



Review

Safety assessment of Ylang–Ylang (*Cananga* spp.) as a food ingredientGeorge A. Burdock^{a,*}, Ioana G. Carabin^b^a Burdock Group, 2001 9th Avenue Suite 301, Vero Beach, FL 32960, United States^b Women in Science, 3785 7th Lane, Vero Beach, FL 32968, United States

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Abstract

Ylang–Ylang oil is used in the food industry as a flavor ingredient. It is a complex chemical mixture in the form of an essential oil extracted by water or water-and-steam distillation from the fresh flowers of *Cananga odorata* Hook. f. & Thomson. Ylang–Ylang oil has been reported to cause dermal sensitization reactions in animals and humans, but it is unclear what constituent(s) within the essential oil comprise the offending agent(s) and whether some Ylang–Ylang oils that have had certain constituent(s) removed are any less prone to cause such allergic reactions. There is no indication in the literature that food exposure to Ylang–Ylang oil has caused allergic reactions. One subchronic inhalation toxicity study, involving Ylang–Ylang oil as part of a larger fragrance raw materials mixture, gave no indication of causing adverse effects, but the relevance to risk assessment of oral food flavoring use exposures is likely minimal. No further toxicity data for Ylang–Ylang oil have been reported. Notwithstanding the foregoing, Ylang–Ylang oil has a long history of fragrance and food flavoring use, with no indication that its estimated consumption from food flavoring use (0.0001 mg/kg/day) has led to any adverse human health effects. These data indicate that at the current level of intake as a food ingredient, Ylang–Ylang oil does not pose a health risk to humans.

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Keywords: Ylang–Ylang; Burdock; Toxicity; Food additive; GRAS

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Abbreviations: CAS, chemical abstracts service; CFR, code of federal regulations; DINFO, daily intake via natural food occurrence; FEMA, flavor and extract manufacturers association; FDA, United States food and drug administration; GRAS, generally recognized as safe; IOFI, International organization of flavor industries; MIC, minimally inhibiting concentration; MSDI, maximum survey-derived daily intake; NACGM, National association of chewing gum manufacturers; NAS, United States national academy of sciences; NOEL, no observed effect level; PADI, possible average daily intake; PMDI, possible maximum daily intake; TAMDI, theoretical added maximal daily intake.

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1. Introduction

Ylang–Ylang oil (CAS No. 8006-81-3) (pronounced *ee-lang ee-lang*) is the essential oil derived from the flowers of the tree of the same common name, known botanically as *Cananga odorata* (Family: *Annonaceae*). In the food industry, Ylang–Ylang oil is used as a flavoring agent and adjuvant. Ylang–Ylang oil is approved for food uses by the US food and drug administration (FDA) and has been judged generally recognized as safe (GRAS) for food uses by the flavor and extract manufacturers association (FEMA). This review evaluates the safety-in-use of Ylang–Ylang oil as a food ingredient.

1.1. Historical perspective

Buccellato (1982) reports that the Ylang–Ylang industry got its start in Manila, the Philippines, around 1860 by a stranded sailor named Albert Schwenger who became enchanted by the odor of the flowers. He set out traveling the countryside and distilling Ylang–Ylang in small quantities from the back of his wheelcart. In short time, the industry moved to French possessions in the Indian Ocean, and by 1909 there were a reported 200,000 Ylang–Ylang trees on the island of Réunion. Opdyke (1974) states that Ylang–Ylang oil has been in public use since the 1880s and that its use in fragrances totaled approximately 76,000 lb/year in the US in 1974.

1.1.1. Description, natural occurrence and sources

Ylang–Ylang essential oil is derived from the flowers – yellow with long trailing petals – of the Ylang–Ylang tree (*Cananga odorata* Hook. f. & Thomson [family: *Annonaceae*]) (Greuter, 2000; Tradewinds, 2004; Tropilab Inc, 2004) *Cananga odorata* is a large tree (up to 50–75 feet tall), with large, hairy, green fruit that turns yellow when ripe. The tree is native to Malaysia and Indonesia, but is now naturalized to most of the larger Pacific Island groups, northern Australia, Thailand, and Vietnam. Historically, the cananga and Ylang–Ylang trees were assumed identical species, but a more thorough study reclassified the true cananga plant as *Canangium odoratum* Baill. f. *macrophy-*

lla, and the Ylang–Ylang tree as *Canangium odoratum* Baill. f. *genuine* (Burdock, 2002b) (Table 1). Though listed as a synonym of Ylang–Ylang oil (Table 2), cananga oil is more accurately described by Bauer et al. (1997) as originating from the former plant (i.e., cananga plant) and almost exclusively in Java, where flowers are collected throughout the year.

Currently, all Ylang–Ylang oil production comes from cultivated trees. As noted above, the Ylang–Ylang industry appears to have gotten its start in the Philippines around 1860. Large-scale commercial production subsequently moved to Nossi-Bé island and to the Comoro islands, in the Indian Ocean off the northwest coast of Madagascar; more recently, production has been centered specifically on two of the Comors, Anjouan and Mayotte (Arctander, 1960; Buccellato, 1982).

Ylang–Ylang essential oil is primarily extracted from the flowers by water or water-and-steam distillation. This distillation is typically interrupted multiple times based on specific gravity, thereby yielding fractions of varying desirability and value from a perfumery perspective. These distillate fractions are often referred to as “Ylang–Ylang Extra”, “Ylang–Ylang First”, “Ylang–Ylang Second”, “Ylang–Ylang Third”, and “Ylang–Ylang Complete”. The fractions will vary in physical/chemical properties, but definitive boundaries are often blurred. Traditionally, Ylang–Ylang essential oil is considered to consist of the

Table 1
Classification of *Cananga odorata* (Lam.) Hook. f. & T. Thomson

Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Magnoliidae –
Order	Magnoliales –
Family	Annonaceae – Custard-apple family
Genus	<i>Cananga</i> (DC.) Hook. f. & T. Thomson – ilang-ilang
Species	<i>Cananga odorata</i> (Lam.) Hook. f. & T. Thomson – ilang-ilang

Source: USDA Plants Database at <<http://plants.usda.gov>> (Accessed 8.7.2007).

Table 2
General description of Ylang–Ylang oil

Botanical source	<i>Cananga odorata</i> Hook. f. & Thomson
Botanical family	Annonaceae
Other names of botanical source	<i>Canangium odoratum</i> Baill. f. <i>genuine</i>
Synonyms	Oils, Ylang–Ylang; Ylang–Ylang absolute; Ylang–Ylang oil distillates; Cananga oil (note distinction above, Section 1.1.1)
Functional use in food	Flavoring agent or adjuvant
CAS No.	8006-81-3
NAS No.	3119
FEMA No.	3119
Packing and storage	Preserve in tight containers of steel or aluminum; preferably in a cool dark place

CAS = chemical abstracts service; FEMA = flavor and extract manufacturers' association; NAS = National academy of sciences.

