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# **Vegetable Oils in Food Technology**

*Composition, Properties and Uses*

Second Edition

Edited by

Frank D. Gunstone

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## Preface to the First Edition

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Our dietary intake comprises three macronutrients (protein, carbohydrate and lipid) and a large but unknown number of micronutrients (vitamins, minerals, antioxidants etc.). Good health rests, in part, on an adequate and balanced supply of these components. This book is concerned with the major sources of lipids and the micronutrients that they contain.

Supplies and consumption of oils and fats are generally described in terms of seventeen commodity oils, four of which are of animal origin and the remainder of which are derived from plants. This selection of oils does not include cocoa butter, with an annual production of around 1.7 million tonnes, which is used almost entirely for the purpose of making chocolate. Nor does it include oils consumed in the form of nuts. The production and trade data that are available and are detailed in the first chapter relate to crops either grown and harvested for the oils that they contain (e.g. rape and sunflower oils) or crops that contain oils as significant by-products (e.g. cottonseed and corn oils).

Annual production and consumption of oils and fats is about 119 million tonnes and rising steadily at a rate of 2–6 million tonnes per year. This is required to meet the demand, which also grows at around this rate, partly as a consequence of increasing population but more because of increasing income, especially in developing countries. Around 14% of current oil and fat production is used as starting material for the oleochemical industry and around 6% is used as animal feed (and indirectly therefore as human food). The remaining 80% is used for human food – as spreads, frying oil, salad oils, cooking fat etc. These facts provide the framework for this book.

After the first chapter on production and trade, there follow ten chapters covering thirteen oils. The four dominant oils are discussed first: soybean, palm, rape/canola and sunflower. These are followed by chapters on two lauric oils (coconut and palmkernel), cottonseed oil, groundnut (peanut) oil, olive oil, corn oil and three minor but interesting oils (sesame, rice bran and flaxseed). The authors – from Europe, Asia and North America – were invited to cover the following topics: the native oils in their original form and in modified forms resulting from partial hydrogenation, fractionation or interesterification, and related oils produced by conventional seed breeding and/or genetic modification. For each of these, information is provided on component triacylglycerols, fatty acids, minor components (phospholipids, sterols, tocopherols, carotenoids etc.) and their major food uses.

The book will serve as a rich source of data on these oils and the important minor components that they contain. It should therefore be of special value to food producers requiring up-to-date information on their raw materials, which will probably already have been processed, at least in part.

The editor thanks the authors for their efforts to convert his concept into a reality and for their patience and willing cooperation, and he acknowledges the generous help and advice that he has received from the publisher, Dr Graeme MacKintosh and his colleagues.

*Frank D. Gunstone*

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## Preface to the Second Edition

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It is nine years since the first edition of this book was published. The success of this led to the idea that we should produce a second, updated and extended edition. Each revised chapter has new information that has been published since 2002 and the final chapter has been extended to cover the more important minor seed oils. As in the first edition, there is an emphasis on data for both the major and minor components present in each oil.

Significant changes in the last nine years have been the development of seeds producing oils with a different fatty acid composition based on current nutritional views. For example, there are more high-oleic varieties of several oils. Current views on the nutritional properties of *trans* acids and the requirement in some countries to report these on food labels have had an influence on avoiding partial hydrogenation and finding alternative ways of producing oils and fats with the required nutritional and physical properties.

In the years between 2001/02 and 2008/09, production of the nine major vegetable oils rose 42% from 93 to 132 million tonnes. In this period there was an increased use for non-food purposes and consequent pressure on the supplies required to meet the food needs of a population growing in number and in disposable income.

While many of the chapters have been revised by the original authors, new authors were found for three of the chapters. I am indebted to all the authors for their efforts and for their patience with the editor. I also acknowledge the assistance provided by David McDade and his colleagues at Wiley-Blackwell.

