EVALUATION OF NUTRITIONAL QUALITY OF RAPESEED - FUTURE GOALS

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INTRODUCTION

Double low rapeseed is the most important oil and protein crop grown in Denmark as source to high quality oil and protein as well as other products with added value. Rapeseed production is correspondingly wanted in other countries in Europe, where it, together with legumes as e.g. peas and lupins, is considered an important alternative to imported soybean meal and oil (Bjergegaard & Sørensen, 1996). The yield and nutritive quality of both rapeseed oil and protein is generally high, however, the content of antinutrients as dietary fibres (DF), glucosinolates, phytic acid, and aromatic choline esters restricts the use of rapeseed meal (Bjergegaard *et al.*, 1998 and refs. cited therein). There is thus a need to reduce or eliminate the unwanted effects from these compounds (Bjerg *et al.*, 1987; Bjergegaard *et al.*, 1991; Danielsen *et al.*, 1994) in order to produce various products with added value and applicability needed for products available today. This could be performed by plant breeding, proper processing or a combination of breeding and processing (Hill *et al.*, 1995; Bjergegaard *et al.*, 1996; Bagger *et al.*, 1998a). Gene modification of plants (GMP) can be used as supplement to traditional plant breeding, to increase the amount of some wanted compounds or reduce the amount of unwanted compounds as well as some pest and weed problems in relation to rapeseed production. However, many questions concerning use of GMP still exists, including unforeseen problems with use of such techniques to crosspollinators. In all cases, isolation and separation by appropriate techniques of the seed constituents are needed for obtaining the added value of rapeseed constituents. Complete characterisation, chemical as well as nutritional (Sørensen & Sørensen, 1998; Sørensen *et al.*, 1999), will then be necessary in order to obtain a proper evaluation of the value of these rapeseed products as feed and/or their potentialities for direct use as foods or non-food (Bagger *et al.*, 1998b).

The present paper comprises a discussion of some of the factors important for rapeseed product quality. Firstly, the main rapeseed products, its use in EU, and traditional as well as alternative processing methods are presented. Secondly the quantitatively dominating groups of antinutritive compounds are evaluated briefly with respect to their effects on the quality of rapeseed/rapeseed products and suggestions of possible future investigations.

OIL-LIPIDS

Oil, triacylglycerols, and other lipids are the most important part of rapeseed, both quantitatively (40-46% of dry matter (DM)) and for economical reasons. Rapeseed is thus a quantitatively important crop for EU as competitor to soybean, as seen from the amount of oilseed crushed in EU during the recent years (Figure 1).

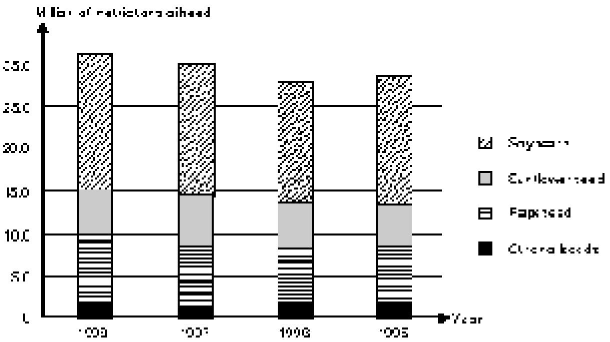

Figure 1. Recent years amount of oilseed crushed in EU. Other oilseeds comprise cottonseed, peanut, sesame seed, linseed, castor-bean, palm kernel and copra.

Properly treated rapeseed oil is also from a nutritive point of view of very high quality (Trautwein, 1997), which need to be documented by appropriate methods of analyses as e.g. SFT (Bagger *et al.*, 1998b; Sørensen *et al*., 1999).

