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CONSENSUS DOCUMENT ON COMPOSITIONAL CONSIDERATIONS FOR NEW VARIETIES OF SUNFLOWER: KEY FOOD AND FEED NUTRIENTS, ANTI-NUTRIENTS AND TOXICANTS

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Series on the Safety of Novel Foods and Feeds

No. 16

CONSENSUS DOCUMENT ON COMPOSITIONAL CONSIDERATIONS FOR NEW VARIETIES OF THE SUNFLOWER: KEY FOOD AND FEED NUTRIENTS, ANTI-NUTRIENTS AND TOXICANTS

Environment Directorate

Organisation for Economic Co-operation and Development

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FOREWORD

The OECD's Task Force for the Safety of Novel Foods and Feeds decided at its first session, in 1999, to focus its work on the development of science-based ***consensus documents,*** which are mutually acceptable among member countries. These consensus documents contain information for use during the regulatory assessment of a particular food/feed product. In the area of food and feed safety, consensus documents are being published on the nutrients, anti-nutrients or toxicants, information of its use as a food/feed and other relevant information.

This consensus document addresses compositional considerations for new varieties of sunflower by identifying the key food and feed nutrients and anti-nutrients. A general description of these components is provided. As well, there is background material on the production, processing and uses of sunflowers and considerations to be taken when assessing new sunflower varieties.

A steering group comprising Canada, France (chair), Germany, Sweden and the United States served as the lead countries for this document.

The Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology has recommended that this document be made available to the public. It is published on the authority of the Secretary-General of the OECD.

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PREAMBLE

Food and feed products of modern biotechnology are being commercialised and marketed in OECD member countries. The need has been identified for detailed technical work aimed at establishing appropriate approaches to the safety assessment of these products.

At a Workshop held in Aussois, France (OECD, 1997), it was recognised that a consistent approach to the establishment of substantial equivalence might be improved through consensus on the appropriate components (*e.g.*, key nutrients, key toxicants and anti-nutritional compounds) on a crop-by-crop basis, which should be considered in the comparison. It is recognised that the components may differ from crop to crop. The Task Force therefore decided to develop consensus documents on phenotypic characteristics and compositional data. These data are used to identify similarities and differences following a comparative approach as part of a food and feed safety assessment. They should be useful to the development of guidelines, both national and international and to encourage information sharing among OECD member countries.

These documents are a compilation of current information that is important in food and feed safety assessment. They provide a technical tool for regulatory officials as a general guide and reference source, and also for industry and other interested parties and will complement those of the Working Group on Harmonisation of Regulatory Oversight in Biotechnology. They are mutually acceptable to, but not legally binding on, member countries. They are not intended to be a comprehensive description of all issues considered to be necessary for a safety assessment, but a base set for an individual product that supports the comparative approach. In assessing an individual product, additional components may be required depending on the specific case in question.

In order to ensure that scientific and technical developments are taken into account, member countries have agreed that these consensus documents will be reviewed periodically and updated as necessary. Users of these documents are invited to provide the OECD with new scientific and technical information, and to make proposals for additional areas to be considered.

A short, pre-addressed questionnaire is included at the end of this document. The information requested should be sent to the OECD at one of the addresses shown.

THE ROLE OF COMPARATIVE APPROACH AS PART OF A SAFETY ASSESSMENT

In 1990, a joint consultation of the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO) established that the comparison of a final product with one having an acceptable standard of safety provides an important element of safety assessment (WHO, 1991).

In 1993 the Organisation for Economic Co-operation and Development (OECD) further elaborated this concept and advocated the approach to safety assessment based on substantial equivalence as being the most practical approach to addressing the safety of foods and food components derived through modern biotechnology (as well as other methods of modifying a host genome including tissue culture methods and chemical or radiation induced mutation). In 2000 the Task Force concluded in its report to the G8 that the concept of substantial equivalence will need to be kept under review (OECD, 2000).

The Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology in 2000 concluded that the safety assessment of genetically modified foods requires an integrated and stepwise, case-by-case approach, which can be aided by a structured series of questions. A comparative approach focusing on the determination of similarities and differences between the genetically modified food and its conventional counterpart aids in the identification of potential safety and nutritional issues and is considered the most appropriate strategy for the safety and nutritional assessment of genetically modified foods. The concept of substantial equivalence was developed as a practical approach to the safety assessment of genetically modified foods. It should be seen as a key step in the safety assessment process although it is not a safety assessment in itself; it does not characterise hazard, rather it is used to structure the safety assessment of a genetically modified food relative to a conventional counterpart. The Consultation concluded that the application of the concept of substantial equivalence contributes to a robust safety assessment framework.

A previous Joint FAO/WHO Expert Consultation on Biotechnology and Food Safety (1996) elaborated on compositional comparison as an important element in the determination of substantial equivalence. A comparison of critical components can be carried out at the level of the food source (*i.e.*, species) or the specific food product. Critical components are determined by identifying key nutrients, key toxicants and anti-nutrients for the food source in question. The comparison of key nutrients should be between the modified variety and non-modified comparators with an appropriate history of safe use. The data for the non-modified comparator can be the natural ranges published in the literature for commercial varieties or those measured levels in parental or other edible varieties of the species (FAO, 1996). The comparator used to detect unintended effects should ideally be the near isogenic parental line grown under identical conditions. While the comparative approach is useful as part of the safety assessment of foods derived from plants developed using recombinant DNA technology, the approach could, in general, be applied to foods derived from new plant varieties that have been bred by other techniques.

SECTION I – SUNFLOWER ORIGINS, PRODUCTION AND PROCESSING OF THE SEEDS, APPROPRIATE COMPARATORS AND TRADITIONAL CHARACTERISTICS

A. History of the sunflower crop

The sunflower (*Helianthus annuus L.*, 2n = 34) is a member of the Compositae (Asteracea) family and the genus *Helianthus*. It originates from North America, where it was traditionally cultivated by the Native Americans. The sunflower was introduced into Spain in the middle of the 16th century, where it was cultivated essentially as an ornamental plant. Its oil-bearing qualities were only discovered in the 18th century. Since that time the sunflower for oil production has been considerably genetically improved. Some of the first improvements, through trait selection and hybridisation, took place in Russia, then in USA and aimed at increasing the oil content of the seeds. The breeding resulted in the development of strains with high oleic acid content (Soldatov, 1976). Nowadays, depending on the variety, sunflower contains between 14 and 90 % oleic acid (Codex, 2005). Recently strains with a low content saturated fatty acids have been developed (Delplanque, 2000; Vick *et al*., 2003).

