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The China Oil Plant Species (COPS) Database: A Comprehensive Web-Based Database and Informatics System Providing Ecological and Chemical Traits of Oil Plants in China

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The China Oil Plant Species (COPS) database is the first to provide comprehensive and systematic web-based classification, search and selection under given criteria of oil plants distributed in China, covering 1409 different species belonging to 139 families in total. The web-based database is constructed on the basis of experimental data and related information from authoritative books and academic journals, using ASP as execution environment with 7 different functions, including data input, multiple searching, statistics, etc. Users of the platform can conveniently acquire abundant information on ecological and biochemical traits of oil plants in China, including basic category, classification, florescence and maturity period, geographical distribution, elevation, climate and terrain of growth, oil content, fatty acid composition and content, besides the related statistical data. The database will be of great value in studying the present situation of utilization of oil plants and the future exploitation of new species adapted in given environment in China.

Keywords: oil plants; vegetable oil; database; ASP; oil content; fatty acid content

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INTRODUCTION

For millennia oil plants and vegetable oil have been important part of human culture and since oil plants have great impact on human life, their exploitation and utilization have always been under the spotlight. Oil plants are widely spread in nature, which are not only used as essential components of nutriment in food, but also used as ingredients in quantities of industrial products. There are approximately 300 million square kilometers of forest land throughout China, where oil plants cover 1554 species belonging to 697 genera and 151 families. *Euphorbiaceae*, *Lauraceae*, *Celastraceae*, *Leguminosae*, *Compositae* and *Labiatae* are the families containing majority of oil plants (The compilation committee of China oil plant, 1987).

Vegetable oils are always playing an important role in human health. A vegetable oil is extracted from seeds, pulps or other parts from a plant, which commonly consists of over 95% of triglyceride along with a small quantity of phospholipid, sterol, vitamin and other lipoid. As one of the three major dynamophore, oil can release 2.25 times as much energy as carbohydrate or protein of the same weight. After assimilated and transformed into fats, oil can maintain healthy skin and hair, insulate body organs against shock, maintain body temperature, and promote healthy cell function (Nelson *et al.* 2008). Fatty acid, which is released from triglyceride in TCA cycle, can be classified into saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acids (PUFA). SFA is regarded as the major fatty acid raising serum cholesterol in human diet, which will lead to atherosclerosis. However, recent researches found

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Table 1. The development environment of COPS database

Operating System	Windows XP/Windows7
Execution Environment	ASP
Programming Language	VBScript, JavaScript, HTML, CSS
Server Software	Internet Information Server (IIS)
Database Software	Microsoft Office Access 2007

that stearic acid and SFA with carbon atoms less than 12 only have slight effect on raising serum cholesterol (Hui 2005). In contrast, a dietary fat rich in MUFAs, which is high in olive oil, have beneficial effects on blood coagulation factor VII (FVII), a key protein in thrombosis and an ischemic heart disease (IHD) risk factor (Larsen *et al.* 1999, Rapaport *et al.* 1995, Meade *et al*. 1993, Ruddock *et al*. 1994, Heinrich *et al.* 1994, Junker *et al.* 1997). PUFA is an essential component in membrane system of cells, and it can also regulate the gene expression of fatty acid synthetase, nitric oxide synthase and sodium channel protein to affect the synthesis of fatty acids and the content of cholesterol in human body (Birch et al. 2000). Our previous work studied the hypolipidemic activity of a novel natural vegetable oil from *Cornus wilsoniana* fruits and indicated this function were possibly related to the high content of PUFA (Fu *et al.* 2012).

Vegetable oils are widely used as an ingredient or component in industries for making soaps, skin products, candles, perfumes and other personal care and cosmetic products which consume large quantities of vegetable oils. With some traits like quick-drying and glutinous, some oils are particularly suitable as drying oils, and are used in making paints and other wood treatment products. Furthermore, vegetable oils are increasingly being used in the electrical industry as insulators as vegetable oils are not toxic to the environment, biodegradable if spilled and have high flash and fire points. Additionally, vegetable oils are being used to produce biodegradable hydraulic fluid and lubricant (McGraw 2000).