Table 3
Ylang–Ylang oil specifications, Burdock (1997)

	First distilled ('Extra')	I Quality ('First')	II Quality ('Second')	III Quality ('Third')
Appearance	Yellow liquid	Pale yellow liquid	Pale yellow liquid	Pale yellow liquid
Acid value	2.8 (max)	2.8 (max)	2.8 (max)	2.8 (max)
Ester value	130–182	89–130	56–89	34–56
Odor	Suave, floral	Floral	Floral	Floral
Optical rotation	–25° to –40° at 20 °C	–33° to –60° at 20 °C	–40° to –68° at 20 °C	–35° to –67° at 20 °C
Solubility	1:0.5 in 90% ethanol	1:0.5 in 90% ethanol	1:0.5 in 90% ethanol (occasionally)	1:0.5 in 90% ethanol (sometimes)
Specific gravity at 20 °C	0.946–0.982	0.928–0.949	0.918–0.933	0.906–0.923
Refractive index at 20 °C	1.498–1.509	1.5000–1.5090	1.5057–1.5117	1.5070–1.5150

volatilized oil collected in the first few hours of distillation ("Ylang–Ylang Extra") (Arctander, 1960; Burdock, 1997; Burdock, 2002b). Derivatives of the oil include the concretes, which are obtained through solvent extraction (e.g., petroleum ether) of the flowers, and the absolutes, obtained through alcoholic extraction of the concretes (Buccellato, 1982; Acda et al., 1995; Burdock, 1997; Burdock, 2002b).

Ylang–Ylang oil has a medium to strong initial aroma that is described as fresh, floral, sweet, slightly fruity, fragrant yet delicate¹. Taste and aroma threshold values for Ylang–Ylang oil have not been published (Burdock, 2002b). Synonyms and other descriptive characteristics of Ylang–Ylang oil are provided in Table 2.

1.1.2. Specifications

The Ylang–Ylang essential oil ("Extra" or "First Distilled") is a yellow liquid with a suave, floral aroma; additional specifications for this and the other distillation fractions are provided in Table 3 (Burdock, 1997). Buccellato (1982) states that the typical chemical composition of Ylang–Ylang oil, in general terms, consists of sesquiterpene hydrocarbons, alcohols, esters, ethers, phenols, and aldehydes; he also identifies various individual constituents as being key drivers of the unique aspects of the oil's flavor and odor characteristics (e.g., medicinal, floral, spicy/balsamic, fruity, woody). A qualitative chemical constituent analysis has been reported by several

authors and is shown in Table 4. In an investigation of potential cytotoxic constituents from the fruits of *Cananga odorata*, Hsieh et al. (2001) make the general statement that "plants of the genus *Cananga* are rich in alkaloids and terpenoids." Timmer et al. (1975) have also reported qualitative characterization of the free acid fraction of Ylang–Ylang oil, but did not report any estimation of the quantitative fraction of the acids (either wholly or individually) within the oil. Several reports generally state that the precise chemical mix of the individual components within the oil will vary amongst the various essential oil distillate fractions, the concrete, and the absolute (Buccellato, 1982; Bauer et al., 1997). However, a specific and quantitative chemical composition analysis for distillation fraction II of Ylang–Ylang oil has been reported by (Hongratanaworakit and Buchbauer, 2004) (Table 5).

1.1.3. Uses

Facciola (1990) describes the use of Ylang–Ylang flowers to add scent to coconut oil; the essential oil is used as a flavoring in candies, icings, baked goods, soft drinks, and chewing gum in Southeast Asia. Other sources (NMCD, 2004) indicate Ylang–Ylang oil is used topically as a sedative, antiseptic, hypotensive, and aphrodisiac. In addition, it is used in foods and beverages as a flavoring agent and in consumer product manufacturing as a fragrance for cosmetics and soaps (maximum use level of 1% in perfumes). Opdyke (1974) reports this same maximum usage level in perfumes and, in addition, provides usage levels for other fragranced consumer products (Table 6).

¹ (<<http://www.aromaweb.com/essentialoilspz/ylangylang.asp>>) (Accessed 13.7.2007).

Table 4
Chemical composition of Ylang–Ylang oil

Constituent	References
Acetic acid	Duke 1992
Acetone	Duke 1992
(+)- <i>N</i> -Acetlnornuciferine	Hsieh et al., 1999
α -Amorphene	Stashenko et al., 1996
(–)-Anaxagoreine	Hsieh et al., 1999
<i>Trans</i> -Anethol	Stashenko et al., 1996
(–)-Anonaine	Hsieh et al., 1999
<i>cis</i> -Asarone	Stashenko et al., 1996
(–)-Asimilobine	Hsieh et al., 1999
Benzaldehyde	Duke 1992; Stashenko et al., 1996
Benzoic acid	Duke 1992
Benzyl acetate	Duke 1992; Stashenko et al., 1996
Benzyl alcohol	Duke 1992; Stashenko et al., 1996
Benzyl benzoate	Duke 1992; Stashenko et al., 1996
Benzyl <i>n</i> -butyrate	Stashenko et al., 1996
Benzyl cinnamate	Stashenko et al., 1996
Benzyl salicylate	Duke 1992; Stashenko et al., 1996
Bisabolene	Stashenko et al., 1996
α -Bisabolol	Stashenko et al., 1996
3-Buten-2-ol benzoate	Stashenko et al., 1996
Butyl acetate	Duke 1992
Butyl benzoate	Stashenko et al., 1996
Cadinene	Duke 1992
δ -Cadinene	Duke 1992; Stashenko et al., 1996
ε -Cadinene	Duke 1992
γ -Cadinene	Duke 1992; Stashenko et al., 1996
α -Cadinol	Stashenko et al., 1996
δ -Cadinol	Stashenko et al., 1996
<i>l</i> -Cadinol	Duke 1992
Calamenene	Stashenko et al., 1996
Camphene	Stashenko et al., 1996
Canangine	Duke 1992
Caryophyllene	Duke 1992
β -Caryophyllene	Stashenko et al., 1996
Caryophyllene oxide	Stashenko et al., 1996
α -Cedrene	Stashenko et al., 1996
Cedrol	Stashenko et al., 1996
1,8-Cineole (Eucalyptol)	Stashenko et al., 1996
Cinnamaldehyde	Stashenko et al., 1996
<i>trans</i> -Cinnamic acid	Hsieh et al., 1999
Cinnamyl acetate	Stashenko et al., 1996
Cinnamyl alcohol	Stashenko et al., 1996
Citronellyl acetate	Stashenko et al., 1996
Cleistoeholine	Hsieh et al., 1999
α -Copaene	Stashenko et al., 1996
Creosol	Duke 1992
<i>p</i> -Cresol	Duke 1992; Stashenko et al., 1996
<i>p</i> -Cresol-methyl-ether	Duke 1992
<i>p</i> -Cresol-acetate	Duke 1992
<i>p</i> -Cresyl acetate	Stashenko et al., 1996
β -Cubebene	Stashenko et al., 1996
1,4-Dimethoxybenzene	Stashenko et al., 1996
3,4-Dimethoxytoluene	Stashenko et al., 1996
δ -Elemene	Stashenko et al., 1996
Elemol	Stashenko et al., 1996
Ethyl benzoate	Stashenko et al., 1996
Ethylene oxide	Duke 1992
Eugenol	Duke 1992; Stashenko et al., 1996
Eugenol-methyl-ether	Duke 1992
Farnesol	Duke 1992
(<i>E,E</i>)Farnesene	Stashenko et al., 1996
(<i>E,E</i>)-Farnesol	Stashenko et al., 1996
Farnesyl acetate	Stashenko et al., 1996
<i>N-trans</i> -Feruloyltyramine	Hsieh et al., 1999