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## List of Abbreviations

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|      |  |
|------|--|
| ABTS | 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) |
| ALA  | alpha-linolenic acid (18:3n-3, all <i>cis</i> )        |
| AMF  | anhydrous milk fat                                     |
| AOCS | American Oil Chemists' Society                         |
| AOM  | active oxygen method                                   |
| AP   | ascorbyl palmitate                                     |
| B    | behenic acid   |
| BCO  | blackcurrant oil                                       |
| BF   | butterfat  |
| BfR  | Federal Institute for Risk Assessment                  |
| BHA  | butylated hydroxyanisole                               |
| BHT  | butylated hydroxytoluene                               |
| BNO  | Brazil nut oil   |
| BO   | borage oil   |
| CAE  | caffeic acid equivalent                                |
| CAN  | canola oil   |
| cp   | Centipoise   |
| CB   | cocoa butter   |
| CBE  | cocoa butter equivalent                                |
| CBI  | cocoa butter improver                                  |
| CBR  | coca butter replacement                                |
| CHD  | cardiovascular heart disease or coronary heart disease |
| CLA  | conjugated linoleic acid                               |
| CLnA | conjugated linolenic acid (18:3)                       |
| CO   | coconut oil  |
| CPKO | crude palm kernel oil                                  |
| CPO  | crude palm oil   |
| CVD  | cardiovascular disease                                 |
| DAF  | days after flowering                                   |
| DAG  | diacylglycerol(s)                                      |
| DGDG | digalactosyl diglyceride                               |
| DHA  | docosahexenoic acid                                    |
| DMPS | dimethylpolysiloxane                                   |
| DNA  | deoxyribonucleic acid                                  |
| DOBI | deterioration of bleachability index                   |
| DPPH | 1,1-diphenyl-2-picrylhydrazyl                          |
| DSC  | differential scanning calorimetry                      |
| EDTA | ethylenediaminetetraacetic acid                        |

|         |   |
|---------|---|
| EPA     | eicosapentaenoic acid; or Environmental Protection Agency |
| EPO     | evening primrose oil                                      |
| EU      | European Union  |
| EU-27   | 27 countries of the European Union                        |
| FA      | fatty acid  |
| FAC     | fatty acid composition                                    |
| FAO     | Food and Agriculture Organisation                         |
| FAS     | Foreign Agricultural Service                              |
| FDA     | Food and Drug Administration (US)                         |
| FFA     | free fatty acids  |
| FFB     | fresh fruit bunch   |
| FHSBO   | fully hydrogenated soybean oil                            |
| GC      | gas chromatography  |
| GE      | glycidol fatty acid esters                                |
| GG      | galactosyl glycerol                                       |
| GHG     | greenhouse gas(es)  |
| GLA     | gamma-linolenic acid (18:3n-6, all <i>cis</i> )           |
| GLC     | gas liquid chromatography                                 |
| GLCO    | gamma linolenic canola oil                                |
| GM      | genetically modified or genetic modification              |
| HDL     | high-density lipoprotein(s)                               |
| HEAR    | high-erucic rapeseed oil                                  |
| HLaCO   | high-lauric canola oil                                    |
| HNO     | hazelnut oil  |
| HO      | high-oleic oil  |
| HOCO    | high-oleic canola oil                                     |
| HOLLCO  | high-oleic low-linolenic canola oil                       |
| HOLLSOY | high-oleic low-linolenic soybean oil                      |
| HOSO    | high-oleic sunflower oil                                  |
| HOSUN   | high oleic sunflower oil                                  |
| HP HL   | high-palmitic/high-linoleic sunflower oil                 |
| HP HO   | high-palmitic/high-oleic sunflower oil                    |
| HPKS    | hydrogenated palm kernel stearin                          |
| HPLC    | high-performance liquid chromatography                    |
| HPO     | hydrogenated palm oil                                     |
| HPOo    | hydrogenated palm olein                                   |
| HS HL   | high-stearic/high-linoleic sunflower oil                  |
| HS HO   | high-stearic/high-oleic sunflower oil                     |
| HS HP   | high-stearic/high-palmitic sunflower oil                  |
| HSCO    | high-stearic canola oil                                   |
| HYDCO   | hydrogenated canola oil                                   |
| HYDSOY  | hydrogenated soybean oil                                  |
| ICCA    | Interstate Cottonseed Crushers Association                |
| IEPO    | interesterified palm oil                                  |
| IOOC    | International Olive Oil Council                           |
| ISO     | International Standard Organisation                       |
| IV      | iodine value  |
| L       | linoleic acid   |