Table 2. The top 10 families that contain the most species of oil plants

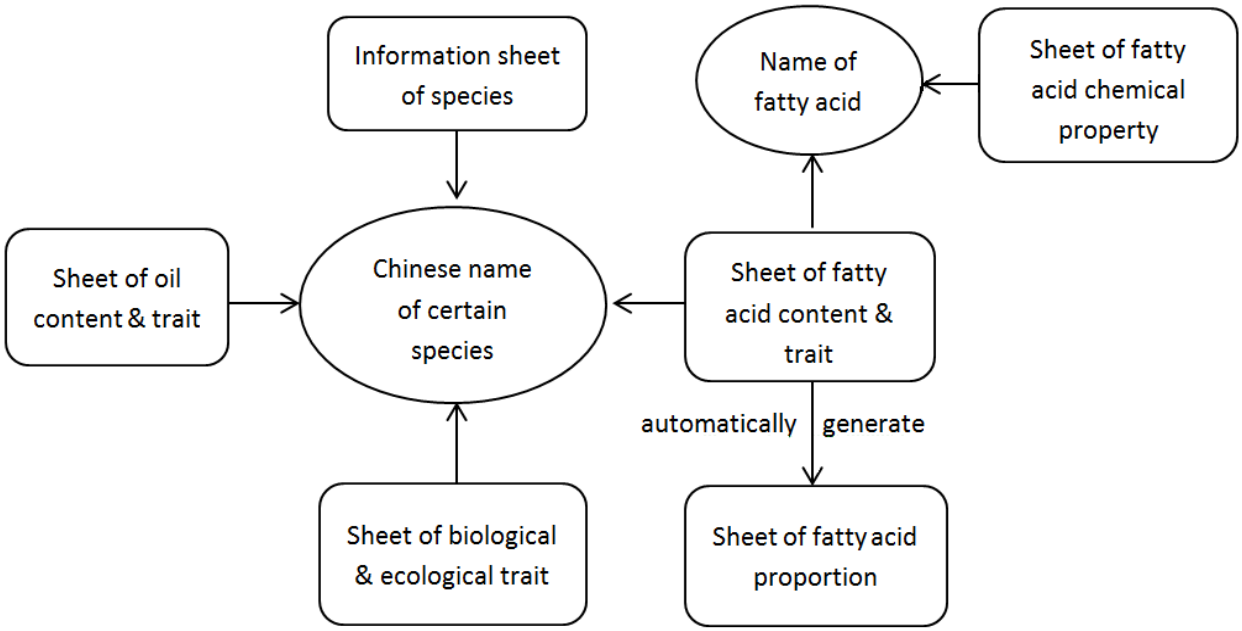
Ranking	Latin name of family	Species number
1	*Leguminosae*	86
2	*Lauraceae*	83
3	*Rosaceae*	74
4	*Rutaceae*	56
5	*Euphorbiaceae*	53
6	*Cruciferae*	51
7	*Theaceae*	43
8	*Pinaceae*	43
9	*Labiatae*	39
10	*Compositae*	39

Vegetable oils have been exploited as biodiesel for long and still needs more efficient utilization at lower cost and commercialization (Shay 1993). Recently, biodiesel has become more attractive because it is biodegradable and nontoxic, having low emission profiles and so is environmentally beneficial (Krawczyk 1996). On the other hand, because of increases in crude oil prices, limited resources of fossil oil and environmental concerns there has been a renewed focus on vegetable oils and animal fats to make biodiesel fuels (Fangrui *et al*. 1999). As is predicted by the United States Department of Energy, over 80% of the global liquid fuel will be renewable biodiesel from oil plants and algas by the year of 2050 (Wang 2007).

However, the authoritative books which record oil content and fatty acid composition are both few and dated in China, while new data on oil plants are scattered sporadically in various academic journals. On one hand, there are great quantities of wild oil plants remaining to be exploited in and on the other hand, there are still 20 million square hectometers of saline-alkali land distributed in China (Zhao *et al.* 2001) that can be used for cultivating saline-alkaline tolerant oil plants, such as *Cyperus esculentus* and *Euphorbia lathyris*. In order to search useful information, select data under given criteria and analyze results comprehensively, the China Oil Plant Species (COPS) database has been constructed which will provide ecological and biochemical traits of oil plants in China. The COPS database will be of great value in learning the regional distribution, oil and fatty acid content of oil plants, searching and importing species adapted in local environment or have the given biochemical traits.

We began building the first comprehensive database of oil plants in China in the year of 2011

Fig 1. The logical relationship of the COPS database. Each box represents a certain spreadsheet. Each circle represents a certain connected keyword. The arrows between the boxes indicate which sheets can be linked to on.



with great effort. The web-based COPS database is constructed by selecting data from authoritative books and academic journals, creating associated data sheet in specific logic, using ASP as execution environment and applying VBScript, JAVA, SQL, etc. languages to write the program. The present platform has 7 different functions, including data input, multiple searching, statistics, etc. The COPS database includes basic category, classification, florescence and maturity period, geographical distribution, elevation, climate & terrain of growth, oil content, fatty acid composition & content, and related statistical results of 1409 different species of oil plants belonging to 139 families.