Table 4 (continued)

Constituent	References
Formic acid	Duke 1992
Furfural	Duke 1992
Geraniol	Duke 1992; Stashenko et al., 1996
Geranyl acetate	Duke 1992; Stashenko et al., 1996
Germacrene-D	Stashenko et al., 1996
Hexadecanoic acid	Stashenko et al., 1996
3-Hexen-1-ol	Stashenko et al., 1996
3-Hexenyl acetate	Stashenko et al., 1996
3-Hexenyl benzoate	Stashenko et al., 1996
α -Humulene	Stashenko et al., 1996
Hydrocarbon, C 20	Stashenko et al., 1996
Hydrocarbon, C 26	Stashenko et al., 1996
Indole	Stashenko et al., 1996
Isoeugenol	Duke 1992; Stashenko et al., 1996
Isosafrole	Duke 1992
Limonene	Stashenko et al., 1996
Linalool	Stashenko et al., 1996
<i>l</i> -Linalool	Duke 1992
Liriodenine	Hsieh et al., 1999
Lyscamine	Hsieh et al., 1999
2-Methoxy-4-methylphenol	Stashenko et al., 1996
2-Methoxyphenol	Stashenko et al., 1996
4-Methoxyphenylmethyl acetate	Stashenko et al., 1996
Methyl 2-methoxybenzoate	Stashenko et al., 1996
Methyl 4-methoxybenzoate	Stashenko et al., 1996
<i>p</i> -Methylanisole	Stashenko et al., 1996
Methyl anthralinate	Duke 1992; Stashenko et al., 1996
4-Methylbenzaloxime	Stashenko et al., 1996
Methyl benzoate	Duke 1992; Stashenko et al., 1996
2-Methyl-but-3-en-2-ol	Duke 1992
3-Methyl-but-2-en-1-ol	Duke 1992
3-Methyl-but-3-en-1-ol	Duke, 1992; Stashenko et al., 1996
3-Methyl-2-buten-1-yl acetate	Stashenko et al., 1996
2-Methyl-3-buten-2-ol	Stashenko et al., 1996
Methyleugenol	Stashenko et al., 1996
Methyl salicylate	Duke 1992; Stashenko et al., 1996
α -Muurolene	Stashenko et al., 1996
γ -Muurolene	Stashenko et al., 1996
β -Myrcene	Stashenko et al., 1996
Muurolol T	Stashenko et al., 1996
Nerol	Duke 1992; Stashenko et al., 1996
Nerolidiol	Duke 1992
Nerolidol	Stashenko et al., 1996
(+)-Nornuciferine	Hsieh et al., 1999
(–)-Norushinsunine	Hsieh et al., 1999
β - <i>trans</i> -Ocimene	Stashenko et al., 1996
2-Phenyl-1-nitroethane	Stashenko et al., 1996
Phenylacetaldehyde	Stashenko et al., 1996
Phenylacetoneitrile	Stashenko et al., 1996
2-Phenylethyl acetate	Stashenko et al., 1996
Phenylethyl alcohol	Duke 1992
Phenylethyl benzoate	Stashenko et al., 1996
α -Pinene	Stashenko et al., 1996
β -Pinene	Stashenko et al., 1996
<i>d</i> - α -Pinene	Duke 1992
4-(2-Propenyl)-phenol	Stashenko et al., 1996
(+)-Reticuline	Hsieh et al., 1999
Safrole	Duke 1992
Salicylic acid	Duke 1992
Sampangine	Duke 1992
Sesquiterpenes	Duke 1992
β -Sitosterol	Hsieh et al., 1999
Stigmasterol	Hsieh et al., 1999
Terpenes	Duke 1992
α -Terpineol	Stashenko et al., 1996

Table 4 (continued)

Constituent	References
Tetradecanal	Stashenko et al., 1996
<i>n</i> -Tetradecane	Stashenko et al., 1996
Thujene	Stashenko et al., 1996
<i>p</i> -Tolylmethylether	Duke 1992
(–)-Ushinsuine	Hsieh et al., 1999
(+)-Ushinsuine- β - <i>N</i> -oxide	Hsieh et al., 1999
Ylangene	Duke 1992
α -Ylangene	Stashenko et al., 1996

Table 5

Chemical composition of Ylang–Ylang oil, fraction II (Hongratanaworakit and Buchbauer, 2004)

Constituent	Amount (%)
Methyl benzoate	34.00
4-Methylanisole (<i>p</i> -tolylmethylether)	19.82
Benzyl benzoate	18.97
<i>iso</i> -Caryophyllene	9.28
Germacrene D	8.15
α -Farnesene	2.73
Linalyl acetate	2.11
α -Caryophyllene	2.04
Copaene	1.65
Cadinene	1.25

Table 6

Use levels of Ylang–Ylang oil in fragrance products (Opdyke, 1974)

Product	Usual level (%)	Maximum level (%)
Soap	0.02	0.3
Detergent	0.002	0.03
Creams, lotion	0.01	0.1
Perfumes	0.3	1.0

1.1.4. Regulatory history

Ylang–Ylang oil has been approved for use in food by FDA; FEMA and the International Organisation of Flavor

Industries (IOFI) have also evaluated its use in food and judged it to be safe (Table 7). FEMA (Burdock, 2002b) and National Association of Chewing Gum Manufacturers (NACGM) (1977) reported food uses of Ylang–Ylang oil are provided in Table 8.