The introduction of hybrids led to higher yields (Merrien, 1992; Bonjean, 1993). The creation of the first mildew-resistant hybrids also meant that sunflowers could be cropped in areas prone to infection with this disease.

B. World production of sunflower

The world production of sunflower has reached 23,960 thousand tones in 2002/2003, with an average yield of nearly 1.2 t/ha. The European Union is the world's largest producer, followed by Russian Federation, Ukraine, Argentina, China and the USA (Table 1).

Table 1. Main sunflower producing countries in 2002/2003

Rank	**Country**	**Production area (1,000 ha)**	**Production (1,000 t)**
1	European Union (25 countries)	2,147	3,718
2	Russian Fed.	3,782	3,684
3	Ukraine	2,810	3,510
4	Argentina	2,272	3,340
5	China	1,131	1,946
6	USA	0,877	1,112
	World	**19,889**	**23,960**

Source : Oil World, 2005

C. Oilseed and non-oilseed sunflowers

There are two types of sunflowers, oilseed and non-oilseed (or confectionery), which are nevertheless of the same species. Oilseed sunflower seeds, constituting the major part of the world production, are characterised by their solid black hulls that are firmly attached to the seed, are used in the crushing industry for oil and for use in wild and domestic bird feeding. Meal resulting from their crushing is mainly used for livestock feeding. The industry has bred high oleic acid oilseed sunflower that has a fatty acid profile similar to Canola oil. The market share for this variety is relatively small, but increasing. It is estimated that 95 % of the world production is the traditional oilseed type, and only 5% is the confectionery type (Skrypetz, 2005).

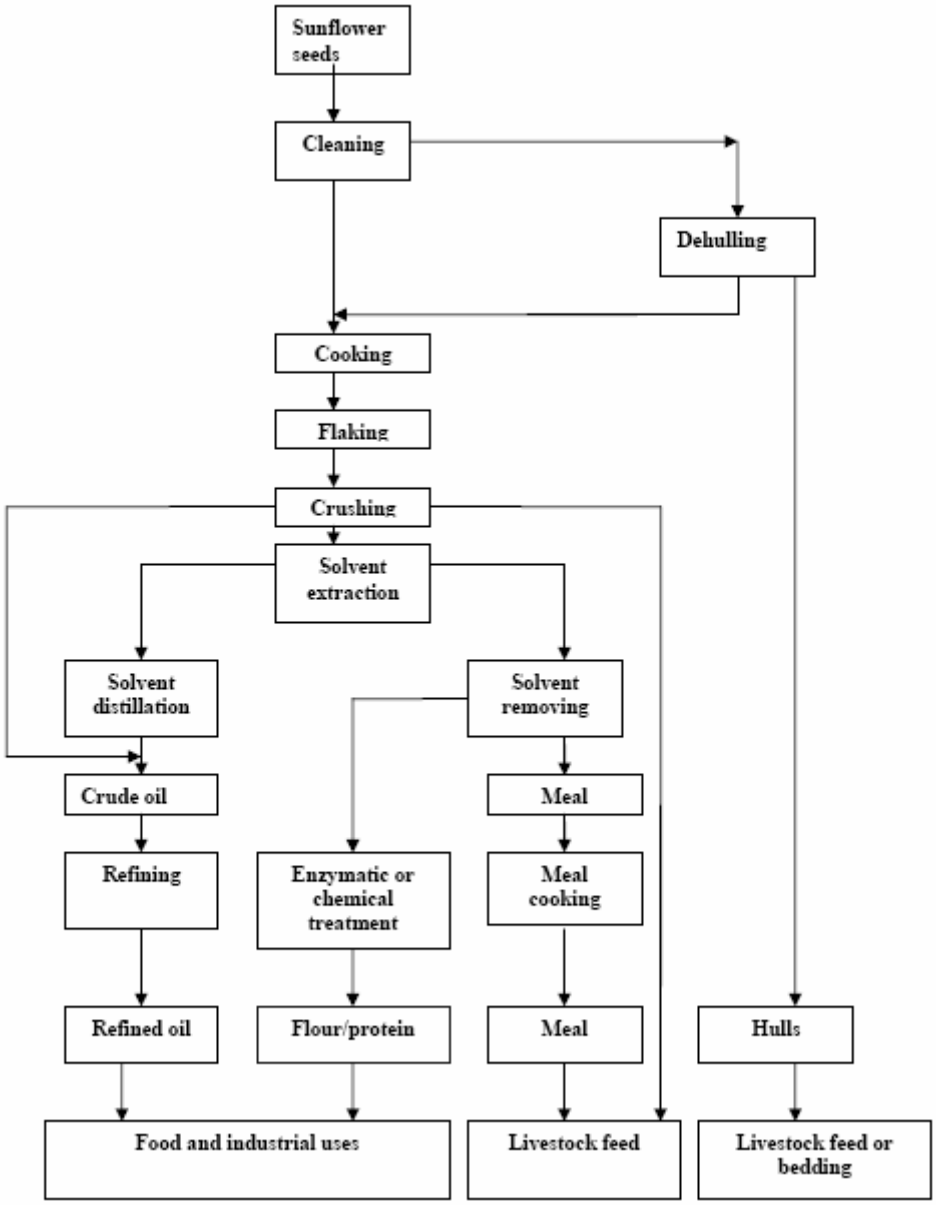
Seeds of non-oilseed sunflowers are characterised by larger, thick, striped, loosely attached hulls that lend themselves to a relative complete dehulling process. These seeds are used for the human food market, as roasted snack foods with shell or as dehulled seeds for the baking industry. Material from non-oilseed sunflowers may be used as both livestock and bird feed (Schild *et al*., 1991).

D. Processing of oilseed sunflower seeds

European crushing of sunflower has stabilised at approximately 4,800 thousand tones in 2000, after a large increase between 1991 and 1997, due to the high worldwide demand for oils (and particularly sunflower oil) during this period.

The process traditionally used worldwide in crushing plants is described in Figure 1.

Figure 1. Classical flowchart for processing oilseed sunflower seeds in the crushing industry



Source : Modified from Laisney, 1984 & 1992

Sunflower oil for food consumption is traditionally obtained through two main steps: the crushing of the seeds (mechanical compression followed by solvent extraction) and the refining of the crude oil. The co-product of oil extraction is the meal, which is used in animal feeding as a protein source. In the 1980's, the fibre fraction of the sunflower meal was reduced by dehulling the seeds. Dehulling increases the protein and energy contents of meal and decreases the amount of wax in the crude oil (Evrard *et al*., 1986).