MATERIALS AND METHODS

Data selection

The data of oil plants and associated information are selected from authoritative books and academic journals on oil plants, including China Oil Plant, Handbook of Fat- or Oil-bearing Plants of China, China Oils and Fats (1979-2012).

Development environment

The COPS database is developed in the environment (Table 1).

Database structure

The COPS database consists of 6 spreadsheets connected by the Chinese name of specific species in the environment of Access, including Information sheet of species, Sheet of biological & ecological trait, Sheet of oil content & trait, Sheet of fatty acid content & trait, Sheet of fatty acid chemical property, Sheet of fatty acid proportion. The data of the former 5 sheets are directly selected from authoritative books and academic journals. And the last sheet (Sheet of fatty acid proportion) is generated automatically according to the Sheet of fatty acid content & trait and the Sheet of fatty acid chemical property.

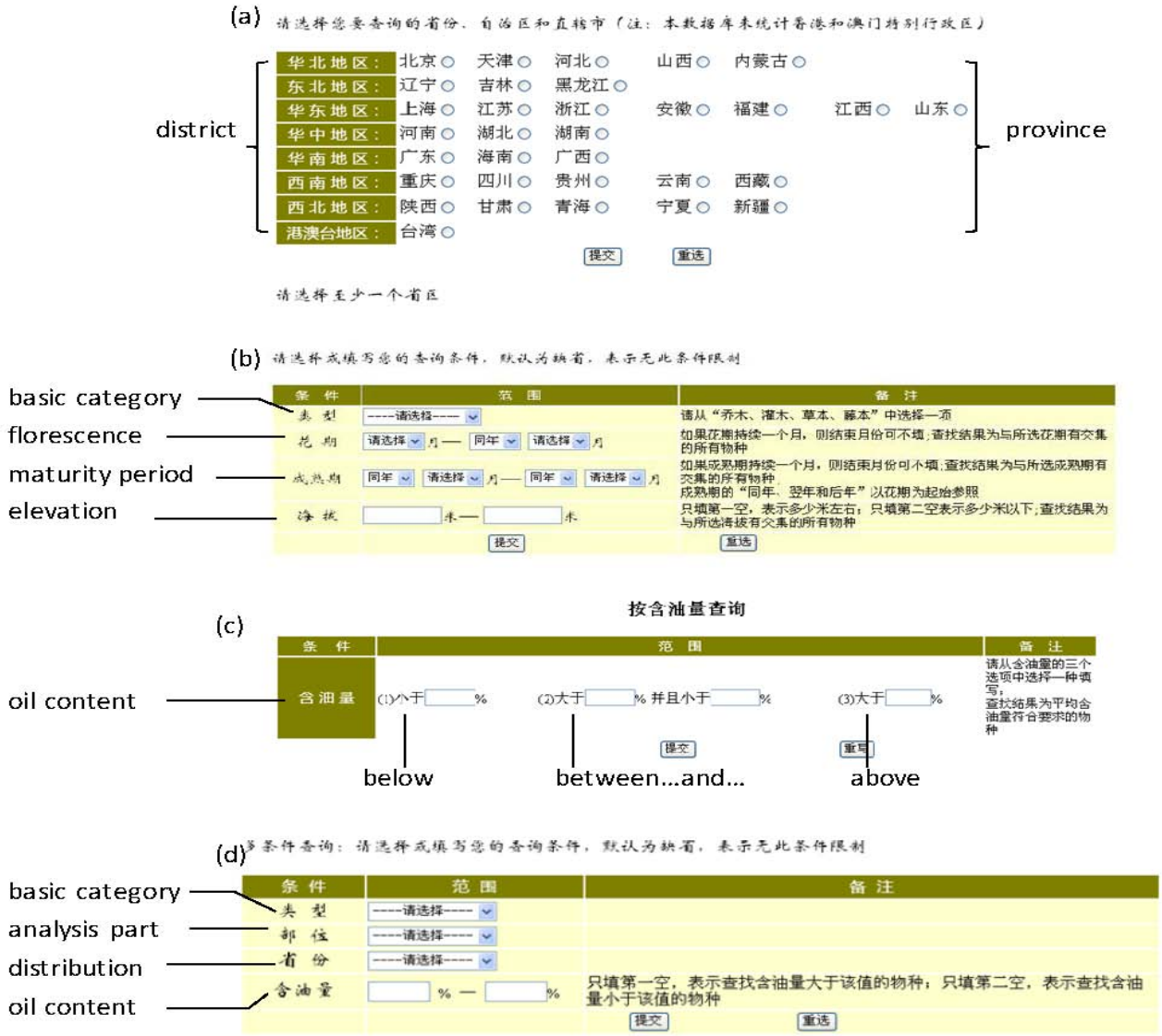
Give below is a concise account of the 6 spreadsheets.