|        |  |
|--------|--|
| LCA    | life-cycle analysis                                      |
| LCPUFA | long-chain polyunsaturated fatty acids                   |
| LDL    | low-density lipoprotein                                  |
| LEAR   | low-erucic rapeseed oil                                  |
| LFRA   | Leatherhead Food Research Association (UK)               |
| LLCO   | low-linolenic canola oil                                 |
| Ln     | linolenic acid   |
| LPC    | lysophosphatidylcholines                                 |
| LPE    | lysophosphatidylethanolamines                            |
| M&I    | moisture and impurities                                  |
| MAG    | monoacylglycerol(s)                                      |
| MCF-7  | human breast cancer cell line                            |
| MCFA   | medium-chain fatty acid                                  |
| MCPD   | 3-monochloro-1,2-propanediol                             |
| MEOMA  | Malayan Edible Oil Manufacturers' Association            |
| MGDG   | monogalactosyl diglycerol                                |
| MNO    | macadamia nut oil  |
| MO     | mid-oleic oil  |
| MOSUN  | medium-oleic sunflower oil                               |
| MPOB   | Malaysian Palm Oil Board                                 |
| MPP    | dipalmitoyl myristoyl glycerol                           |
| MT     | metric ton (tonne, 1000 Kg)                              |
| mt     | million tonnes   |
| MUFA   | monounsaturated fatty acids                              |
| NCPA   | National Cottonseed Products Association                 |
| NCVT   | National Cotton Variety Trials                           |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NSA    | National Sunflower Association (US)                      |
| NMR    | nuclear magnetic resonance                               |
| ND     | non detectable   |
| nr     | not recorded   |
| O      | oleic acid   |
| O/L    | ratio of oleic acid to linoleic acid                     |
| OOO    | oleic-oleic-oleic triacylglycerol (triolein)             |
| OSI    | oxidative stability index                                |
| P      | palmitic   |
| PA     | phosphatidic acids                                       |
| PBSY   | prime bleachable summer yellow (grade of cottonseed oil) |
| PC     | phosphatidylcholines                                     |
| PCR    | polymerase chain reaction                                |
| PDG    | palm diacylglycerols                                     |
| PDI    | protein dispersibility index                             |
| PDO    | Protected Designations of Origin                         |
| PE     | phosphatidylethanolamines                                |
| PET    | polyethylene terephthalate                               |
| PFAD   | palm fatty acid distillate                               |
| PG     | phosphatidylglycerols; or propyl gallate                 |
| PHSBO  | partially hydrogenated soybean oil                       |

|                            |   |
|----------------------------|---|
| PI                         | phosphatidylinositols   |
| PKO                        | palm kernel oil   |
| PKOo                       | palm kernel olein   |
| PKS                        | palm kernel stearin   |
| PL                         | phospholipids   |
| PMF                        | palm mid-fraction   |
| PO                         | palm oil  |
| POME                       | palm oil mill effluent  |
| POO                        | dioleo palmitoyl glycerol (includes OPO isomer)   |
| POo                        | palm olein  |
| POP                        | dipalmitoyl oleoyl glycerol (includes PPO isomer)   |
| POs                        | palm stearin  |
| ppm                        | parts per million (mg/kg)   |
| PPP                        | tripalmitoyl glycerol (tripalmitin)   |
| PPSt                       | dipalmitoyl stearoyl glycerol   |
| PS                         | phosphatidylserines   |
| PV                         | peroxide value  |
| RBD                        | refined, bleached and deodorised  |
| RI                         | refractive index  |
| RNAi                       | RNA interference (genetic technique used to interrupt the normal translation of mRNA molecules) |
| RSO                        | rapeseed oil  |
| S                          | stearic; or saturated (type of fatty acid)  |
| SBDD                       | soybean deodorizer distillate   |
| SBO                        | soybean oil   |
| SCPA                       | Society of Cotton Products Analysts   |
| SDA                        | stearidonic acid (18:4n-3, all- <i>cis</i> )  |
| SEP                        | sequential extraction process   |
| SFI                        | solid fat index   |
| SfMF                       | soft milkfat fraction   |
| SFO                        | sunflower oil   |
| SG                         | esterified phytosterol glycoside; or specific gravity   |
| SMP                        | slip melting point  |
| <i>sn-</i>                 | stereospecific or regiospecific numbering   |
| <i>sn-1, sn-2 and sn-3</i> | positions of the glycerol backbone  |
| SOO                        | stearic-oleic-oleic triacylglycerol   |
| SOS                        | stearic-oleic-stearic triacylglycerol   |
| SPC                        | soy protein concentrates  |
| SPI                        | soy protein isolate   |
| SSS                        | trisaturated acylglycerols or trisaturates  |
| St                         | stearic acid  |
| StOO                       | stearic-oleic-oleic triacylglycerol   |
| StOSt                      | stearic-oleic-stearic triacylglycerol   |
| SUS                        | disaturated monounsaturated acylglycerols   |
| SUU                        | diunsaturated monosaturated acylglycerols   |
| SV                         | saponification value  |
| TAG                        | triacylglycerol(s)  |
| TBARS                      | thiobarbituric acid-reactive substances   |