It also has technological benefits: increasing the output, while decreasing wear and tear on the equipment, although the benefits from dehulled seeds do generally not compensate for the processing costs.

There is no good estimate of the amount of the world's oilseed sunflower seeds that are dehulled or partially dehulled (part-dehulled) prior to crushing. In the U.S., the main crushing plants are partially dehulling sunflower seeds prior to crushing to obtain a meal with greater than 30% crude protein and 21% or less crude fiber (Sunflower Technology and Production Agronomy, 1997). In Europe, the dehulling or part-dehulling[1] process is operating in only a few small plants.

E. Appropriate comparators for testing new varieties

This paper suggests parameters that sunflower developers should measure. Measurement data from the new variety should ideally be compared to those obtained from the near isogenic non-modified counterpart. A developer can also compare values obtained from new varieties with data available in the literature, or chemical analytical data generated from other commercial sunflower varieties. Components to be analysed include key nutrients, anti-nutrients, and toxicants. Key nutrients are those components in a particular product, which may have a substantial impact in the overall diet. These may be major constituents (fats, proteins, and structural and non-structural carbohydrates) or minor compounds (vitamins and minerals). They may be complemented with selected secondary plant metabolites for which characteristic levels in the species are known. Similarly, the levels of known anti-nutrients and allergens should be considered. Key toxicants are those toxicologically significant compounds known to be inherently present in the species, *i.e.*, compounds whose toxic potency and levels may impact human and animal health. The key components analysed are used as indicators of whether unintended effects of the genetic modification influencing plant metabolism has occurred or not.

F. Traditional characteristics screened by sunflower developers

Phenotypic characteristics provide important information related to the suitability of new varieties for commercial distribution. Selecting new varieties is initially based on parent data. Plant breeders developing new varieties of sunflower evaluate many parameters at different stages in the developmental process. In the early stages of growth, breeders evaluate stand count and seedling vigour. As the plant matures, pesticide resistance and disease data is evaluated. The harvested sunflower is measured for yield and seed size. In some cases, plants are modified for specific increases in certain components, and the plant breeder would be expected to analyse for such components (Anonymous, 2004). A complete review of the biology of sunflower is published in the OECD 'Consensus Document on the Biology of *Helianthus annuus* L. (Sunflower) (OECD, 2005).

1. Also referred to as sunflower seed, partially decorticated, extracted, by M4 Council (European) Directive 96/25/EC of 29 April, 1996;

SECTION II. NUTRIENTS IN WHOLE SUNFLOWER AND SUNFLOWER PRODUCTS

A. Composition of oilseed sunflower seeds and non-oil sunflower seeds and kernels.

Sunflower seeds are the complete seeds including the hulls, and sunflower kernels are the seeds with the hulls removed. The hulls are difficult to remove from the oilseed type of sunflower and thus, the data on oilseed includes the hulls. Hulls are readily separated from the non-oilseed (confectionary) types of sunflower, and thus, the non-oilseed data does not include the hull. According to USDA, hulls make up 46 % of the non-oilseeds, leaving 54 % as the kernel. The nutrient content of these two types of sunflowers are shown in Tables 2 – 6.

Table 2. Proximate nutrient content of whole sunflower oilseeds and non-oilseeds

Sunflower seed type	Whole oilseed					Non-oilseed	
						Whole seeds	Kernels
Reference [1]	ST&PA	NRC	Hartman	Ensminger	Kepler	ST&PA	USDA
	g/100g FW[2]						
Dry matter	90.0	91.8	92.6	94.0	91.2	90.0	94.6
	g/100g DM[2]						
Crude protein	19.6	19.2	19.1	22.2	19.0	23.5	24.1
Crude Fat	44.0	41.9	43.1	34.4	41.6	25.0	52.4
NDF [3]	24.1	24				32.0	
ADF [3]	16.5	16.7				28.5	
Crude fibre	22.5		15.6	24.1	17.7	24.1	
TDF [3]							11.1
Ash	3.7	5.1	3.9	4.0	4.2	3.8	3.7

[1] Source: Sunflower Technology and Production Agronomy, 1997; NRC, 2001; Hartman *et al.*, 1985; Ensminger *et al.* 1990; Kepler *et al*, 1982; and USDA, 2004.

[2] FW = fresh weight, DM = dry matter

[3] NDF = neutral-detergent fibre, ADF = acid-detergent fibre, TDF = total dietary fibre

Table 3. Amino acid content (g/100 g DM) of whole sunflower oilseeds and non-oilseed kernels

Sunflower seed type	Oilseed		Non-oilseed kernels
Reference [1]	ST&PA	Kepler	USDA
Lysine	0.68	0.71	0.99
Histidine	0.49	0.46	0.67
Arginine	1.57	1.79	2.54
Aspartic Acid		1.63	2.58
Threonine	0.71	0.68-0.71	0.98
Serine		0.84	1.14
Glutamic acid		4.35	5.89
Alanine		0.53	1.18
Proline		0.93	1.25
Glycine		0.98	1.54
Methionine	0.44	0.33	0.52
Isoleucine	0.79	0.75	1.20
Cystine	0.34	0.34	0.48
Leucine	1.23	1.23	1.75
Phenylalanine	0.89		1.24
Valine	0.95		1.39
Tryptophan	0.23		0.37

Source: Sunflower Technology and Production Agronomy (ST&PA), 1997; Kepler *et al*, 1982; and USDA, 2004

Table 4. Mineral content (per 100 g DM) of whole sunflower oilseeds and non-oilseed kernels

Sunflower seed type	Oilseeds		Non-oilseed kernels
Reference	NRC	Beauchemin	USDA
Calcium, g	0.71	0.21	0.12
Phosphorus, g	0.51	0.35	0.74
Magnesium, g	0.34	0.25	0.37
Potassium, g	1.06	0.72	0.73
Sodium, g	0.01	0.02	0.003
Sulphur, g	0.21		
Copper, mg	2.0	1.6	1.75
Iron, mg	14.4	4.7	
Manganese, mg	4.5	1.5	2.13
Zinc, mg	5.3	5.4	5.06
Molybdenum, mg	0.18		
Selenium, µg			59.5

Source: NRC, 2001; Beauchemin, 2005; and USDA, 2004

Table 5. Vitamin content (per 100 g DM) of non-oilseed kernels

Reference	USDA
Vitamin C, mg	1.48
Thiamine, mg	2.42
Riboflavin, mg	0.26
Niacin, mg	4.75
Pantothenic acid, mg	7.13
Vitamin B-6, mg	0.81
Folate, µg	239.86
Vitamin A, IU	52.84
Vitamin E (α tocopherol), mg	36.46
Vitamin K, µg	2.85