Information sheet of species includes the Chinese name of certain species, the Latin name of certain species, the Chinese name of certain family and the Latin name of certain family. There are 1409 different data in total.

Sheet of biological & ecological trait includes the Chinese name, alias, basic category (including arbor, shrub, herbal and liana), florescence, maturity period, geographical distribution in China, geographical distribution abroad, elevation, adaptive climate, terrain of growth and usage of certain species. There are 1306 different data in total.

Sheet of oil content & trait includes the Chinese name, sample source, analysis part, oil content, iodine value, saponification value, acid value, unsaponifiable matter, specific gravity (certain temperature) and refractive index (certain temperature) of certain species.

Fig 2. Functional modules of COPS database. (a) Search according to geographical distribution in multiple provinces. (b) Search according to biological & ecological trait. c) Search according to oil content under single condition. (d) Search according to oil content under multiple conditions.



There are 2200 different data in total.

Sheet of fatty acid content & trait includes the Chinese name, sample source, analysis part, fatty acid content and fatty acid composition. There are 11040 different data in total.

Sheet of fatty acid chemical property includes the Chinese scientific name, the English scientific name, the Chinese abbreviation, the English abbreviation, degree of saturation, category, molecular formula, molecular weight, boiling point, melting point, density (certain temperature), refractive index (certain temperature) and iodine value of certain fatty acid. There are 96 different data in total.

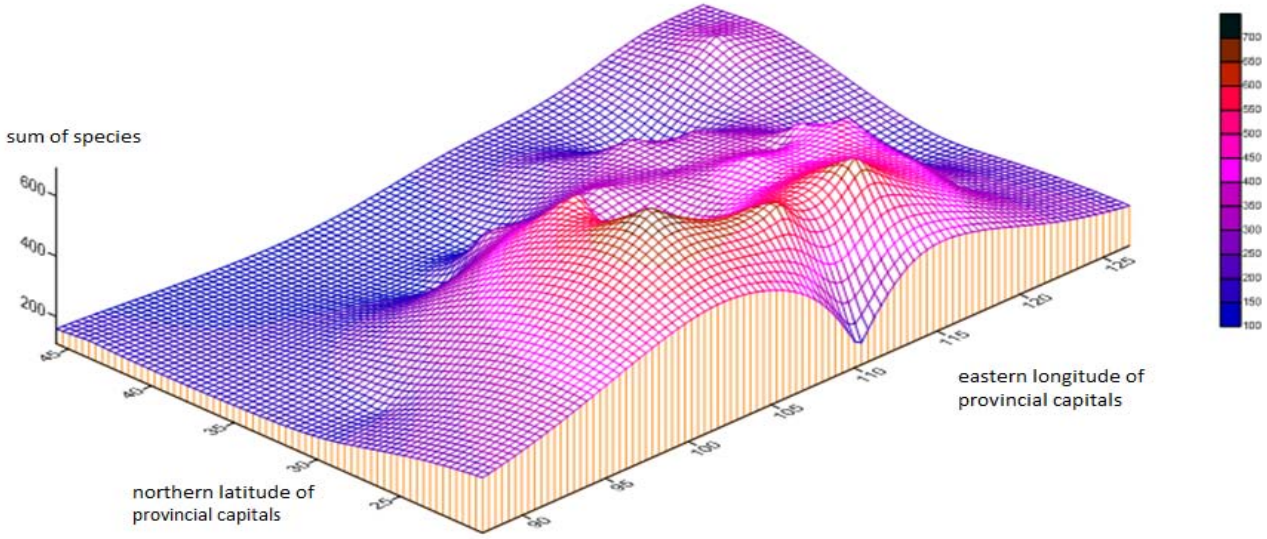
Sheet of fatty acid proportion includes the Chinese name, analysis part, provenance, SFA, MUFA, PUFA, other fatty acid, proportion of unsaturated fatty acid/SFA and proportion of PUFA/SFA. There are 1807 different data in total.