1.2. Consumption

1.2.1. Estimation methods

Several methods can be applied to estimate the consumption of a substance in the diet. First, the *per capita* estimate of intake, also called Maximum Survey-derived Daily Intake (MSDI), is based on “disappearance data” of the amounts added to food as an ingredient. The second, Daily Intake *via* Natural Food Occurrence (DINFO), is intake as the result of the presence of a substance as an intrinsic or natural part of food (Burdock, 2002a). In contrast to these methods, which are estimated intakes of the food ingredient from survey data, the Theoretical Added Maximal Daily Intake (TAMDI) values such as FEMA Possible Average Daily Intake (PADI) and Possible Maximum Daily Intake (PMDI) are calculated based on theoretical consumption of food to which the ingredient has been added. DINFO is calculated based on the concentration of substance in food and the consumption of the food(s). A brief description of each of these methods is provided below along with the calculated values.

1.2.1.1. Per capita consumption. *Per capita* estimate of intake, MSDI, is based on “disappearance data” from periodic surveys of ingredient manufacturers of the volume of ingredients produced during the survey year. The method is easy to use because it divides the total annual production by the population in the survey year and the number of days *per year*. The assumption is that there is a finite amount of substance available and the general population ingests it as an added food ingredient regardless of source at the retail level.

The primary sources of data for *per capita* estimates are the surveys conducted by the National Academy of Sci-

Table 7

Regulatory status of Ylang–Ylang oil

Agency	Comments	Permitted functionality	Use limits	Reference
FDA	21 CFR 182.20 Food for human consumption. GRAS substances. Essential oils, oleoresins (solvent free), and natural extractives (including distillates)	No limitation	cGMP	21 CFR 182.20 ^a
FDA	21 CFR 582.20 Animal drugs, feeds, and related products. GRAS substances. Essential oils, oleoresins (solvent free), and natural extractives (including distillates)	No limitation	cGMP	21 CFR 582.20 ^b
FEMA	No. 3119, GRAS	Flavor ingredient	(Refer to Table 6)	Hall and Oser (1965)
IOFI	Natural flavor isolated by physical methods			Clydesdale (1997)

CFR = code of federal regulations; cGMP = current good manufacturing practices; FDA = US food and drug administration; FEMA = flavor and extract manufacturers' association; GRAS = generally recognized as safe; IOFI = international organisation of flavour industries.

^a Title 21 of the US Code of Federal Regulations (CFR), section 182.20, 2002 edition.

^b Title 21 of the US Code of Federal Regulations (CFR), section 582.20, 2004 edition.

Table 8
Reported food uses of Ylang–Ylang oil by FEMA^a (Burdock, 2002b) and NACGM (1977)

Food category	Use level (ppm)		Food category	Use level (ppm)	
	Usual	Max		Usual	Max
Alcoholic beverage	0.99	2.91	Gelatin, pudding	1.03	3.00
Baked goods	3.03	5.03	Hard candy	1.05	1.38
Chewing gum	12.04	58.81	Hard candy ^b	3.18	4.19
Chewing gum ^b	11.65	12.31	Nonalcoholic beverage	0.98	2.85
Frozen dairy	2.92	4.89	Soft candy	3.00	4.98

FEMA = flavor and extract manufacturers' association.

^a FEMA approved uses are for flavor ingredients.

^b NACGM = National association of chewing gum manufacturers.

ences (NAS) under contract to FDA (NAS, 1989). The last survey, conducted in 1987, was based on voluntary reporting by manufacturers. Because the NAS has not conducted a survey since 1987, Lucas et al. (1999) conducted the FEMA 1995 Poundage and Technical Effects Update Survey². Lucas et al. (1999) claimed a response rate of 87% among all FEMA-affiliated flavor manufacturers and users with regards to reported total annual sales volume.

Some considerations are necessary in the use of these survey data: (1) it is generally held that the amount reported is a fraction of the actual volume, because not all producers participate, and (2) distribution of consumption may be uneven, because not all persons eat all foods each day in each category in which the substance may be added and, conversely, some consumers may seek out the substance. In order to compensate for these variables, FDA assumes (1) only 60% of the actual value was reported and (2) only 10% of the US population (243.9 million in 1987) consumes 100% of the calculated amount (NAS, 1989). Based on these variables and the annual poundage “disappearance” reported by the producers to NAS of 73.0 lb for the year 1987 (NAS, 1989), the calculated individual consumption of Ylang–Ylang oil is 0.0062 mg/day or 0.0001 mg/kg/day (for an average individual weighing 60 kg).

For consumption estimates based on the Lucas et al. (1999) reported disappearance value, the following assumptions are made: (1) 10% of the population consumes the entire flavoring, (2) a correction factor of 80% is used and (3) a 1995 US population of 261.1 million. Based on these factors and the Lucas et al. (1999) reported disappearance value of 97 lb, the calculated individual consumption of Ylang–Ylang oil is 0.006 mg/day or 0.0001 mg/kg/day.

1.2.1.2. Theoretical added maximum daily intake (TAMDI). The TAMDI is calculated based on upper use levels

² Lucas et al. (1999) reported the consumption of food ingredients when used as a flavoring, while the older NAS survey reported consumption of food ingredients that was not limited by a particular technical effect.

and the estimated daily intakes of foods. For example, the FEMA GRAS determination encompasses two levels of use as a flavoring, the “average usual” and “average maximum” (Burdock, 2002b). The TAMDI is determined using the “average maximum” level times the estimated daily intake of the food to which the substance is added. The estimated daily intake would presumably be maximized as well, using the 90th percentile consumption.

The FEMA PADI is similar to the TAMDI concept, but instead employing “usual” use level values and mean consumption estimates of designated food categories (based on Market Research Corporation of America (MRCA) mean frequency of eating and USDA mean portion size of 34 general food categories) (MRCA, 1965). Therefore, the FEMA PADI of 0.666 mg/day or 0.011 mg/kg/day is the mean consumption of Ylang–Ylang oil that is based on a reported “usual” level of use as a flavoring by FEMA. The conservatism of the PADI method assumes that the usual amount of flavoring is added to the entire food category, not just the substance within that category. For example, the consumption of a flavoring added only to marshmallow cream cookies (a relatively rarely eaten food) would account for very little consumption, but the FEMA assumption is that the substance is added to *all* baked goods, not just the small portion of baked goods represented by an exotic cookie.