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|           |  |
|-----------|--|
| TBHQ      | tertiary-butylhydroquinone   |
| TIU       | trypsin inhibitor unit   |
| TRF       | tocotrienol rich fraction  |
| tr        | trace  |
| U         | unsaturated (type of fatty acid)   |
| US        | unsaponifiable matter  |
| USDA      | United States Department of Agriculture  |
| USDA–NASS | United State Department of Agriculture – National Agricultural<br>Statistics Service |
| VCO       | virgin coconut oil   |
| WHO       | World Health Organisation  |
| WNO       | walnut oil   |
| wt        | weight   |

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# 1 Production and Trade of Vegetable Oils

Frank D. Gunstone

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## 1.1 EXTRACTION, REFINING AND PROCESSING

Most vegetable oils are obtained from beans or seeds, which generally furnish two valuable commodities: a fatty oil and a protein-rich meal. Seed extraction is achieved by pressing and/or by extraction with hexane. Oils such as palm and olive, on the other hand, are pressed out of the soft fruit (endosperm). Seeds give oils in differing proportions. Using USDA figures for 2008/09, world average oil yields are: soybean (18%), rapeseed (39%), sunflower (41%), groundnut (32%), cottonseed (14%), coconut (62%) and palmkernel (44%). In addition, yields from palm fruit (45–50%), olive (25–30%) and corn (about 5%) are as indicated. The relatively low yield of oil from soybeans is compensated for by the value of the high-quality protein meal (79%) accompanying the oil.

Some oils, such as virgin olive oil, are used without further treatment other than filtering, but most are refined in some measure before use. The refining processes remove undesirable materials (phospholipids, monoacylglycerols, diacylglycerols, free acids, colour and pigments, oxidised materials, flavour components, trace metals, sulphur compounds and pollutants), but may also remove valuable minor components, including antioxidants and vitamins such as carotenes and tocopherols. The refining processes must therefore be designed to maximise the removal of undesirable components and minimise the removal of the valuable minor components. Some of the latter are recovered from side streams of the refining process to give commercial products such as phospholipids, free acids, tocopherols, carotenes, sterols and squalene. Because of changes that occur during refining, it is important to know whether compositional data refer to crude or refined oil. Details of the levels of these in the various seed oils are given in appropriate chapters in this volume. Extraction processes have been described by Fils (2000), De Greyt and Kellens (2000) and, more recently, Dijkstra and Segers (2007). Hamm (2001) has discussed the major differences in extraction and refining procedures in Europe and North America as a consequence of the size of the industrial plant and of the differing oilseeds to be handled.

With only a limited number of oils and fats available on a commercial scale, it is not surprising that on their own these are sometimes inadequate to meet the physical, chemical and nutritional properties required for use in food products. Over a century or more, lipid technologists have designed procedures for overcoming the limitation of having only a restricted range of natural products. In particular, they have sought to modify fatty acid and

**Table 1.1** Methods of changing fatty acid and triacylglycerol composition to modify physical, chemical and nutritional properties.

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|   |
|---|
| Technological solutions                                     |
| Blending  |
| Distillation  |
| Fractionation   |
| Hydrogenation   |
| Interesterification with chemical catalysts                 |
| Interesterification with specific lipases                   |
| Enzymatic enhancement                                       |
| Biological solutions  |
| Domestication of wild crops                                 |
| Oils modified by conventional seed breeding                 |
| Oils modified by (intra-species) genetic engineering        |
| Lipids from micro-organisms or other unconventional sources |

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Source: Gunstone (2006).

triacylglycerol composition, knowing that such changes influence the important properties of food fats. These have been classified (Gunstone 2006) into technological and biological procedures such as those listed in Table 1.1.