The logical relationship of the 6 spreadsheets is shown in Fig. 1.

Functional module

The COPS database is developed using ASP as execution environment with 7 different functional modules in dynamic pages, namely information input, search according to family, search according to species, search according to geographical distribution,

Fig 3. 3D data map of the longitude and latitude of the provincial capitals and the sum of species of certain province. The different colors and elevations in the map indicate the difference in the sum of species of certain province.



search according to biological & ecological trait, search according to oil content and search according to fatty acid. The detailed introduction is as follows.

Information input

New data on oil plants outside the COPS database can be input into the database, including basic classification information, biological & ecological traits, oil content, fatty acid content & composition, etc.

Search according to family

The platform provides two viewing modes, namely page turning and browsing. The former can displays 20 data on each page, sequencing according to certain Chinese names. The latter displays all the Chinese & Latin names of families and all the oil plants belonging to certain families in the database. Additionally, it can sequence the data according to any term mentioned above and click the hyperlink can view all the oil plants and related information of a certain family.

Search according to species

The platform provides searching according to both Chinese name and Latin name of certain species. After the keywords input, the platform will search for all the species containing the Chinese or Latin words in the information sheet of species using fuzzy search method. Furthermore, if you search for a Chinese word, it will retrieve in both Chinese standardized name and alias.

Search according to geographical distribution

The platform provides searching in single province and searching for common species & total species in multiple provinces. The former will display all the species of oil plants distributed in the province you choose after clicking a province on the map of China. The latter will display the common species and total species distributed in the provinces you choose in the list (Fig. 2(a))

Search according to biological & ecological trait

The biological & ecological traits which can be chosen as searching conditions include basic category (namely arbor, shrub, herbal and liana), florescence, maturity period and elevation (Fig. 2(b)).

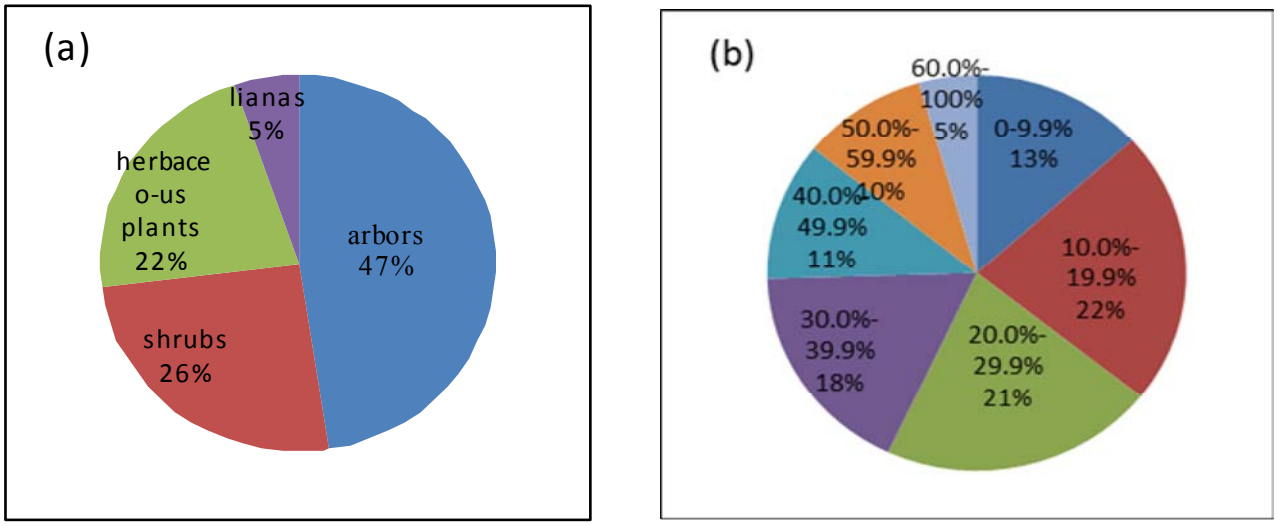
Search according to oil content

The platform provides searching according to both single condition and multiple conditions. The former will display all the species and related information, including analysis part, range of oil content, distribution in China, etc. and sequence the data according to average oil content after the range of oil content is input in the blank (Fig. 2(c)). Moreover, it will count eligible families and the number of species belonging to them. The latter provides basic category, analysis part, geographical distribution and oil content as multiple searching conditions (Fig. 2(d)).