Source: USDA, 2004

Table 6. Fatty acid composition (g/100 g DM) of whole conventional sunflower oilseeds and conventional non-oilseed kernels

Sunflower type	Oilseed	Non-oilseed kernels
Reference	Mir	USDA
Myristic acid (C 14:0)	0.02	0.05
Palmitic acid (C 16:0)	2.84	2.95
Palmitoleic acid (C 16:1)	0.03	0.05
Stearic acid (C 18:0)	2.12	2.33
Oleic acid (C18:1)	8.48	9.89
Linoleic acid (C18.:2)	27.8	34.48
Linolenic acid (C18:3)	0.04	0.07
Arachidic acid (C 20:1)	0.06	0.05

Source: Mir, 2005; USDA, 2004

B. Composition of sunflower oil

Roughly 80 % of the value of sunflower seeds is attributed to their oil content. Like all vegetable oils, sunflower oil is composed of triglycerides (98 to 99 %) and other substances in the unsaponifiable fraction, which are also known as the "minor components" (Evrard *et al*., 1986; Prévot, 1986).

The fatty acid composition is used for the classification of oils. Depending on the predominant type of fatty acid, they can be regarded as either mid oleic, oleic or high oleic. Sunflower oil from conventionally-bred varieties is considered a highly polyunsaturated oil due to its high linoleic acid (C18:2, n-6) content (48.3 to 74.0 %) and its moderate oleic acid (C 18:1) content (14.0 to 39.4 %) (Table 7). The level of saturates is 12 % on average.

Table 7. Fatty acid profile (% of total fatty acids) of conventional, mid-oleic, high-oleic and high-linoleic sunflower oils

Sunflower oilseed varieties	Conventional[1]	Mid-oleic[1]	High-oleic[1]
Saturated fatty acids			
Palmitic acid (C 16:0)	5.0 – 7.6	4.0 – 5.5	2.6 – 5.0
Stearic acid (C 18:0)	2.7 – 6.5	2.1 – 5.0	2.9 – 6.2
Monounsaturated fatty acids			
Oleic acid (C 18:1)	14.0 – 39.4	43.1 - 71.8	75 – 90.7
Polyunsaturated fatty acids			
Linoleic acid (C 18:2)	48.3 – 74.0	18.7 – 45.3	2.1 – 17
Linolenic acid (C 18:3)	ND – 0.3	ND – 0.3	ND – 0.3

[1] Source : Codex, 2005.
[2] Source : Gunstone, 2002 ; Gibb *et al.*, 2004

The benefits of the modified varieties (mid-oleic and high-oleic) is a higher stability due to their lower content in polyunsaturated acids. Mid-oleic and high-oleic sunflower oils do not need to be hydrogenated when used as frying oil.

Conventional sunflower oil is rich in linoleic acid. Hybrid sunflowers with high oleic acid contents were developed in the USA, France and Spain in the 1980's. They were obtained by mutagenesis breeding of lines in which the desaturase system is blocked to varying degrees. These varieties may contain more than 83 % oleic acid and they are considered as high oleic acid sunflower when their content is higher than 75 % (Codex, 2005). The main differences in fatty acid composition between conventional mid-oleic and high oleic acid are summarised in Table 7.

The oleic acid and linoleic acid contents vary widely according to the variety, the growing conditions and the climate. In oleic sunflowers this is due to:

- Environmental origins: this is essentially a temperature effect. Hot-dry conditions at the end of the crop period lead to an overall decrease in the oil content of sunflower seeds and the fatty acid pattern fluctuates. Whereas, low temperatures during the maturation phase reduce the oleic acid content and increase the linoleic acid content. Since sunflowers mature in the fall, they produce the most amount of oil and desirable pattern of fatty acids in regions where the autumn is warm.

- Genetic origins: cross pollination also influences the fatty acids patterns of sunflower kernels. When an oleic sunflower field is planted less than 200 m from a conventional sunflower field, it is quite possible that the oleic sunflower will be pollinated with pollen from conventional sunflowers, reducing the oleic acid content of the harvested seeds. To reduce the chance of cross pollination in certified seed, it has been recommended that the oleic sunflower fields be at least 500 m from conventional sunflower fields (OECD, 2005).

Between 0.6 % and 0.7 % of the refined oil is unsaponifiable. This fraction of the oil contains several minor components: waxes, carbohydrates, sterols and antioxidants. It is characterised by high levels of tocopherols (including vitamin E) and phytosterols (Table 8). It also has low squalene content.

Table 8. Composition (mg/100g DM) of the minor components of the unsaponifiable fraction of the oil of sunflower varieties

Sunflower oilseed varieties	Conventional	Mid-oleic	High -Oleic
Total Sterols	240 – 500		170 - 520
Beta-sitosterol [1]	50 – 70	56 – 58	42 - 70
Campesterol [1]	6.5 – 13.0	9.1 – 9.6	5 - 13
Stigmasterol [1]	6.0 – 13.0	9.0 – 9.3	4.5 - 13
Total Tocopherols	44 – 152	50.9 – 74.1	45 - 112
alpha (vitamin E)	40.3 – 93.5	48.8 – 66.8	40 - 109
beta	ND[2] – 4.5	1.9 – 5.2	1.0 – 3.5
Gamma	ND[2] – 3.4	0.2 – 1.9	0.3 – 3.0

[1] As a percentage of the total sterol content

[2] ND = non detected

Source : Codex, 2005

C Composition of flour and protein concentrate

Sunflower flour and protein concentrate are processed from sunflower seeds for their amino acid content. Table 9 provides the essential amino acid content of these products. Sunflower proteins are rich in globulins (55 to 60 %), albumins (17 to 23 %) and glutelins (11 to 17 %) (Canella *et al*., 1982).

Table 9. Essential amino acid profile of flour and protein concentrates (g/100 g of crude protein)

Amino acid	Flour	Concentrate
Isoleucine	3.7	4.6
Leucine	6.5	6.8
Lysine	3.4	3.4
Methionine + cystine	4.1	3.5
Tryptophan	1.5	1.4
Phenylalanine + tyrosine	8.2	8.7
Valine	4.9	4.6
Threonine	3.3	3.4

Source: FAO, 1981

D. Composition of sunflower meal

Sunflower meal is a by-product of oil processing as shown in Figure 1.