The PMDI can be calculated using the mean consumption of food as above and the maximum use levels reported by FEMA (Table 7). The PMDI calculated theoretical value for Ylang–Ylang oil, when used as a flavor ingredient, was 1.31 mg/day or 0.022 mg/kg/day.

1.2.2. Consumption summary

To arrive at an estimate of total consumption of a substance, the amount purposefully added to food as an ingredient should be added to the amount consumed of the substance when it is present as a natural constituent in foods. A single point estimate of the total amount of a substance consumed from all food sources is not possible with the data available. However, to obtain a reasonable estimate of total consumption of a substance, the various consumption estimates that are discussed in the preceding paragraphs are combined to generate what are often two different intake values, a lower one and a higher one.

In the case of Ylang–Ylang oil, these intake values turned out to be very similar. The typically lower total consumption value for Ylang–Ylang oil was estimated by the FEMA disappearance *per capita* consumption, and is equal to 0.0062 mg/day or 0.0001 mg/kg/day. The typically higher total consumption value for Ylang–Ylang oil was estimated by the NAS disappearance *per capita* consumption, and is equal to 0.006 mg/day or 0.0001 mg/kg/day (Table 8). The reasons for this similarity are not entirely clear and it may be purely coincidental. However, it may also reflect that the technical reason for using Ylang–Ylang oil in food is solely that of a flavoring ingre-

Table 9
Consumption of Ylang–Ylang oil

	FEMA <i>per capita</i> low-intake value		NAS <i>per capita</i> high-intake value	
	mg/day	mg/kg/day	mg/day	mg/kg/day
Added	0.006	0.0001	0.0062	0.0001
Ingredient	0.006	0.0001	0.0062	0.0001

FEMA = flavor and extract manufacturers' association; NAS = National academy of sciences.

dient and, therefore, that the total annual production poundage numbers reported by NAS and FEMA are reflecting similar and consistent exposure rates over the years. For perspective, while definitive exposure numbers are not available, it is likely that dermal and inhalation exposures in select populations of cosmetic and aromatherapy users significantly exceed the food exposures summarized below (Table 9).

2. Biological data

2.1. Absorption, metabolism and excretion

There are no data available on the pharmacokinetics of Ylang–Ylang oil, *per se*, by any route of administration. Moreover, Ylang–Ylang oil is a complex chemical mixture, the quantitative make-up of which has only been minimally defined in published scientific literature. Thus, it is unclear which individual chemical constituent(s) of Ylang–Ylang would be most representative of the mixture as a whole from a pharmacokinetic perspective. Of the three primary constituents noted above (Table 5) (Hongratanaworakit and Buchbauer, 2004) – methyl benzoate, 4-methylanisole, and benzyl benzoate – benzyl benzoate appears to be the only one with published information on pharmacokinetics in mammalian systems and even that information – investigations of its dermal absorption (Bronaugh et al., 1990) – would have little relevance to human food use risk assessment.

2.2. Biochemical/Pharmacological effects

Numerous investigators have studied the potential of Ylang–Ylang oil to exhibit various biochemical/pharmacological effects. Frequently, Ylang–Ylang oil was one of many from the class of essential oils to be tested for potential antibacterial activity and other effects. Relevant reports are reviewed briefly below.

An essential oil of “*Cananga odorata* (Lamarck) Hook et al., Thomson” (*sic*) (cf. Table 2) was one of 37 essential oils that were evaluated for antifungal activity (Delespaul et al., 2000). No activity was detected by the methods employed. Chu et al. (1998) report that extracts (in both methylene chloride and methanol) of the flowers of *C. odorata* obtained from Southeast Asia exhibited amebicidal activity against three species of *Acanthamoeba*.

Ylang–Ylang oil was one of 73 essential oils tested for possible antimicrobial activity against two different strains of *Streptococcus pneumoniae*, one unencapsulated (R36A) and the other encapsulated (IC2) (Horne et al., 2001). Ylang–Ylang oil was reported to have no antimicrobial activity under the conditions of the assay.

The filter paper disk method was employed to assess the antibacterial activity of 110 volatile oils, 11 terpeneless oils, eight fixed oils, and six infused oils in 10 different bacterial strains (Maruzzella and Lichtenstein, 1956). Ylang–Ylang oil was one of the oils tested and it showed modest inhibitory activity against only two out of the 10 bacterial strains (*Bacillus mesentericus* and *B. subtilis*).

Maudsley and Kerr (1999) investigated the sterility and antibacterial activity of eight commercially available essential oil products, including Ylang–Ylang oil. Survival curves and minimum inhibitory concentrations against seven bacterial strains (coagulase-negative *Streptococcus*, *Staphylococcus aureus*, methicillin-resistant *S. aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Stenotrophomonas maltophilia*) and *Candida albicans* were assessed. Ylang–Ylang oil exhibited modest inhibitory activity against all strains except *P. aeruginosa*; *C. albicans* was able to survive, but not multiply, for up to 48 h in Ylang–Ylang oil.

Ontengco and Torres (2000) speculating about the emergence of antibiotic resistant bacterial strains, tested the MIC of hydro-distilled Ylang–Ylang flowers, using the agar dilution method against *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853) and clinical pathogens from urine, wound and sputum. *S. aureus*, *Citrobacter* spp. and *Klebsiella* spp. were found susceptible at various concentrations (concentrations not given).

The potential of a number of odorants, including Ylang–Ylang oil, to alter pentobarbital-induced sleep time was assessed in male Sprague–Dawley rats (Komori et al., 1997). Animals were exposed to “odorized air” for one hour. Pentobarbital (50 mg/kg) was then administered intraperitoneally and sleep time was “measured under the inhalation of odorized air”. No further characterization of the animal exposures was provided. Ylang–Ylang oil inhalation exposure was reported to have no effect on pentobarbital under the conditions of the assay (Komori et al., 1997). This lack of effect of Ylang–Ylang oil inhalation on sleeping time in rats in response to 50 mg/kg pentobarbital (i.p.) was confirmed in a subsequent report (Komori et al., 2006).

The *in vitro* free radical scavenging capacity of various plant oil extracts, including Ylang–Ylang oil, was assessed by three complementary methods (Mantle et al., 1998). Ylang–Ylang oil exhibited only minimal radical quenching activity under the conditions of the assays employed. Notwithstanding the foregoing, Wei and Shibamoto (2007), found that Ylang–Ylang essential oil exhibited significant antioxidant activity in the aldehyde/carboxylic acid assay, the DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical

scavenging assay and the malonaldehyde formation assay (in response to UV-irradiation of squalene).