Search according to fatty acid

The platform provides 3 modules on searching

Fig 4. Pie charts of basic category and oil content of oil plants in COPS database. (a) Proportion of different categories of oil plants recorded in COPS database. (b) Proportion of different range of oil content of oil plants recorded in COPS database.



according to fatty acid, namely searching according to type of fatty acid, proportion of fatty acid and physical & chemical property of fatty acid. The first module classifies all the species together with analysis part into SFA, PUFA, MUFA and other types of fatty acid, and sequences the data according to the average fatty acid content. Additionally, the platform will provide related information, including the average fatty acid content, the range of fatty acid content, distribution in China, etc. The second module lists all the species which the proportion of PUFA/SFA is above 2 (in which condition the oil has a function of reducing blood fat) (Min *et al.* 2005; Chang *et al.* 1998) and related information. The third one provides the physical & chemical property of certain fatty acid, including the Chinese & English scientific name, degree of saturation, category, molecular formula, molecular weight, boiling point, melting point, density (certain temperature), refractive index (certain temperature), iodine value and isomerides.

RESULTS

Search according to family

The COPS database covers 1409 species of oil plants belonging to 139 families, being close to data from authoritative books, which is 1554 species belonging to 151 families (The compilation committee of China oil plant, 1987). The top 10 families that contain the most species are shown as Table 2.

Search according to geographical distribution

As is analyzed using COPS database, the provinces/municipalities/autonomous regions (except Hong Kong and Macao) with the number of oil plant species in descending order are Yunnan (701), Guangdong (655), Guangxi (634), Sichuan (581), Guizhou (465), Hubei (452), Zhejiang (450), Hunan (440), Jiangxi (436), Fujian (434), Jiangsu (420), Shaanxi (390), Anhui (365), Liaoning (352), Hebei (325), Shandong (323), Gansu (323), Henan (317), Taiwan (302), Jilin (297), Shanxi (295), Heilongjiang (281), Inner Mongolia (243), Tibet (191), Sinkiang (169), Hainan (169), Chongqing (165), Shanghai (157), Qinghai (157), Ningxia (140), Beijing (132) and Tianjin (124). The result of multiple provincial distribution indicates that the number of oil plant species shared by provinces throughout China is 87, most of which are herbaceous plants.

Implementing correlation analysis to the longitude and latitude of the provincial capitals and the sum of species of certain province, the statistics indicates that there is no significant correlation between the longitude of the provincial capitals and the sum of species of certain province ($r=0.05$, $P=0.78$), while there is extremely significant correlation between the latitude of provincial capitals and the sum of species of certain province ($r=-0.52$, $P=0.002$). In other words, the number of oil plant species decreases progressively from south to north in China (Fig. 3).

Search according to biological & ecological traits

Irrespective of other conditions, the statistics on the

basic category of oil plants indicate that there are 651 species of arbors, 352 species of shrubs, 300 species of herbaceous plants and 70 species of lianas. The proportion of xylophyta/ herbaceous plants is approximately 3.12:1, which is consistent with the statistics of Wei *et al*. (2008) (Fig. 4 a).

Irrespective of other conditions, the statistics on growth elevation of oil plants indicates that there are 99 species suitable for growing on plains (elevation below 200m), 233 species suitable for growing on hills (elevation between 200-500m), 310 species suitable for growing on mountain lands (elevation between 500-1000m) and 302species suitable for growing on plateaus (elevation over 1000m). More detailed selection should take florescence, maturity period, climate etc. into consideration. Furthermore, oil xylophyta growing on mountain lands can help improve soil property and reduce water and soil loss. The statistics show that there are 250 species of oil xylophyta suitable for growing on lands where elevation is over 500m, and some of them can be used to produce biodiesel.

Taking maturity period into consideration, the number and proportion of oil plants species mature in different seasons are spring (Mar.-May) (79, 7%), summer (Jun.-Aug.) (378, 32%), autumn (Sep.-Nov.) (632, 54%) and winter (Dec.-Feb.) (84, 7%).

Search according to oil content

Proportion of different range of oil content of oil plants recorded in COPS database is shown in Fig. 4 (b). Further statistics and analysis will be discussed in another paper.

Search according to fatty acid

The database covers 11 kinds of SFAs, 19 kinds of MUFAs (isomerides included), 29 kinds of PUFAs (isomerides included) and 13 kinds of other fatty acids. For further discussion and analysis of this section, refer He *et al. (*2013).