PROTEINS

Rapeseed has a relatively high content of protein (18-28% of DM). From a nutritional point of view these proteins have a well balanced amino acid composition reflected by their biological values (Bjergegaard & Sørensen, 1996). The digestibility of the proteins is however too low owing to association to dietary fibres both from the hull and the dehulled meal (Danielsen *et al.*, 1994). In addition, processing conditions (*vide infra*) have also strong influence on the proteins nutritive quality (Bjergegaard *et al*., 1996) as well as on the protein solubility affecting the possibilities for production of protein concentrates and isolates. As rapeseed protein is characterised by a relatively high level of sulphur-containing amino acids, threonine and tryptophan compared to legume and cereal proteins, combinations of legume proteins with high content of lysine give opportunities for well balanced protein mixtures (Bjergegaard & Sørensen, 1996). Pea proteins with high digestibility (Bjergegaard & Sørensen, 1996) but relatively low content of methionin, cysteine and threonine but high in lysine, could by combination of peas and rapeseed meal take advantage of this potential to supplement each other and result in a good alternative to soybean meal. A factor, which should be born in mind, is the occurrence of trypsin inhibitors, which may be of importance for the protein utilisation. The level of trypsin inhibitors in rapeseed is generally considered to be lower than in pea, which again has a much lower level than found in soybean. Studies of the combined influence of trypsin inhibitors from cereals, legumes and rapeseed need however to be performed by biological, biochemical and analytical evaluations combined with feeding trials (Sørensen & Sørensen, 1998).

PROCESSING

Traditional rapeseed processing comprise pressing or extraction of oil using hexane with concurrent heating to inactivate the glucosinolate degrading enzyme myrosinase (Unger, 1990). Hexane has particularly been used because a high oil yield is thus obtainable. However, some drawbacks of the method exist in relation to the effects there can be on the meal or protein products for animal feed (Bjergegaard *et al* ., 1996), mainly due to effect from dietary fibres, the glucosinolates and especially degradation products hereof (Bjerg *et al*., 1987, Bjergegaard & Sørensen, 1996). The high temperatures employed in some oilmills in connection with hexane extraction seems to be the main cause for this, as simultaneous thermal degradation of the glucosinolates appears as a side effect of myrosinase inactivation (Bjergegaard & Sørensen, 1996 and refs. cited therein). Improvement of oil and meal quality can be obtained by pressing instead of extraction, if too high temperatures are avoided. This rapeseed processing gives generally oil of higher quality than extracted oil (Pokorny *et al*., 1987; Niewiadomski, 1990), but the oil content left in the press cake is higher. Evaluation of traditional rapeseed processing in order to obtain improved products may include investigation of controlled pressing and extraction techniques exposed to different heat and moisture treatments.

An attractive supplement to the traditional protein-containing meals obtained after hexane extraction or pressing the products obtained by biorefining, when high quality is needed (Bagger *et al*., 1998ab). This processing technology has been developed for gentle isolation of various lipids (oil) and protein fractions from oil- and protein-rich crops. This type of processing is an environmental friendly ``green chemistry process'' based on aqueous-enzymatic extraction resulting in high quality oil as well as protein products (Bioraf products) (Bagger *et al*., 1998a). The technique developed for the extraction of rapeseed oil, moreover allows the production of more specialised products as e.g. soluble and insoluble protein fractions, lipid-protein fractions, dietary fibres (DF), hulls, pure enzymes (e.g. myrosinase) and groups of low molecular weight compounds (e.g. glucosinolates) (Bagger *et al*., 1998b)

DIETARY FIBRES

Animal studies have indicated, that the DF fraction are partly responsible for the relatively low protein and energy digestibility in rapeseed compared with soybean meal (Bjergegaard *et al*., 1991, Danielsen *et al*., 1994; Jensen *et al*., 1995ab, Ochodzki *et al*., 1995), and DF have thus influence on nitrogen loss to the manure (Kreuzer *et al*., 1998). The main components of DF, non-starch polysaccharides and lignins, are closely associated to a wide range of non-carbohydrate components, including proteins, oligosaccharides, phytate, tannins, low molecular weight phenolics etc. (Cho *et al*., 1997). Especially the rapeseed hulls has a high proportion of insoluble dietary fibres (IDF) and dietary fibre associated proteins (Jensen *et al*., 1990), and it has been shown, that the digestibility of protein and energy is negatively correlated to the hull and lignin content (Jensen *et al*., 1995a). This finding is in agreement with results from a similar trial with full fat rapeseeds of different size to broilers (Liu *et al*., 1995). However, DF from outside the hulls is also of great importance in this respect (Bjergegaard *et al*., 1991; Danielsen *et al*., 1994).