The procedures most relevant to this book are fractionation, hydrogenation and modification of fatty acid composition by conventional seed breeding or genetic engineering. Details are given in some of the following chapters. As an example, the usefulness of palm oil and palmkernel oil is greatly extended by fractionation. Hydrogenation may be applied in three ways. A very light hydrogenation (brush hydrogenation) applied to soybean oil or rapeseed oil will halve the level of linolenic acid and thereby increase oxidative stability (shelf-life). More extensive, but still partial, hydrogenation is applied to unsaturated liquid oils to produce semi-solid fats that can be used as margarines and spreads. Through this process the levels of polyunsaturated fatty acids are markedly reduced, saturated acid content rises slightly, and there is a large rise in the levels of monounsaturated acids, much of it with *trans* configuration. The *trans* acids have higher melting points than their *cis* isomers, thereby contributing to the desired increase in solid acids. However, *trans* acids are now accepted as having undesirable nutritional properties and the food industry has revised procedures to limit their level. In some countries the level of *trans* acids has to be reported on the packaging and this increases the pressure to minimise the levels of these acids (Wilson 2009). Complete hydrogenation gives a product with virtually no unsaturated acids and therefore no *trans* acids. This is hardstock that can be blended with unsaturated oil, often before interesterification.

In the following chapters examples are cited of where fatty acid composition has been modified by biological methods, both traditional and modern. Well-known examples include low-erucic acid rapeseed oil (canola oil), high-oleic sunflower oil and low-linolenic soybean oil, but attempts to develop oils with modified fatty acid composition and/or a changed composition of minor products such as tocopherols are being pursued actively in many countries. Some of these have been described (Gunstone 2007b; Watkins 2009) and others are cited in the following chapters of this book. Perhaps the most exciting of these are the attempts to produce long-chain polyunsaturated fatty acids such as eicosapentaenoic acid (20:5) and docosahexaenoic acid (22:6) in a field crop (Napier 2006).

Following their introduction into commercial agriculture in 1996, genetically modified (GM) crops are now grown in many countries. Nevertheless, opposition to such crops

remains in Europe and elsewhere and GM-free products are in demand (Section 1.3.8). This restriction also applies to minor products and it has sometimes been difficult to obtain GM-free lecithin (phospholipid), which comes mainly from soybean oil (Gunstone 2008c).

## 1.2 VEGETABLE OILS: PRODUCTION, CONSUMPTION AND TRADE

### 1.2.1 Nine vegetable oils

Oils and fats are produced from animal and vegetable sources, with the former group declining in market share though not in production tonnage. Tallow, lard and butter still occupy the fifth, sixth and seventh positions after the four dominant vegetable oils (palm, soybean, rapeseed and sunflower seed). During the twentieth century the contribution of animal fats fell from 50% to 20% and in 2009 it was less than 16%, showing that vegetable fats have become increasingly dominant (Table 1.2).

Statistical information about production, consumption and trade in oils and fats comes from two major sources. Oil World ISTA Mielke of Hamburg, Germany, is a market analyst producing weekly, monthly, annual and occasional reports on 10 oilseeds, 17 oils and fats (13 vegetable and 4 animal) and 10 oil meals. This valuable information has to be purchased. In contrast, information from the USDA is available free online and is updated each month (search for 'USDA-FAS oilseeds' in Google or any other search engine). However, this latter source does not include animal fats and covers only seven oilseeds (copra, which is the source of coconut oil, cottonseed, palmkernel, groundnut, rapeseed, soybean and sunflower seed), nine oils (from these seven oilseeds and from palm and olive) and eight oilmeals (from the seven oilseeds and from fish). The four additional vegetable oils covered by Oil World are corn, sesame, linseed and castor oils. These two sources of information show good but not perfect agreement. It is not easy for those who produce these reports to collect all the necessary data and figures continue to be subject to revision over several years. Figures in this chapter will come primarily from the USDA source and only occasionally from Oil World. This makes it easier for readers to consult the website themselves for up-to-date information.

The nine vegetable oils can be classified in several ways. One categorisation recognises four major oils (palm, soybean, rapeseed and sunflower), two lauric oils (coconut and palmkernel, with a very different fatty acid composition from the other commodity oils) and the remaining oils (cottonseed, groundnut and olive).

