of the extracted oil and the remaining seed components, as well as producing unwanted environmental effects due to smell and toxicity. This gives a need for special care concerning myrosinase inactivation as the initial step during processing of oilseed rape, including technologies applied for biodiesel/bioenergy production. The myrosinase inactivation is thus a critical processing step, which needs to be performed at conditions with limited negative effects on other seed components, including proteins and glucosinolates. New bioprocessing technologies are now developed at levels that allow technology transfer from laboratory scale through pilot plant to industrial scale. The extraction of glucosinolates from the seed components remaining after oil separation-pressing and/or extraction is technically possible and has proven successful with the use of bioprocessing technologies. This is also the case concerning isolation of active myrosinases. The possibilities therefore exist for extraction and formulation of glucosinolates as "natural product derived" food and plant protection agents. With the great amounts of partly de-oiled rapeseed meal resulting from bioenergy/biodiesel production, the new bioprocessing technologies call thus for attention in relation to environmental friendly production of food (vegetable oil, protein and DF products), feed and other non food products.

Introduction

The current interest in cruciferous oilseed crops, especially double low oilseed rape, is mainly focused on the oil for uses both in the traditional areas of food, feed and non-food (GCIRC conf., 2003) and with increasing interest in biofuels- biodiesel (Inform AOCS, 2006, No.1). Quantitatively this oil is an important contributor to the total global production of vegetable oil, where it accounts for about 10 % and ranks third together with sunflower oil. Rapeseed oil is also the favoured feedstock for biofuels in EU, with a production of 3.2 MMT in 2005, and this figure is expected to be 6. MMT in 2006 (Inform AOCS, 2006, 17 (7)). Several EU countries contribute to this production, which currently is dominated by Germany followed by France and Italy (Inform AOCS, 2006, No.1). It is also claimed (Inform AOCS, 2006, No.1), that the future lies in the production of high quality biofuels from different kinds of feedstocks. We need thus to consider the opportunities for use of other cruciferous oilseed crops than double low oilseed rape. This can give a demand of SME-bioprocessing plants as supplement to the traditional oilmill processing units. In addition, the profitability of biofuel productions by SME and industrial oilmill processing plants may be determined by the added value of by-products (deoiled meal), rather than only the value of biofuel / biodiesel.

Following the production of large quantities of cruciferous oil, the result is the production of a great amount of deoiled meal, which has the potential to give added value products by appropriate applications (GCIRC conf. 2003). The chemical composition of cruciferous oilseed dry matter (DM) is approximately 40-45 % oil, 20-25% protein, 20-28 % dietary fibre (DF) and 5-15 % minor components, which reveals clearly the demand for utilization of the deoiled meal. The native components of double low oilseed rape, especially the oil and protein, have a high nutritive value if problems caused by unfavourable processing, storage and too high concentrations of antinutrients are avoided (Bellostas et al., this conference). The use of appropriate processing and/or bioprocessing procedures is also important for obtaining added value of production and use of cruciferous oilseed crops and products thereof.

Results and Discussion

The conventional processing procedures used by most oilmill industries are in a great part an adaptation of the technology used for soybean processing, which needs to be adjusted to the seed size, high oil content and the presence of glucosinolates characteristic to all cruciferous seeds. The crushing is then followed by heating to 90-110 °C for 15-20 min. in order to inactivate enzymes critical for the product quality i.e. myrosinase isoenzymes (EC 3.2.1.147) (Bellostas et al., this conference), lipase (EC 3.1.1.3) and lipoxygenase (EC 1.13.11.12). A varying part of the oil is then removed by pressing and most of the remaining oil in the resultant cake can then be extracted from flakes press cakes with petroleum ether/hexane using percolating bed extractors. Hexane is removed by heating under vacuum and the resulting meal can then be further treated with steam to give the resultant rapeseed meal (Figure 1).

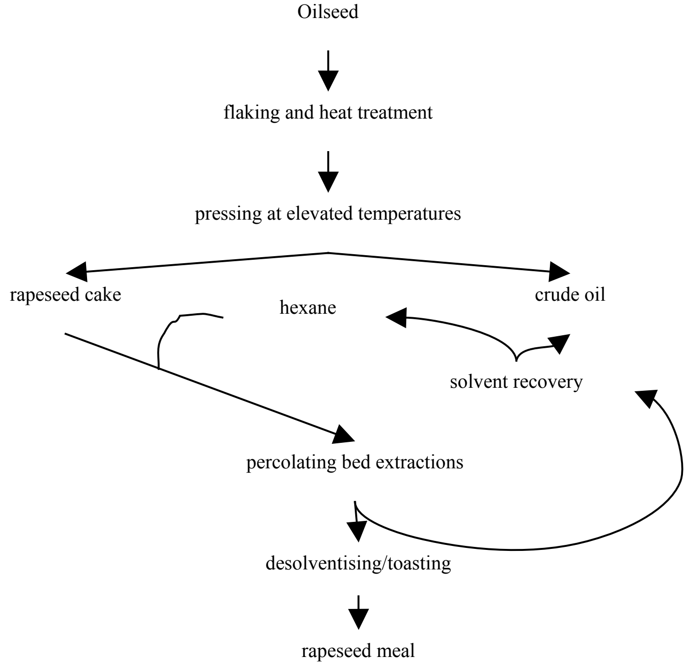

Figure 1. Flow diagram illustrating techniques often used for processing of oilseed rape in conventional oilmills.