Woo et al. (1997) report isolation of the cytotoxic oxoaporphine alkaloid, liriodenine, from *Cananga odorata*, but do not describe what part of the plant was used, what extraction methods were employed, or what levels were present in the plant (described only as “unpublished data”). The authors cite references to liriodenine’s known biological activity, including mutagenicity and clastogenicity; the subject of the present report is identification of topoisomerase II inhibition as a purported mechanistic basis for this biological activity. There have been no other reports in the literature that indicate the presence of liriodenine in Ylang–Ylang oil extracted from *C. odorata* flowers. In fact, two other published reports that link liriodenine with *C. odorata* identify the plant bark as the source part of the plant (Lebcoeur et al., 1973; Rao et al., 1986).

2.3. Toxicological studies

Toxicity studies reported in the literature on Ylang–Ylang oil, as a whole, are very limited. Available reports address briefly the acute oral and dermal hazard posed by the oil, plus numerous evaluations of its potential for causing dermal irritation and/or sensitization reactions in animals and humans. One subchronic inhalation toxicity study, involving Ylang–Ylang oil as part of a larger fragrance raw materials mixture, is also available. No further toxicity data for Ylang–Ylang oil have been reported.

As for the toxicity of key constituents of the complex chemical mixture that makes up Ylang–Ylang essential oil, these have only been imperfectly defined from a quantitative standpoint, as noted above (Section 2.1). Two reports (Cockayne and Gawkrödger, 1997; Hongratanaworakit and Buchbauer, 2004) do give some indication that the following – methyl benzoate, 4-methylanisole, benzyl benzoate, and linalool – are present in Ylang–Ylang oil in fairly significant amounts. For these four compounds, at least, the hazard posed to humans by their use as food flavoring agents is considered to be negligible, as they have all been approved by FDA as GRAS or as food additives with no limitations other than current good manufacturing practice.

2.3.1. Acute toxicity studies

The acute oral LD₅₀ in rats and the acute dermal LD₅₀ in rabbits were both reported to have exceeded 5 g/kg, with no further study details provided (Moreno, 1973).

Ylang–Ylang oil is classified (without further reference) as non-toxic orally (i.e., rodent LD₅₀ values > 5 g/kg), very mildly irritating to the skin when tested between 1% and 30%, non-phototoxic, and equivocal evidence as a sensitizer (Tisserand and Balacs, 1995).

These data, though few, suggest Ylang–Ylang exhibits a low order of acute toxicity, save for the potential to elicit skin sensitization reactions (discussed further in Section

2.3.3 below). Based on the information provided, it is unlikely that any of the studies meet FDA Redbook core standards (FDA, 2003).

2.3.2. Irritation studies

Ylang–Ylang oil was reported as non-irritating when applied undiluted to the backs of hairless mice; these same authors reported an absence of phototoxic effects in response to Ylang–Ylang oil (Urbach and Forbes, 1973). It was reported as slightly irritating when applied undiluted under occlusion for 24 h to intact or abraded rabbit skin (Moreno, 1973). In humans, 10% Ylang–Ylang oil in petrolatum elicited no irritation in two separate 48-h closed-patch tests (Kligman, 1971; Kligman, 1972).

2.3.3. Sensitization studies

Two separate 48-h closed-patch tests (maximization tests) with Ylang–Ylang oil in 25 human subjects produced no sensitization responses when tested at 10% in petrolatum (Kligman, 1971, 1972). Opdyke (1974) also reports results from three primary human repeated-insult patch tests and one rechallenge study (Kanof, 1971; Majors, 1971a, 1971b, 1972), in all of which Ylang–Ylang oil was tested at a concentration of 10%. Sensitization responses were reported in two out 188 total subjects tested.

Ylang–Ylang oil is briefly summarized as frequently being the cause of allergic reactions to cosmetics (Burfield, 2000), but according to Uter et al. (2007), sensitivity to Ylang–Ylang is more prevalent in perfume-positive groups than in groups reporting sensitivity to deodorants. Ernst also gives brief mention of Ylang–Ylang as a topical cause of allergic contact dermatitis (erythematous eruption) following aromatherapy (Ernst, 2000).

Fujii et al. report of human patch results with various natural and synthetic perfumes, including Ylang–Ylang oil (Fujii et al., 1972). Three different studies are described, all involving closed-patch exposures ranging from 24 to 72 h in duration. Ylang–Ylang oil test concentrations were 20% in vaseline/ointment base (29 subjects), 2% in combination ointment base (30 subjects), and 0.2% in 99% ethanol/cream base (43 subjects). Only one subject in the 2% exposure group exhibited an equivocal, slight erythema response; all other subjects exhibited negative reactions (Fujii et al., 1972).

In investigations intended to find additional known sensitizing agents beyond the standard fragrance mix (FM) that might be included in dermatological sensitization screening batteries, Frosch et al. (2002) tested Ylang–Ylang oil distillation fractions I and II (i.e., those distilled after the initial ‘extra’ fraction) as two of 18 different test articles. Ylang–Ylang oil is described as being a “major cause of allergic contact dermatitis in Asian countries, where it is frequently followed by hyperpigmentation”. Test article concentrations ranged from 0.2% to 10%; both Ylang–Ylang fractions were tested at 10%. A total of 1606 patients were tested across six different European centers. Positive skin reactions to Ylang–Ylang oil occurred in from 1.3%

to 6.2% of the tested patients across the six centers, and Ylang–Ylang oil was second only to FM in terms of its reactivity. The authors conclude that Ylang–Ylang oil should be included in standardized sensitization test batteries and, further, they urge caution with respect to increasing topical and/or inhalation exposures to concentrated solutions of it and other essential oils that are occurring through aromatherapy (Frosch et al., 2002).

Larsen et al. (2002) report on Part III of a worldwide, multi-center investigation into fragrance material contact dermatitis. A test population of 218 confirmed fragrance-sensitive volunteers (mean age 46.3 years; 85.3% female) were tested at seven centers in industrialized countries from around the globe. Subjects were patch tested “according to internationally accepted criteria” with a standard fragrance mixture (FM) and 17 other less-studied fragrance materials, including “synthetic Ylang–Ylang oil” (not otherwise defined) (10% in petrolatum). Positive responses were reported in 6.4% of the 218 subjects exposed to the Ylang–Ylang oil test article, some of which were not captured by testing with the FM alone (Larsen et al., 2002). This report is a follow-up to an earlier report (Larsen et al., 1996) wherein Ylang–Ylang oil had also tested positive in significant numbers (17.4%) of the test subjects.