DISCUSSION

First comprehensive web-based database and informatics system has been constructed to provide informations of oil plants in China pertaining to their classification, biological and ecological traits, oil contents, fatty acid contents etc. The development of COPS database has greatly improved the efficiency of information retrieval of oil plants in China.

However, there are still several challenges with the COPS database which have been listed below.

1. The major one is that the present COPS database lacks internationalization because majority of informations and interface of the database have been presented in Chinese and the translation and re-input of entire data in the database from Chinese to English will need lot of time and effort.
2. Another challenge is the accuracy of legacy data from sources with a low degree of measurement standardization, frequently from dated paper documents. Moreover, some plants in the data base lack comprehensive biological & ecological traits, which should be imported in the further development.
3. While searching according to multiple conditions of oil content, the result presented by the database has not merged the same analysis part of the same species from different provinces. The same problem emerges when searching according to fatty acid proportion. So the structure and instructions of the system need improving and simplifying.
4. The fourth challenge is the database needs more functions on selection with multiple conditions and multilists. To mention a few, a comprehend sive functional module should be developed to select species of oil plants that yield vegetable oil meeting the biodiesel standard of EN 142 (density at 15°C from 860 kg/m³ to 900 kg/m³, etc.) (Berrios *et al.* 2010; Juan *et al.* 2010).

As the ASP programming has high flexibility and associativity with database, it is convenient to add new data and new functional modules to the COPS database in practical research.

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REFERENCES

Berrios M, Gutiérrez MC, Martín MA and Martín A (2010). Obtaining biodiesel from spanish used frying oil: Issues in meeting the EN 14214 biodiesel standard. Biomass Bioener **34**(3): 312-318. http://www.sciencedirect.com/science/article/pii/S0961953409002311# DOI:10.1016/j.biombioe.2009.11.002

Birch EE, Garfield S, Hoffman DR, Uauy R and Birch DG (2000). A randomised controlled trial of early dietary supply of long chain polyunsaturated fatty acids and mental development in term infant. Dev Med Child Neurol **42**: 174-181. http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8749.2000.tb00066.x/abstract;jsessionid=01C23FADE6733C4F0F0D627397098377.f03t03DOI: 10.1111/j.1469-8749.2000.tb00066.x

Changa NW and Huang PC (1998). Effects of the ratio of polyunsaturated and monounsaturated fatty acid to saturated fatty acid on rat plasma and liver lipid concentrations. Lipids **33**(5): 481-487. http://link.springer.com/article/10.1007%2Fs11745-998-0231-9 DOI: 10.1007/s11745-998-0231-9

Chinese Academy of Sciences (1973). Handbook of fat-or oil-bearing plants of China. Science Press, Beijing.

Fu J, Zhang XW, Liu K, Li QS, Zhang LR, Yang XH, Zhang ZM, Li CZ, Luo Y, He ZX and Zhu HL (2012). Hypolipidemic activity and constituents of a novel natural vegetable oil from Cornus wilsoniana fruits. J Food Sci 77(8), H160-H169.http://onlinelibrary.wiley.com/doi/10.1111/j.1750-3841.2012.02786.x/abstract DOI: 10.1111/j.1750-3841.2012.02786.x

Guo LF, He JX, Wang XG, Lin CR and He CX (2009). Research progress on exploitation of main oil plants of Euphorbiaceae. China Oils Fats **34**(10): 57-61. http://caod.oriprobe.com/articles/16839989Research_progress_on_exploitation_of_main_oil_plants_of_Euphorbiaceae.htm

He ZX, Yin ZF, Hu YM, Zhang LB, Li CZ and Fu J (2013). Assessment of biodiversity of oil plant species in China: type, content and distribution characteristics of fatty acids. Adv Food Sci **35**(3): 117-125.http://www.psp-parlar.de/details_artikel.asp?tabelle=FEBArtikel&artikel_id=4842&jahr=2013

Heinrich J, Balleisen L, Schulte H, Assmann G and van de Loo J (1994). Fibrinogen and factor VII in the prediction of coronary risk. Results from the PROCAM study in healthy men. Arterioscl Thromb Vas **14**: 4-9.http://atvb.ahajournals.org/content/14/1/54.longDOI: 10.1161/01.ATV.14.1.54

Hui YH (1996). Bailey's Industrial Oils & Fats Products (5th Edition). Vol. 1, John Wiley & Sons, New York. **Pp**. 346-359. http://onlinelibrary.wiley.com/book/10.1002/047167849X DOI: 10.1002/047167849X