It is also useful to distinguish between oils and fats obtained from tree crops (coconut, palm and olive) and those from annual seed/bean crops, and also to recognise those that are

**Table 1.2** Average annual production of total oils and fats and of animal fats (million tonnes and % of total) during the twentieth century.

| Years              | 1909/13 | 1936/39 | 1958/62 | 1976/80 | 1986/90 | 1996/2000 |
|--------------------|---------|---------|---------|---------|---------|-----------|
| Oils and fats (17) | 13.1    | 20.2    | 29.8    | 52.6    | 75.7    | 105.1     |
| Animal fats (mt)   | 6.5     | 8.5     | 11.8    | 17.2    | 19.8    | 21.3      |
| Animal fats (%)    | 50      | 42      | 40      | 33      | 26      | 20        |

Source: Based on Mielke (2002) for 17 commodity oils and Hatje (1989).

by-products. These are important factors in understanding the dynamics of production and trade. Trees have to be planted and mature, usually for many years, before they produce an economic crop. Yields from tree crops are influenced by climatic changes from season to season and by inputs such as fertiliser, pesticides, herbicides and irrigation, although crops will continue for many years (25–35 years for palm, around 100 years for olive). Annual crops (soybean, rapeseed, sunflower etc.), on the other hand, depend on planting decisions that farmers make each year based on agricultural and economic factors. These decisions result in changes in supply from year to year. For vegetable oils that are by-products, decisions on annual production depend on factors other than oil production. For example, cotton is grown according to the demand for fibre and not for cottonseed oil. Corn is not grown primarily for its oil and peanuts are grown as much for consumption as nuts as for oil production. It is also worthy of note that crushing soybeans produces two components – soybean oil (18%) and soybean meal (79%) – both of which are valuable commercial products. At different times the oil or the meal is in greater demand.

Annual crops are produced at harvest time, which comes late in the calendar year in the northern hemisphere and early in the calendar year in the southern hemisphere. However, equatorial tree crops such as palm and coconut are harvested throughout the year, though there is some seasonal variation in quantity. Production data are often reported in harvest years such as 2008/09. These relate to 2008 harvests in the northern hemisphere and 2009 harvests in the southern hemisphere.

**Table 1.3** Population (millions), production, exports, imports and total consumption (million tonnes) of seven oilseeds and nine vegetable oils in selected countries in 2008/09.

|           | Pop  | Oilseeds* |                  |      | Oils <sup>§</sup> |                  |      |         |
|-----------|------|-----------|------------------|------|-------------------|------------------|------|---------|
|           |      | Prod      | Exp <sup>†</sup> | Imp  | Prod              | Exp <sup>†</sup> | Imp  | Consump |
| World**   | 6829 | 395.3     | 94.4             | 92.9 | 131.8             | 55.1             | 54.3 | 129.3   |
| China     | 1323 | 57.8      | 1.2              | 44.1 | 16.0              |                  | 9.8  | 24.6    |
| EU-27     | 497  |           |                  | 17.8 | 15.4              |                  | 8.7  | 22.6    |
| India     | 1198 | 33.7      |                  |      | 6.8               |                  | 8.8  | 14.7    |
| USA       | 315  | 89.2      | 35.8             |      | 9.6               | 1.5              | 3.2  | 11.2    |
| Indonesia | 230  |           |                  | 1.4  | 22.7              | 16.6             |      | 6.0     |
| Brazil    | 194  | 59.5      | 30.1             |      |                   | 2.0              |      | 5.1     |
| Malaysia  | 27   |           |                  |      | 19.4              | 16.8             | 1.3  | 4.6     |
| Pakistan  | 181  |           |                  |      |                   |                  | 2.2  | 3.4     |
| Russia    | 141  |           |                  |      |                   |                  |      | 3.0     |
| Japan     | 127  |           |                  | 5.8  |                   |                  |      | 2.1     |
| Mexico    | 110  |           |                  | 4.9  |                   |                  |      | 2.0     |
| Argentina | 40   | 35.7      | 6.3              |      | 7.7               | 5.8              |      | 1.8     |
| Turkey    | 75   |           |                  | 1.7  |                   |                  | 0.8  | 1.7     |
| Egypt     | 83   |           |                  | 1.2  |                   |                  | 1.5  | 1.6     |

Source: USDA, December 2009.