There is as revealed from the above mentioned results a distinct need for more research within the DF area in order to correlate data from chemical characterisation of DF to biological data on protein and energy utilisation. Investigations on release of DF associated proteins would be one way to get closer to the mechanisms of binding between DF, protein and other compounds (Bjergegaard *et al.*, 1999), and thereby possibilities of improved protein digestibility and opportunities for higher yield in procedures for protein isolations.

GLUCOSINOLATES AND OTHER LMW RAPESEED COMPONENTS

Glucosinolates and their degradation products are far the most important antinutritional factors in rapeseed. Glucosinolates has been intensively studied for several years, the results showing that the structure of the glucosinolates highly influences their antinutritional effect (Bille *et al*., 1983; Bjerg *et al* ., 1989; Darroch *et al*., 1991; Jensen *et al*., 1991; Liu *et al*., 1994; Mawson *et al*., 1995ab). Recently, it has also been shown that glucosinolate products can be found in meat or organs of animals fed rapeseed (Thomke *et al*., 1998). The possible isolation of glucosinolates and myrosinase in kg amounts by use of the above mentioned biorefining process technique has opened up for a continuation of these studies using animal trials with chickens and pigs as a supplement to the trials performed with smaller animals as e.g. rats and mice. Moreover, the beneficial effect of glucosinolates and their degradation products shown in several papers (Loft*et al.*, 1992; Musk & Johnson, 1993; Agerbirk *et al*., 1998; Palmieri *et al*., 1998 and refs. cited therein) should be given further attention.

Rapeseed contains 2.0-4.0% phytic acid (myo-inositol 1,2,3,4,5,6-hexakis-dihydrogen phosphate), which at physiological pH occurs as a very reactive anion towards positively charged compounds as smaller cations and positively charged proteins (Thompson, 1990). Nutritional significant is the reduced bioavailability of minerals as well as a reduced protein digestibility, and DF associated phytic acid may be of importance in this respect. Products low in phytic acid, which can be produced by biorefining of rapeseed, may be of interest in overcoming this problem.

Aromatic choline esters in rapeseed are dominated by sinapine, which have attracted much interest in relation to the quality of rapeseed meal. Sinapine may cause reduced palatability of rapeseed products (Kozlowska *et al*., 1990) and are moreover involved in problems such as disagreable flavours in meat, milk and eggs of animals fed rapeseed (Fenwick *et al*., 1979; Andersen & Sørensen, 1985). Plant breeding and suitable processing are well known tools in limiting the content of aromatic choline esters in rapeseed products and protein meal from biorefining is thus low in sinapine, as the main part hereof accumulates in the aqueous syrup fraction produced (Jensen *et al* ., 1990; Bagger *et al*., 1998b).

CONCLUSION

Optimal utilisation of rapeseed do imply heating in order to inactivate the glucosinolate degrading enzyme myrosinase as well as lipoxygenase, but too much heating and certain experimental conditions at other steps in the traditional processing chain may reduce the quality of rapeseed products. An obvious future goal must then be to optimise well known traditional processing techniques as well as developing new alternative techniques as supplement to these techniques and to the general plant breeding effort exerted. Attention should be paid especially to the importance of investigating the processing with respect to the effect on compounds as glucosinolates and dietary fibres present in rapeseed. Information already exists on the antinutritive effect of these components, but much work still remains. First of all with respect to a chemical evaluation of the individual compounds in different fractions of rapeseed but also when it comes to investigations of correlations between individual well characterised compounds and the biological effects observed in animal trials.

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