The proximate composition of whole sunflower seed meal and part-dehulled sunflower meal is reported in Tables 10 and the amino-acid composition in Table 11.

Table 10. Composition of sunflower meal derived from whole and part-dehulled seeds

	Whole sunflower seed meal			Part-dehulled sunflower meal		
Reference [1]	Sauvant *et al.*		NRC	Sauvant *et al.*		Preston
	Mean	Standard deviation	Mean	Mean	Standard deviation	Mean
	g/100g FW[2]					
Dry matter	88.7	1.4		89.7	1.2	92.0
	g/100g DM[2]					
Crude protein	27.7	2.2	28.4	33.4	2.2	38.0
Crude fibre	25.5	2.6		21.2	2.0	20.0
Crude fat	2.0	0.8	1.4	1.7	0.6	2.5
Minerals (ash)	6.2	0.6	7.7	6.7	0.5	8.0
NDF [3]	41.1	3.7	40.0	35.9	3.6	36.0
ADF [3]	29.3	3.0	30.0	24.7	2.4	24.0
Lignin	10.1	1.4		8.2	1.2	

[1] Source: Sauvant *et al.*, 2004 (Argentinian type, 2729 samples whole, 1141 samples part-dehulled) ; NRC, 2001 ; Preston, 2005.

[2] FW = fresh weight, DM = dry matter

[3] NDF = neutral-detergent fibre, ADF = acid-detergent fibre

Table 11. Amino-acid and protein content (g/100 g DM) of sunflower meal derived from whole and part-dehulled seeds

	Non-dehulled Sunflower Meal[1]			Dehulled Sunflower Meal [2]	
Reference	NRC 2001	NRC, 1998	NRC 1994	NRC, 1998	NRC 1994
Arginine	2.32	2.64	2.56	3.15	3.17
Histidine	0.74	0.73	0.61	0.99	0.97
Isoleucine	1.16	1.43	1.11	1.55	1.59
Leucine	1.82	2.07	1.78	2.48	2.47
Lysine	1.01	1.12	1.11	1.29	1.38
Methionine	0.65	0.66	0.56	0.88	0.89
Cystine	0.50	0.53	0.56	0.71	0.71
Phenylalanine	1.31	1.37	1.28	1.78	1.85
Threonine	1.06	1.16	1.17	1.43	1.44
Tryptophan	0.34	0.42	0.50	0.47	0.46
Valine	1.41	1.66	1.78	1.87	1.94
Glycine					2.26
Tyrosine		0.84		1.11	1.01
Serine			1.11		1.66
Crude Protein	28.4	29.8	25.9	45.4	41.0

[1] Source: NRC, 2001 (Calculated from % crude protein, using referenced crude protein content of 28.4 %); NRC, 1998 and NRC 1994 (Calculated from referenced dry matter content of 90 %).

[2] Source: NRC, 1998 (Calculated from referenced dry matter content of 93 %); NRC 1994 (Calculated from referenced dry matter content of 89.8 %).

E. Composition of sunflower hulls

Sunflower hulls are derived from the process shown in Figure 1. The proximate nutrient composition and the quantity of some minerals are shown in Table 12.

Table 12. Nutrient content of sunflower hulls[1]

Parameter	Mean	Range
	g/100g FW [2]	
Dry matter	87.8	85.0 – 92.0
	g/100g DM [2]	
Crude protein	5.0	3.5 – 9.0
Crude Fat	3.0	0.5 – 3.0
NDF [3]	70.0	65.0 – 75.0
ADF [3]	56.0	50.0 – 63.0
Crude fibre	45.0	40.0 – 50.0
Ash	2.7	2.0 – 3.0
Calcium	0.30	0.25 – 0.35
Phosphorus	0.15	0.10 – 0.20
Magnesium	0.20	0.15 – 0.25

[1] Source: Sunflower Technology and Production Agronomy, 1997

[2] FW = fresh weight, DM = dry matter.

[3] ADF = acid-detergent fibre; NDF = neutral-detergent fibre.

F. Composition of sunflower forage.

The green sunflower plant is used as silage and forage. The content of nutrients of the green plant is dependent on its stage of maturity. Sunflower forage has a high amount of moisture at maturity. It is cut and wilted prior to ensiling. The nutrient composition of sunflower silage is shown in Table 13.

Table 13. Composition of sunflower silage

Source[1]	Putnam	Gregorie	Kling and Wöhlbier			
Stage of maturity	mature		Before bloom	Beginning of bloom	in bloom	after bloom
	g/100 g FW[2]					
Dry matter		30	12	20	14	15
	g/100g DM[2]					
Crude protein	11-12	12.5	19.3	13.9	14.7	14.0
Crude fat	10-12	10.7	2.7	4.4	2.4	2.8
Crude fibre	31.0		21.1	19.8	23.0	27.4
ADF [3]	32.0	39				
Lignin	10-16	12.3				

[1] Source: Putnam et al., 1990; Gregorie, 2006; Kling and Wöhlbier, 1983.

[2] FW = fresh weight, DM = dry matter

[3] ADF = acid-detergent fibre.

SECTION III – ANTINUTRIENTS AND TOXICANTS IN SUNFLOWER

Sunflower seeds are not known to contain significant quantities of antinutritional factors or toxicants. However, Mulvenna *et al.* (2005) have detected a precursor of a cyclic trypsin inhibitor in sunflower seeds.

Sunflower kernels and hulls contain phenolic compounds, including chlorogenic and caffeic acids, which are easily oxidised during common processing causing green to brown discoloration in protein isolates and/or concentrates (Sabir *et al*., 1974a; Sabir *et al*., 1974b). These compounds have been studied both for their additive/synergistic effect on carcinogenesis and their anti-carcinogenic properties (Hirose *et al*., 1997).

Recent studies have shown that sunflower seeds have been found to contain an allergen, the 2S albumin, which shows homology to the 2S albumins from allergenic nuts (Kelly *et al.,* 2000). However, according to the European legislation, sunflowers and seeds are not required to be labelled as allergens (European Commission, 2005).

The nitrate content of green sunflower plants was found to be almost as high as in oat forage. With concentrations of 0.8 % of the dry matter being nitrate, sunflower belongs to the category of plants with a high capacity of nitrate storage (Liebenow, 1971).

Sunflower leaves are known to contain high levels of saponins. The saponin concentration is found to be two to three times higher than in alfalfa or red clover. However, it has not yet been investigated to what extent these substances act as haemolytic agents in farm animals (Koch and Pintácsi, 1969).