Notes:

\* Oilseeds are copra, cottonseed, palmkernel, peanut (groundnut), rapeseed, soybean and sunflowerseed. Oils also include palm and olive.

\*\* The countries selected are the largest consumers of vegetable oils.

§ These figures cover oil extracted from both indigenous and imported seeds.

† Canada (population 34 million) exported 10.0 million tonnes of seed and 1.6 million tonnes of oil. Ukraine (population 46 million) exported 3.7 million tonnes of seed and 2.2 million tonnes of oil.

In discussing trade in oilseeds and oils in geographical terms, it is useful to recognise four types of countries/regions. These are discussed below and illustrated in Table 1.3. Population figures are in millions and relate to 2009.

- Countries with small populations that produce large amounts of oilseeds/oils and are large exporters of these commodities. Examples are Australia (population 21 million), Malaysia (27 million), Canada (34 million), Argentina (40 million) and Ukraine (46 million).
- Countries with large populations that produce large amounts of oilseeds/oils and fats to feed their own populations but are still significant exporters. Examples are the USA (315 million), Indonesia (230 million) and Brazil (194 million).
- Countries with very large populations that are major importers despite local production. China (1323 million), India (1198 million) and other highly populated countries in Asia belong to this category. The Indian subcontinent of India, Pakistan (181 million), Bangladesh (162 million) and Sri Lanka (20 million) is a very large importer of vegetable oils.
- Finally there are countries/regions that are essentially traders. They produce, consume, import and export these commodities. The 27 countries of the European Union (EU-27) form the biggest example, but Hong Kong and Singapore are also significant traders by virtue of their geographical closeness to the world's largest importer (China) and exporters (Indonesia and Malaysia).

Tables 1.4 and 1.5 show the annual production of nine vegetable oils between 1995/96 and 2008/09 (14 years). Total production of the nine oils rose from 71 to 133 million tonnes

**Table 1.4** Production (million tonnes) of nine vegetable oils during the period 1995/96 to 2008/09.

|                                | 9 oils | Palm | Soya | Rape | Sun  | 5 oils* |
|--------------------------------|--------|------|------|------|------|---------|
| 1995/96                        | 71.2   | 16.2 | 20.3 | 11.1 | 9.1  | 14.5    |
| 1996/97                        | 73.8   | 17.6 | 20.4 | 10.5 | 8.6  | 16.7    |
| 1997/98                        | 75.2   | 16.9 | 22.4 | 11.4 | 8.5  | 16.0    |
| 1998/99                        | 80.3   | 19.2 | 24.4 | 11.8 | 9.3  | 15.6    |
| 1999/2000                      | 86.0   | 21.8 | 24.5 | 14.0 | 9.3  | 16.4    |
| 2000/01                        | 89.8   | 24.3 | 26.7 | 13.3 | 8.2  | 17.3    |
| 2001/02                        | 92.7   | 25.3 | 28.9 | 13.1 | 7.4  | 18.0    |
| 2002/03                        | 96.1   | 27.6 | 30.6 | 12.2 | 8.1  | 17.6    |
| 2003/04                        | 102.8  | 30.0 | 30.2 | 14.1 | 9.2  | 19.3    |
| 2004/05                        | 111.7  | 33.5 | 32.6 | 15.7 | 9.2  | 20.7    |
| 2005/06                        | 118.7  | 35.8 | 34.6 | 17.3 | 10.6 | 20.4    |
| 2006/07                        | 121.5  | 37.2 | 36.4 | 17.0 | 10.6 | 20.3    |
| 2007/08                        | 127.8  | 40.9 | 37.5 | 18.3 | 9.7  | 21.4    |
| 2008/09                        | 131.8  | 42.4 | 35.7 | 20.4 | 11.8 | 21.5    |
| Increase 1995/96<br>to 2001/02 | 21.5   | 9.1  | 8.6  | 2.0  | -1.7 | 3.5     |
| Increase 2002/03<br>to 2008/09 | 35.7   | 14.8 | 5.1  | 8.2  | 3.7  | 3.9     |

Source: USDA, December 2009.

Note:

\* Coconut, cottonseed, olive, palmkernel and peanut (groundnut) oils.



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