The products obtained by the conventional oilmill processing are generally more or less dark, caused by degradation of seed components, including oxidation of some of the native rapeseed constituents. Dark coloured products are easily formed by oxidation of chlorophylls, carotenoids, phenolics and especially 4-hydroxyglucobrassicin (Jensen et al., 1991; Bjergegaard et al., 2001). Part of the other glucosinolates are also degraded and transformed into various products depending on glucosinolate type and processing conditions (Bellostas et al., 2007; Bellostas et al., this conference).

Some of the oxidation- and glucosinolate transformation products are lipophilic and will therefore be present in the oil fractions, which will result in unwanted additional sulphur- and bioactive compounds in the oil and in lipophilic membranes. The crude oil needs therefore refining before use. Volatile transformation products of glucosinolates will give unwanted smell, taste and environmental problems, but by air purification these problems can be solved and the compounds can thereby be used as wanted compounds (Bellostas et al., this conference).

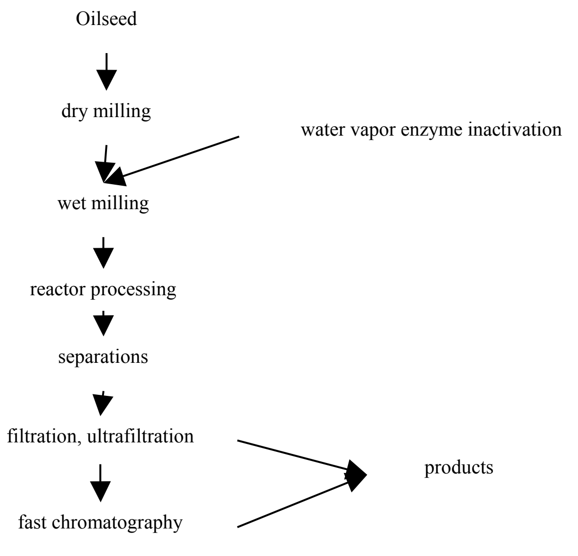

Figure 2. Flow diagram illustrating techniques used in Biorefining of cruciferous oilseeds.

The rapeseed cake and rapeseed meal obtained by conventional oilmill processing are mainly used as feed and for cattle feed as the dark colour does not create problems. The glucosinolates and glucosinolate products may especially create problems when too high concentrations occur in feed for monogastric animals (Bellostas et al., this conference). Both dark colour and glucosinolates or glucosinolate products may also create problems when the rapeseed meal is used for production of food ingredients and for added value non-food products (GCIRC conf. 2003); BOP project 1995-1999; and ENHANCE project 1999-2003).

Biorefining – The Soft Processing Alternative for Processing of Cruciferous Oilseeds has been developed with basis in results obtained in the aqueous enzymatic processing project (Jensen et al. 1990) followed by the EU supported projects (BOP 1995-1999; Bagger et al., 1998; ENHANCE 1999-2003).

This biorefining process has been further developed as semi-industrial scale processing for biorefining of cruciferous oilseed crops based on cold pressing and/or whole seed extractions where SFE and or PSE can be included if or when needed for production of specific products as enzymes (myrosinase) and glucosinolates/glucosinolate products. The developed gentle and environmental friendly process ("Green Chemistry") does not include use of any petrochemicals, and thereby it provides the basis for production of high quality products. The processes have been developed owing to growing interest in obtaining high quality/added value products of the important oil and protein rich agricultural crops, especially double low oilseed rape, which is suitable for growth also in the northern countries in Europe. The aqueous based separation of the constituents in oilseed rape, with intact glucosinolates in well defined fractions, is considered to be a valuable supplement and alternative to traditional rapeseed processing.

This new type of biorefining, where glucosinolate degradation is avoided or strongly reduced, results in a yield of ca. 35% oil from the seed DM by the cold pressing step. This oil is of high quality with its natural content of antioxidants and without appreciable amounts of phospholipids and other constituents unwanted in the oil. Additional refining is principally not needed. Protein products with a high content of protein (60-80 %) can be produced in pilot plant scale, which, in addition to the protein contain especial DF and lipids originally present in the seeds. The concept includes possibilities for preparation of tailor-made specialty products.

Glucosinolates are isolated in separate fractions as are other seed components of interest. The extraction of glucosinolates and active myrosinase isoenzymes has proven successful with the use of bioprocessing techniques now developed. The possibilities hence exist for the extraction and formulation of glucosinolate products as environmental friendly food, feed and plant protection agents.

Liquid chromatographic methods including supercritical fluid techniques (Sørensen et al., 1999; Bjergegaard et al., 2003) are used for analytical process and product control, including oil, its content of chlorophylls, antioxidants, phytosterols, tocopherols, carotenoids and sinapoyl-derivatives.

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