SECTION IV - SUNFLOWER FOR FOOD

A. Whole seeds

Non-oilseed seeds are used for confectionary purposes. De-hulled seeds (*i.e.*, kernels) can be used either to accompany aperitifs (roasted and salted), or in salads or cakes. Whole sunflower seeds (with hulls) are also sold as a snack food. Such seeds are specifically selected and produced for use as snacks (Bonjean, 1993; Agriculture and Agri-Food Canada, 2003). They are bigger, "softer" and contain less oil than oilseed type sunflower seeds. Their hulls are usually striped and relatively thick and can be easily removed.

B. Sunflower oil

Sunflower oil is traditionally used as salad oil or cooking oil. Due to its low linolenic acid content (< 1 %) sunflower oil is sufficiently heat stable to be used for frying.

Sunflower oil is also used in the food industry, mainly in margarines and shortenings as well as in various foods to enhance the composition and physical properties of the food.

Linoleic and linolenic acids cannot be synthesised by humans, and are therefore essential fatty acids in the human diet. A diet either lacking or containing an unbalanced ratio of these fatty acids, results in symptoms of deficiency including reduced growth (IOM, 2002; CNERNA CNRS, 2001).

Sunflower oil contains sterols, of which the most common are beta-sitosterol, campesterol and stigmasterol. The levels of these compounds are shown in Table 8.

C. Protein concentrates and isolates

Sunflower proteins are produced in the form of flours (55 % protein in dry matter), concentrates (70 % protein in dry matter) or isolates (85-90 % protein in dry matter). Proteins extracted from sunflower seeds have potential nutritional and functional advantages, as they do not contain anti-nutritional substances, do not have a specific taste, and contain the two essential sulphur-containing amino acids, methionine and cystine (Table 9.). Sunflower proteins also have certain physico-chemical properties that could be advantageous for their use in foods (Sosulski, 1984).

The use of sunflower proteins in the food industry has been limited due to the negative effects of certain procedures, such as heat treatment under pressure, commonly used in processing of sunflower seeds into oil and meal. It has been reported that proteins generated from seeds subjected to such procedures have poor solubility and functional properties (Vanktesh and Prakash, 1993). Several researchers are pursuing additional processes, such as enzymatic hydrolysis, as a means of producing more desirable products (Cai *et al*., 1996; Conde *et al*., 2005; Parrado *et al*., 1993). Another deterrent to the use of sunflower proteins in food products is the presence of phenolic compounds, which are easily oxidised into dark green and brown compounds and may cause discoloration of processed and cooked foods. Chlorogenic acid is the principal colour-forming constituent of sunflower kernels but small quantities of caffeic acid and other phenolic compounds are also present. These compounds bind to proteins and their removal from sunflower products is difficult (Sabir *et al*., 1974a and 1974b; Saeed and Cheryan, 1989).

D. Recommendation of key components to be analysed

Roughly 80 % of the economic value of oilseed sunflower is attributed to the oil content which approximately represents half of the seed. Proteins constitute the main economic value of the remaining part of the oilseed which also contains fibre and minerals. As noted earlier, sunflower seeds do not contain any natural anti-nutrients or toxicants. It is recommended that for the oilseed varieties sunflower seeds and oil be analysed. The key components to be analysed are listed in Table 14. For the non-oilseed varieties, only kernels need to be analysed.

For human nutrition, it is important to assess the fatty acid composition of the oil (Table 7). Sunflower oil should also be assessed for its tocopherol and sterol content (Table 8). Tocopherol (vitamin E) is an important micronutrient and antioxidant that prolongs the shelf life of the oil and food products containing the oil. Seeds or kernels should be analysed for proximates, amino acids, fatty acids, sterols & tocopherols, minerals and vitamins.

Table 14. Suggested nutrients of sunflower seeds or kernels and oil to be analysed for human food

Nutrients	Oil	Seeds or Kernels
Proximates		X
Amino acids		X
Fatty Acids	X	X
Sterols & tocopherols	X	X
Minerals		X
Vitamins		X

SECTION V – SUNFLOWER FOR FEED

A. Sunflower Seeds

Damaged sunflower seeds from the food industry may be fed to beef cattle (Gibb *et al*., 2004), however some good quality seeds are also used in dairy cattle rations (Linn, 1990). The indigestible hull of sunflower seeds physically protects the highly degradable unsaturated oil from being released too rapidly, thus giving the by-pass fat effect. The by-pass energy effect is only achieved when cows are fed whole, dried sunflower seeds. The nutrient composition of whole oilseed and non-oilseed (confectionary) sunflowers is listed in Table 2.

B Sunflower meal

Sunflower meal has two interesting qualities compared with meal derived from other oilseeds:

- It is composed of proteins that are rich in sulphur-containing amino acids (methionine and cystine) compared to soybean meal.
- It has not been shown to contain any anti-nutritional factors.

Nevertheless, it has three disadvantages:

- A high cellulose content compared to soybean and rapeseed (low energy value) meals.
- A low amount of lysine compared to soybean meal.
- The presence of chlorogenic acid that could interfere with the colour of the protein-based products

The nutrient composition of sunflower meal is dependent on the oil content of the seed, extent of hull removal, efficiency of oil extraction and the processing temperature. The fibre in sunflower meal is low in digestibility and may be a disadvantage when balancing rations for non-ruminant and high producing animals.

The sunflower meal is mainly used for rabbits and ruminants (respective incorporation rates are: 10 – 12 % and 10 – 20 %). Uses for laying birds (less than 5 %) or pigs (less than 1 %) can be noticed (Burghart and Evrard, 2002).

Dehulled meal, such as “Hipro”, in which the protein content has been increased nearly to 40 % by an efficient dehulling, can be useful feeds for broilers and fattening pigs. The incorporation rates may then be increased to at least 10 % (Evrard *et al*., 1986).

Sunflower meal is more ruminally degradable (74 % of crude protein) than soybean meal (66 %) or canola meal (68 %). Sunflower meal is high in protein but due to the lack of a sufficient content of lysine, is more suitable for ruminants than non-ruminants.

Sunflower extracted meal is a valuable protein source for the various species/categories in livestock feeding if the feed specific restrictions, *i.e.* the maximum incorporation rates, are taken into consideration (Table 15).

Table 15. Maximum incorporation rates for sunflower extracted meal in rations for livestock feed

Species / category	Incorporation level (%)
Dairy cows	30
Rearing calves	15
Cattle and bulls	40-50
Sheep, goat	No limitation
Rabbits	30
Growing-finishing pigs	5-10
Poultry	5-10

Source : Hoffmann, 2001

C. Sunflower oil

Sunflower oil has limited applications in livestock feed mainly due to its higher economic value for use with human food preparation for cooking and frying. In small quantities it may be used to reduce dust in animal feeds.