Junker R, Heinrich J, Schulte H, van de Loo J and Assmann G (1997). Coagulation factor VII and the risk of coronary heart disease in healthy men. Arterioscl Throm Vas **17**: 1539-1544. http://atvb.ahajournals.org/content/17/8/1539.long DOI: 10.1161/01.ATV.17.8.1539

Kang MJ, Shin MS, Park JN and Lee SS (2005). The effects of polyunsaturated:saturated fatty acids ratios and peroxidisability index values of dietary fats on serum lipid profiles and hepatic enzyme activities in rats. Brit J Nutr **94**: 526-532. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=921016 DOI: http://dx.doi.org/10.1079/BJN20051523

Krawczyk T (1996). Biodiesel-Alternative fuel makes inroads buthurdles remain. Inform **7**: 801-829.

Larsen LF, Jespersen J and Marckmann P (1999). Are olive oil diets antithrombotic? Diet enriched with olive, rapeseed, or sunflower oil affect postprandial factor VII differently. Am J Clin Nutr **70**: 976-982.http://ajcn.nutrition.org/content/70/6/976.long

Ma F and Hanna MA (1999). Biodiesel production: a review. Bioresour Technol **70**: 1-15. http://www.sciencedirect.com/science/article/pii/S0960852499000255DOI: http://dx.doi.org/10.1016/S0960-8524(99)00025-5

McGraw L (2000). Biodegradable Hydraulic Fluid Nears Market. News & Events, United States Department of Agriculture, April 19. http://www.greenenvironmentnews.com/Environment/Agriculture/Biodegradable+Hydraulic+Fluid+Nears+Market

Meade TW, Ruddock V, Stirling Y, Chakrabarti R and Miller GJ (1993). Fibrinolytic activity, clotting factors, and long-term incidence of ischaemic heart disease in the Northwick Park Heart Study. Lancet **342**: 1076-1079.http://www.sciencedirect.com/science/article/pii/014067369392062XDOI: http://dx.doi.org/10.1016/0140-6736(93)92062-X

Meleroa JA, Vicenteb G, Moralesa G, Paniaguaa M and Bustamante J (2010). Oxygenated compounds derived from glycerol for biodiesel formulation: Influence on EN 14214 quality parameters. Fuel **89**(8): 2011-2018.http://www.sciencedirect.com/science/article/pii/S0016236110001481DOI: http://dx.doi.org/10.1016/j.fuel.2010.03.042

Nelson DL and Cox MM (2008). Lehninger Principles of Biochemistry (5th edition). W H. Freeman and Company, New York, **Pp**. 343-370.http://bcs.whfreeman.com/lehninger5e/default.asp?s=&n=&i=&v=&o=&ns=0&uid=0&rau=0

Rapaport SI and Rao LVM (1995). The tissue factor pathway: how it has become a "prima ballerina". Thromb Haemostasis 74: 7–17.

Ruddock V and Meade TW (1994). Factor VII activity and ischaemic heart disease: fatal and non-fatal events. Q J Med **87**: 403-406. http://qjmed.oxfordjournals.org/content/87/7/403.long

Shay EG (1993). Diesel fuel from vegetable oils: status and opportunities. Biomass Bioenerg **4**: 227-242.http://www.sciencedirect.com/science/article/pii/096195349390080N DOI: http://dx.doi.org/10.1016/0961-9534(93)90080-N

The compilation committee of China oil plant (1987). China oil plant. Science Press, Beijing.

Wang YP, Yao XH and Wang KL (2007). Research present status and development strategy of plant resources for biomass fuel oil. China Oils Fats **32**(5): 7-10.http://caod.oriprobe.com/articles/12458891/Research_present_status_and_development_strategy_of_plant_resources_fo.htm

Wei, W.L., Jin, M.Y. 2008. Analysis of strategies in development of energy oil plants in China. Chinese J Oil Crop Sci 30(2), 260-264. http://caod.oriprobe.com/articles/14461308/Analysis_of_strategies_in_development_of_energy_oil_plants_in_China.htm

Wei, W.L., Jin, M.Y. 2008. Evaluation on the potential of energy utilization for 42 kinds of non-woody oil plants in China. China Oils Fats 33(5), 73-76.http://caod.oriprobe.com/articles/14052847/Evaluation_on_the_potential_of_energy_ utilization_for_42_kinds_of_non_.htm

Zhao, K.F., Feng, L.T. 2001. China Halophyte Resource. Science Press, Beijing, pp. 32-43.