Itoh et al. (1988) report on human patch test results of a range of cosmetic ingredients, among them Ylang–Ylang absolute and Ylang–Ylang oil. When tested at a concentration of 5%, the absolute was reported to have caused eczema and dermatitis in 22/441 (~5%) subjects, compared with 2/58 (3.4%) such responses in the control population. Ylang–Ylang oil (5%) elicited eczema and dermatitis in 25/760 (3.3%) subjects, which was not different from the control group (4/115 subjects, 3.5%) (Itoh et al., 1988).

Imokawa and Kawai (1987) report on investigations intended to clarify the mechanisms of allergen-induced hyperpigmentation, with Ylang–Ylang oil being one of six allergens evaluated. The investigations were carried out using tortoise shell guinea pigs and a cumulative contact-enhancement test. This test involved repeated, 24-h, closed-patch, topical applications (four applications every third day over two weeks) of the test articles, plus an intradermal injection of Freund’s complete adjuvant. Ylang–Ylang oil was tested at 20% in ethanol. Challenge occurred 11 days after the last patch and involved three daily applications of 0.01 mL ethanol containing the test article to untreated areas of the backs of the animals. Reactions were followed for 43 days. Ylang–Ylang oil was among several substances found to induce an allergic response with a definite visible hyperpigmentation that appeared initially by 14 days and that reached a maximum at approximately 40 days. Dopa-positive melanocyte populations were significantly increased within the hyperpigmented areas on day 24 following allergic reactions, as assessed by biopsy. The authors concluded that allergic contact dermatitis is a unique melanogenic stimulant that is different from ultraviolet irradiation (Imokawa and Kawai, 1987).

Kenerva et al. (1995) describe a case report of a 37-year-old female cosmetic packer who developed dermatitis on her hands. Dermatological evaluation determined that she had been occupationally sensitized to Ylang–Ylang oil. The report does not state where the sensitization of the woman occurred, but the address of the authors is reported as Helsinki, Finland. The authors report that the incidence of Ylang–Ylang oil sensitization is rather high (up to 19.8% positive patch test results) in Japan, where the oil is widely used. The report also states that Ylang–Ylang oil is known to contain several allergens, with the main ones being “dihydrodi-isoeugenol” [*sic*] (cf. ‘dehydrodi-isoeugenol’ in (Toyoda et al., 1989), and derivatives of geraniol and linalool. The authors state that the frequency of allergy to Ylang–Ylang oil has decreased in recent years, which they attribute to removal of the “dihydrodi-isoeugenol” [*sic*] from the oil (Kenerva et al., 1995). A case report of occupational contact dermatitis in an aromatherapist (Cockayne and Gawkrödger, 1997) also suggests that a high (>20%) concentration of linolool [*sic*] in Ylang–Ylang essential oil may be the source of its sensitizing potency.

In a case report of a 28-year-old male metal grinder who developed an allergy to a cutting oil reodorant component, Ylang–Ylang oil (2% in petrolatum) is reported to have elicited a positive sensitization reaction in the patient during the dermatological evaluation (Mitchell and Beck, 1988). Ylang–Ylang oil was not a component of the cutting oil, but was tested as part of a “fragrance and flavours battery”.

Rudzki and Gryzwa (1986) report a human sensitization rate of 9.3% (8/86 patients) in response to Ylang–Ylang oil treatment. No further conditions of the testing were provided. In an earlier study (Rudzki and Grzywa, 1977), these same authors reported a 2% sensitization rate (9/450) in dermatitis patients when tested at a concentration of 2% in yellow soft paraffin. More recently, Rudzki and coworkers (Rudzki et al., 1993) published a case report of a 25-year old male working in cosmetics manufacturing who had tested positive to Ylang–Ylang oil (test conditions not stated) in addition to other related substances.

Patch testing with Ylang–Ylang oil (2% in petrolatum) indicated it to be the offending agent in a massage lotion that was the cause of occupational contact dermatitis in a 40-year-old female beautician (Romaguera and Vilaplana, 2000). The undiluted lotion did not elicit any sensitization responses following patch testing in twenty control subjects.

In the North American Contact Dermatitis Group patch test, from which results were gathered over the period from January 1, 2001 to December 31, 2002, 4913 patients were tested against 65 allergens. Patients ranged in age from 2 to 97 years and a range of occupations (including homemaker) was included. Patch testing was standardized for the study and used a Finn chamber which remained in place for 48 h. Test sites were evaluated initially at 48 to 72 h and again between 72 and 168 after placement. Diag-

noses included acute contact dermatitis (43.5%), irritant contact dermatitis (13.3%), other types of dermatitis (14.7%), other dermatoses (9.9%), photo dermatitis (1.1%), and psoriasis (2.7%). Sixty-nine percent of the patients exhibited a positive reaction to one or more of the test substances. Those substances with greater than an incidence of 10% within the test population were nickel sulfate (16.7% positives), neomycin (11.6%), balsam of Peru (11.6%), fragrance mix (10.4%), thimerosal (10.2%) and, sodium gold thiosulfate (10.5%). Ylang–Ylang (2% in petrolatum) ranked 47th with 1.1% of the test subjects exhibiting a positive response (Pratt et al., 2004).

Belsito et al. (2006) evaluated a total of 1603 patients (predominantly Caucasian (87.8%) and female (67.1%), between the ages of 1–88 years) with eczematous dermatitis who were undergoing a diagnostic patch test using the North American Contact Dermatitis Group screening tray and procedure. Positive reactions (delayed type hypersensitivity) were noted (from highest to lowest incidence), to *Myroxylon pereirae* (6.6% of patients), “fragrance mix” (5.9%), cinnamic aldehyde (1.7%), Ylang–Ylang oil (0.7%), jasmine absolute (0.4%), tea tree oil (0.3%), HMPCC (3- and 4-(4-hydroxy-4-methylpentyl)cyclohexane-1-carboxaldehyde) 5.0% concentration (0.4% of patients), HMPCC 1.5% (0.3%) and HMPCC 0.5% (0.2% of patients).

Simpson et al. (2004) sought to determine the prevalence of botanical extract allergy in a group of “high risk” patients, so called because these patients had been using botanical products and exhibited clinically evident allergic contact dermatitis, but not responding to patch testing with standard allergens. These 21 high risk patients and 119 member control group (patients referred for evaluation of allergic contact dermatitis, but a negative history of botanical extract use), were subjected to a standard panel of allergens, plus 47 allergens, including botanical extracts (including Ylang–Ylang). Finn chambers were used and two readings were performed at two and five or seven day time points post application. Within the high risk group, 2 of 21 were judged to have a positive reaction to Ylang–Ylang, but no responses were seen in the control group.