D. Sunflower silage

Sunflowers can be used as a source of forage by livestock producers. Whole plant sunflower silage has slightly more crude protein and considerably more fat than corn silage on a dry matter basis. The high level of lignin from the fibrous stalk is a disadvantage to sunflower silage.

E. Sunflower hulls.

Sunflower hulls are not a suitable feeding stuff due to the high crude fibre content and the type of binding which causes a negative efficiency of energy utilisation, although they are used as a cheap fibre source to a limited extent in cattle or lamb feeding (Kling and Wöhlbier, 1983). They are used for livestock bedding.

F. Recommendation of key components to be analysed

When one considers the sunflower products that might be fed to animals, their nutrient content would not be expected to change if the content of whole sunflower seed is not changed. Hence, only the whole sunflower seed and sunflower meal are suggested to be analysed (Table 16). However, for amino acids, either whole sunflower or sunflower meal would yield equivalent results. For fatty acids, whole sunflower seeds or sunflower oil would yield equivalent results.

Proximate analysis is used by livestock nutritionists to evaluate feed ingredients and to formulate least cost rations for livestock. It includes the amounts of crude protein, fat, ash, and crude fibre. In the case of ruminants and swine, the traditional analysis for crude fibre is considered not informative and has been replaced by analyses for acid detergent fibre and neutral detergent fibre. For amino acids, the ten essential amino acids (argenine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine) plus glycine, cystine, tyrosine, serine and proline are the key nutrients. Linoleic acid is the fatty acid of key importance for the seed (OECD, 2002).

Table 16. Suggested nutrients of sunflower seeds and meal to be analysed for animal feed

Parameters	Seeds	Meal
Proximates	X	x
Neutral Detergent Fibre	X	x
Acid Detergent Fibre	X	x
Amino Acids	X	x
Fatty Acids	X	
Calcium	X	x
Phosphorus	X	x

Other minerals such as selenium are also important, but their concentration in plants has been shown to reflect the amount of the mineral in the soil. Thus, the minerals other than Ca and P, and the vitamins are not considered key nutrients.

It has been noted (Section III) that sunflower seeds do not contain any natural anti-nutrients.

SECTION VI - REFERENCES

Agriculture and Agri-Food Canada. 2003. Sunflower Seed: Situation and Outlook. Bi-weekly Bulletin. Vol. 16, No 16.

Anonymous. 2004. Sunflower Production and Management. Manitoba Agriculture, Food and Rural Initiatives, February, 2004.http:/www.gov.mb.ca/agriculture/crops/oilseeds/bgd01s01.html.

Beauchemin, K. 2005. Personal communication. Rum. Nutr., Ag. and Ag-Food Canada Research Ctr., Lethbridge, Alberta, Can. Beauchemin@agr.gc.ca.

Bonjean, A. 1993. Le Tournesol. Les Éditions de l'Environnement, 242 p.

Burghart, P. and Evrard, J. 2002. Oilseeds: from storage to feed. Les Points Techniques du CETIOM, ed CETIOM, Paris.

Cai, T., K-C Chang and H. Lunde. 1996. Physicochemical Properties and Yelds of Sunflower Protein Enzymatic Hydrolysates as Affected by Enzyme and Defatted Sunflower Meal. J. Agric. Food Chem .44 : 3500-3506

Canella, M., Bernardi, A., Casalaina, A., and Sodini, G. 1982. Albumin and Globulin Components of Different Sunflower Cultivars. Riv. Ital. Delle Sost. Grasse. 59: 377-382.

CNERNA-CNRS. 2001. Daily Recommended Amounts for the French Population, 3rd edition, ed. Lavoisier Tec & Doc, Paris.

Codex. 2005. Standard for named vegetable oils. CODEX-STAN 210 (Amended 2003, 2005).

Conde, J. M., M. Del Mar. Y. Escobar, J. J. P. Jimenez, F. M. Rodriguez and J. M. R. Patino. 2005. Effect of Enzymatic Treatment of Extracted Sunflower Proteins on Solubility, Amino Acid Composition and Surface Activity7. J. Agric. Food Chem. 53: 8038-8045.

Delplanque B. 2000. "Intérêt Nutritionnel Des Huiles De Tournesols : Tournesol Linoléique Et Tournesol À Haute Teneur En Oléique", *Ocl,* Vol.7, No. 6, 467-472.

Ensminger, M. E., J. E. Oldfield, and W. W. Heinemann. 1990. Feeds and Nutrition (Second Edition). The Ensminger Publishing Co., Clovis, CA, USA.

European Commission, 2005. Directive 2005/26/CE of March, 21st, 2005. Official Journal of the European Commission. L 75/33-34.

Evrard, J., Baudet, J.J. et Burghart P. 1986. Conditionnement, Transformation, Produits. Cahier Technique Tournesol, ed. CETIOM, Paris, 40 p.

FAO (Food and Agriculture Organisation) 1981. Helia : scientific bulletin of the F.A.O. Research Network on Sunflower. Vol. 14, no. 14 (July 1991).

FAO/WHO Joint Consultation Report, Biotechnology and Food Safety. FAO Food and Nutrition Paper 61. Food and Agriculture Organization of the United Nations (FAO), Rome, 1996.

Gibb, D.J., F.N. Owens, P.S. Mir, M. Ivan and T. A. McAllister. 2004. Value of Sunflower Seed in finishing Diets of feedlot Cattle. J. Anim. Sci. 82:2679-2692

Gregorie, Terry. 2006. Sunflower Silage. North Dakota State University Extension Service. http://www.ag.ndsu.edu/procrop/sun/sunsil09.htm

Gunstone, F. 2002. Sunflower seed and its products. Inform.13: 159-163.

Hartman, A.D., W.J. Costello, G.W. Libal and R.C. Wahlstrom. 1985 Effect of sunflower seeds on performance, carcass quality, fatty acids and acceptability of pork. J.Anim. Sci. 60:212-219.

Hirose, m., Y. Takesada, H. Tanaka, S. Tamano, t. Kato and T. Shirai. 1997. carcinogenicity of antioxidants BHA, caffeic acid, sesamol, 4-methoxyphenol and catechol at low doses, either alone or in combination and modulation of their effects in a rat medium-term multi-organ carcinogenesis model. Carcinogenesis 19:1:207-212

Hoffmann, M. 2001. Futterspezifische Restriktionen. Arbeitskreis "Futter und Fütterung im Freistaat Sachsen.IOM. 2002. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academies Press, Washington, D.C., USA. http://newton.nap.edu/books/0309085373/html/

IOM. 2002. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academies Press, Washington, D.C., USA. http://newton.nap.edu/books/0309085373/html/

Kelly, J.D., Hlywka, J.J. and Hefle, S.L. 2000. 2s Methionine-Rich Protein (Ssa) from Sunflower Seed Is an Ige-Binding Protein. Allergy. 55: 556-559.

Kepler, M., G.W. Libal and R.C. Wahlstrom. 1982. Sunflower seeds as a fat source in sow gestation and lactation diets. J. Anim. Sci. 55:1082-1086.

Kling, M. und Wöhlbier, W. (Hrsg.) 1983. Handelsfuttermittel. Ulmer Verlag Stuttgart.

Koch, E. and Pintácsi, M. 1969. Investigations into some fodder crops for haemolytic saponine. Agrobotanika XI: 113-117

Laisney, J. 1984. L'huilerie moderne, Art et techniques, ed CFDT, Paris, 318 p.

Laisney, J. 1992. Obtention des Corps Gras. In : Manuel Des Corps Gras, ed Lavoisier Tec & Doc, Paris. 695-730.

Liebenow, H. 1971. Nitrate und Nitrite in ihrer Beziehung zu Mensch und Tier. Arch. Tierernährung 21. 635-648.

Linn, James G. 1990. Feeding sunflowers to dairy cows. Minnesota Ext. Service, Issue 102, St. Paul, MN.

Merrien, A. 1992. Source et Monographie des Principaux Corps Gras. In : Manuel Des Corps Gras, ed Lavoisier Tec & Doc, Paris. 116-123.

Mir, P.S. 2005. Personal communication. Ag. and Agri-Food Can. Canada Research Ctr., Lethbridge, Alberta, Can. mirp@agr.gc.ca.

Mulvenna, J.P., Foley, F.M., and Craik, D.J. 2005. Discovery, structural determination, and putative processing of the precursor protein that produces the cyclic trypsin inhibitor sunflower trypsin inhibitor 1. Journal of Biological Chemistry 280 (37): 32245-32253.

NRC. 1994. Nutrient Requirements of Poultry (Ninth Revised Edition). National Academy Press, Washington D.C., USA, 68.

NRC. 1998. Nutrient Requirements of Swine (Tenth Revised Edition). National Academy Press, Washington D.C., USA, 133.

NRC. 2001. Nutrient Requirements of Dairy Cattle (Seventh Revised Edition). National Academy Press, Washington D.C., USA, 298.

OECD. 1997. Report of the OECD workshop on the toxicological and nutritional testing of novel foods. March 5 to 8, 1997, Aussois, France.

OECD. 2000. Report of the Task Force for the Safety of Novel Foods and Feeds. OECD C(2000)86/ADD1

OECD. 2002. Consensus Document on Compositional Considerations for New Varieties of Maize (Zae mays): Key food and Feed Nutrients, Anti-Nutrients and Secondary Plant Metabolites. OECD EMV/JM/MONO(2002)25 (No. 6)

OECD. 2005. Consensus Document on the Biology of *Helianthus annuus* L. (Sunflower). OECD ENV/JM/MONO(2004)30

Oil World. 2005. World production arrested area. Statistics update, April 2005.

Parrado, J., F. Millan, I. Hernadez-Pinzon, J. Bautista and A. Machado. 1993. Characterization of Enzymatic Sunflower Protein Hydrolysates. J. Agric. Food Chem. 41: 1821-1825.

Preston, R. L. 2005. Feed Composition Tables. Beef, April 1, 2005. http://beef-mag.com

Prévot, A. 1986. L'huile de Tournesol aujourd'hui. Journées d'information ITERG et Journées Chevreul AFECG, 14-15 Octobre 1986.

Putnam, D.H., Oplinger, E.S., Hicks, D.R., Durgan, B.R., Noetzel, D.M., Meronuck, J.D. Doll, R.A., and Schulte, E.E. 1990. Sunflower. Alternative Field Crops Manual. Co-op. Extension Service, U. Wisconsin, Madison, WI. USA.

Sabir, M. A., F. W. Sosulski and J. A. Kernan. 1974a. Phenolic Constituents in Sunflower Flour. J. Agr. Food Chem. 22:572-574.

Sabir, M.A., Sosulski, F.W., and Finlayson, A.J. 1974b. Chlorogenic Acid-Protein Interaction in Sunflower. J. Agr. Food Chem. 22 :575-578.

Saeed, M, and Cheryan, M. 1989. Chlorogenic Acid Interaction with Sunflower Proteins. J. Agric. Food Chem. 37 :1270-1274.

Sauvant, D., Perez, J.-M. et Tran, G. 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage, ed INRA, Paris, 301 p.

Schild, J., D. Baltensperger, D. Lyon, G. Hein and E. Kerr. 1991. Sunflower Production in Nebraska. U.Nb.Coop Ext Ser, file G1026: Field Crops F-12. http://ianrubs.unl.edu/fieldcrops/g1026.htm

Soldatov, K.I. 1976. Chemical Mutagenesis in Sunflower Breeding. Proc. 7th Int. Sunflower Conf. Krasnodar. 7: 352-360.

Sosulski, F.W. 1984. Food uses of sunflower proteins. In: Developments in food proteins, Vol. 3. ed. B.J.F. Hudson, Elsevier Applied Science Publishers, London.

Sunflower Technology and Production Agronomy. 1997. No. 35. Table obtained From National Sunflower Association website (http://www.sunflowernsa.com/buyers/default.asp?contentID=186)

USDA ARS (U.S. Department of Agriculture, Agricultural Research Service). 2004. USDA Nutrient Database for Standard Reference, Release 16.1 Nutrient Data Laboratory Home Page. (http://www.nal.usda.gov/fnic/foodcomp).

Vanktesh, A. and Prakash, V. 1993. Functional Properties of the Total Proteins of Sunflower (*Heliantus annuus* L.) Seed – Effect of Physical and Chemical Treatments. J. Agric. Food Chem. 41:18-23.

Vick, B. A., C. C. Jan and J. F. Miller. 2003. Registration of Two Sunflower Genetic Stocks with Reduced Palmitic and Stearic Acids. Crop Science 43:747 – 748.

WHO. 1991. Strategies of Assessing the Safety of Foods Produced by Biotechnology, Report of a Joint FAO/WHO Consultation. WHO, Geneva, Switzerland.

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