Ylang–Ylang oil was one of 234 chemical substances that were screened in the *Bacillus subtilis* spore Rec-assay during an evaluation of the assay’s potential to replace animal models as a means of detecting skin sensitizing agents (Watanabe, 1994). Results were compared with human maximization and patch test results from the literature. Ylang–Ylang oil was deemed a “non-allergic” substance according to the tentative classification scheme established (Watanabe, 1994).

From the above reports, it is clear that Ylang–Ylang oil has a reputation for being the cause of allergic skin reactions. It is not clear what individual chemical constituent(s) from the complex chemical mixture that makes up Ylang–Ylang essential oil are the primary offending agents in this regard, though dehydrodi-isoeugenol and linalool have

been suggested. None of the available reports from the literature speaks of any allergic response to Ylang–Ylang oil being attributed to exposure to it *via* intake from food ingestion, though Ylang–Ylang oil has been in use as a food flavoring agent for many years. While it is not unheard of for people to exhibit an immune response following oral exposure to an allergen for which sensitization to the allergen had occurred dermally, it is expected that estimated exposures to Ylang–Ylang oil from its use as a food flavoring agent are likely to be beneath the threshold for elicitation of any such immune responses.

2.3.4. Subchronic toxicity studies

Ylang–Ylang oil was tested as part of a general subchronic inhalation toxicity study of consumer product fragrance raw material (FRM) mixtures (Fukayama et al., 1999). In separate exposure groups, female CD rats (20/group) were exposed *via* whole body inhalation to Ylang–Ylang oil at up to 2.8 µg/m³ for six weeks and female Sprague–Dawley rats (24/group) were exposed to up to 75.2 µg/m³ for 13 weeks, in both cases as part of a complex FRM mixture. Paired control groups were exposed to filtered room air. Exposure chamber aerosol concentrations were monitored; aerosol particle sizes ranged from 0.5 to 7.5 µm. All surviving animals were subjected to terminal necropsy with evaluations of hematology, clinical chemistry, gross pathology, and histopathology. No significant toxicological effects were noted in response to any FRM mixture exposure, though no tabular data were provided in the report (Fukayama et al., 1999). The relevance of such concentrated inhalation exposures to risk assessment of human ingestions resulting from food flavoring use is uncertain, but likely very limited.

2.4. Observations in humans

Various subjective and objective physiological responses were assessed in 24 healthy human volunteers (12/treatment group) following a brief (20 min) inhalation exposure to Ylang–Ylang oil fragrance as compared to a water control (Hongratanaworakit and Buchbauer, 2004). The method and concentration of Ylang–Ylang oil (fraction II) inhalation exposure were not described, nor was the patient population any further characterized. Subjective assessments included alertness, attentiveness, calmness, mood, relaxation, and vigor; objective physiological measurements included skin temperature, pulse rate, breathing rate, and blood pressure. Statistically significant decreases in systolic blood pressure, diastolic BP, and heart rate were associated with Ylang–Ylang oil under the conditions of the assay; subjects also reported increased attentiveness and alertness (Hongratanaworakit and Buchbauer, 2004). These authors conducted a similar study published two years later only using transdermal application of 1 mL of a 20% (w/w) solution of Ylang–Ylang oil in sweet almond oil, applied to the lower abdomen, the controls received sweet almond oil alone. All subjects received

pure air through breathing masks. The subjects self-rated themselves and the authors reported that test subjects rated themselves calmer and more relaxed than was indicated by the subjects in the control group (Hongratanaworakit and Buchbauer, 2006).

A similar clinical investigation of Ylang–Ylang oil and other essential oils is reported by Ilmberger et al. (2001). Healthy human subjects (aged 16 to 67 years) were exposed *via* inhalation resulting from application of 10 μ L of Ylang–Ylang oil to a surgical mask that they were asked to put on. Control groups received only water. Immediately after putting on the mask, they were asked to fill out a questionnaire containing subjective assessments of pleasantness, intensity, effect, and relaxation. The motor response time of the subjects was then evaluated through an interactive computer keyboard program. The overall conclusion was that the effects of essential oils or their components on attentional behavior are mainly psychological (Ilmberger et al., 2001).

Very little can be discerned from these two study reports with regards to any hazard that inhaled Ylang–Ylang oil vapors may pose to humans. These reports are even less useful from a perspective of assessing the risk to humans posed by food flavoring use of Ylang–Ylang oil.

3. Discussion

Ylang–Ylang oil is used in the food industry as a flavor ingredient. It is approved as a food additive by FDA and has been determined to be GRAS by FEMA. It is a complex chemical mixture in the form of an essential oil extracted by water or water-and-steam distillation from the fresh flowers of *Cananga odorata* Hook. f. & Thomson. The chemical constituents that make-up Ylang–Ylang essential oil have only been imperfectly defined from a quantitative standpoint, but some reports do indicate methyl benzoate, 4-methylanisole, benzyl benzoate, linalool, and dehydrodi-isoeugenol to be present in significant amounts. Ylang–Ylang oil has been in public use since the 1880s.

Studies reported in the literature of the toxicity of Ylang–Ylang oil, as a whole, are very limited. Available reports indicate that the oil possesses a low order of acute oral and dermal toxicity. Ylang–Ylang oil has been reported to cause dermal sensitization reactions in animals and humans, but it is unclear what constituent(s) within the essential oil comprise the offending agent(s) and whether some Ylang–Ylang oils that have had certain constituent(s) removed are any less prone to cause such allergic reactions. There is no indication in the literature that food exposure to Ylang–Ylang oil has caused allergic reactions. One sub-chronic inhalation toxicity study, involving Ylang–Ylang oil as part of a larger fragrance raw materials mixture, gave no indication of causing adverse effects, but the relevance to risk assessment of oral food flavoring use exposures is likely minimal. No further toxicity data for Ylang–Ylang oil have been reported.

Existing published data are insufficient to establish a tolerable intake for ingestion of Ylang–Ylang oil by humans. However, data and information that are available indicate Ylang–Ylang oil has a long history of fragrance and food flavoring use, with no indication that its estimated consumption from food flavoring use (0.0001 mg/kg/day) has led to any adverse human health effects. These data indicate that at the current level of intake as a food ingredient, Ylang–Ylang oil does not pose a health risk to humans.

4. Conclusion

In summary, based on the data presented above, consumption of Ylang–Ylang oil as an added food ingredient is safe at present use levels.

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