

Identification of Character Impact Odorants of Different Soybean Lecithins

Andreas Stephan* and Hans Steinhart

Institute of Biochemistry and Food Chemistry, University of Hamburg, Grindelallee 117,
D-20146 Hamburg, Germany

The potent odorants of standardized, enzymatically hydrolyzed, and deoiled soybean lecithins were characterized systematically by combined gas chromatography/mass spectrometry and olfactometry. Sixty-one odorants were identified; 53 of these odor-active compounds have not previously been reported as odorants of soybean lecithin flavor. By aroma extract dilution analysis and modified combined hedonic and response measurement the following odorants showed the highest flavor dilution factors and CHARM values: (*E,E*)-2,4-decadienal (deep-fried), (*E*)- β -damascenone (apple-like), 2,3-diethyl-5-methylpyrazine (roasty, earthy), (*E*)-2-nonenal (cardboard-like), *trans*-4,5-epoxy-(*E*)-2-decenal (metallic), 1-nonen-3-one (mushroom-like), 2-ethyl-3,5-dimethylpyrazine (roasty, earthy), and 1-octen-3-one (mushroom-like). Enzymatic hydrolysis intensified especially the roasty sensation of 2,3-diethyl-5-methylpyrazine, whereas deoiling effected a general significant decrease in olfactory perception on the nitrogen-containing compounds. In addition, sensory profiles of nasal and retronasal lecithin odor were performed.

Keywords: Soybean lecithin; AEDA; CHARM; aroma; flavor; phospholipid; odorant

INTRODUCTION

Soybean lecithins have a wide applicability because of their positive technological possibilities. Due to their emulsifying capacity and water dispersibility, especially hydrolyzed lecithins (lysolecithins) are proven to be a more than suitable alternative to synthetic polar emulsifiers. They are used as stabilizers and emulsifiers in food, for example, in shortenings, instant products, mayonnaise, ice cream, coffee whitener, or low-fat products. Lysolecithins show particular advantages compared to the usual additives in bakery products because of their interactions with amylose. These interactions improve elasticity, volume, and pores, thereby decelerating the aging process of the bakery products (Schneider, 1997; Nieuwenhuysen, 1981). However, this applicability is restricted by an off-flavor formation caused by autoxidation of unsaturated fatty acids, contributing to the aroma of soybean oil, and by a series of reactions of nitrogen-containing organic phospholipid residues (Sessa, 1985). In contrast to soybean oil (Pinnel and Vandegans, 1996; Lee et al., 1995; Guth and Grosch, 1989, 1990a,b; Ullrich and Grosch, 1988; Smouse and Chang, 1967), little is known about the aroma/off-flavor-causing compounds and their concentrations in commercial crude soybean lecithins (Kim et al., 1984) and modified lecithin products. Therefore, neither the influence of lecithin addition on the aroma of food nor the changes in lecithin aroma resulting from hydrolysis and deoiling could be realized, despite the fact that an improvement of the aroma through rational experiments could be obtained.

The aims of the following investigations were to develop a standardized description of sensory qualities

of lecithins, to identify the odorants in different treated soybean lecithins, and to characterize the most odor-active compounds by the two different gas chromatography/olfactometry (GC/O) techniques aroma extract dilution analysis (AEDA) and modified combined hedonic and response measurement (CHARM).

MATERIALS AND METHODS

Lecithins. Standardized, hydrolyzed, and deoiled soybean lecithins and hydrolyzed soybean lecithins were purchased from Lucas Meyer Co., Ltd. (Hamburg, Germany). Standardized lecithin (A) had a defined content of phosphatidylcholine, and >60% acetone insoluble, enzymatically hydrolyzed lecithin (B) (phospholipase A₂) had a grade of hydrolysis of ~40%; oil-free lecithin (C) was the acetone-deoiled version of lecithin B.

Chemicals. Diethyl ether, sodium carbonate, sodium chloride, hydrochloric acid, and compounds **1–3**, **5**, **6**, **8–10**, **16**, **19**, **30**, **37**, **42**, **53**, **54**, and **59** (Table 1) were obtained from Merck (Darmstadt, Germany), compounds **7**, **11**, **12**, **20**, **28**, **29**, **39–41**, **43**, **47**, **55–58**, **60**, and **61** from Aldrich (Steinheim, Germany), compounds **4**, **21**, **24**, **25**, and **32** from ACROS (Gelnhausen, Germany), compounds **14**, **22**, **34**, **35**, **38**, and **52** from ABCR (Karlsruhe, Germany), compounds **15** and **23** from Lancaster (Mühlheim, Germany), and compounds **27**, **48**, and **51** from Roth (Karlsruhe, Germany). Compounds **13**, **18**, **46**, and **50** were gifts from the Deutsche Forschungsanstalt für Lebensmittelchemie (Garching, Germany), compound **26** was a gift from Nestec Ltd. (Lausanne, Switzerland), and compound **49** was a gift from Firmenich (Geneva, Switzerland).

Isolation of the Volatile Compounds. The volatiles were distilled off from 25 g of soybean lecithin (dissolved in 100 mL of diethyl ether) in the apparatus shown in Figure 1 under the following conditions: pressure, 1×10^{-4} mbar; temperature, 40 °C; feeding rate, 40 mL/h; falling film glass tubing, 25 cm \times 35 mm; total distillation time, 3.5 h. The volatile fraction was condensed in three cooling traps, cooled by liquid nitrogen. The combined condensates were extracted with 3 \times 50 mL of aqueous sodium carbonate (0.5 mol/L), and subsequently the diethyl ether fraction was washed with 3 \times 15 mL of saturated sodium chloride solution and dried through

* Author to whom correspondence should be addressed (telephone +49-40-42838 4348; fax +49-40-42838 4342; e-mail fc6a080@chemie.chemie.uni-hamburg.de).

Table 1. Odorants of Standardized, Hydrolyzed, and Oil-Free Commercial Soybean Lecithin

no. ^a	odorant	odor ^b	RI ^c on		reported as volatile compound ^d
			BGB-1701	FFAP	
1	methylpropanal ^e	malty, biting	634	<900	
2	2,3-butanedione ^e	buttery	665	987	
3	3-methylbutanal ^e	malty, strawy	729	929	
4	2-methylbutanal ^e	strawy	734	935	
5	2,3-pentanedione ^e	buttery	775	1076	1
6	dimethyl disulfide ^e	cabbage-like	809	1104	
7	hexanal ^e	green	876	1106	1
8	4-methyl-3-penten-2-one ^e	almond-like	879	1159	1
9	methylpyrazine ^e	nutty	905	1297	
10	heptanal ^e	fatty, tallowy	979	1208	
11	(Z)-4-heptenal ^e	fishy	985	1267	
12	diethyl disulfide ^e	sulfury	989	1246	
13	2-acetyl-1-pyrroline ^f	popcorn-like	1012	1371	
14	pentylfuran ^e	beany	1023	1251	1
15	1-octen-3-one ^e	mushroom-like	1063	1327	
16	1-octen-3-ol ^e	mushroom-like	1068	1459	1
17	2-ethyl-5-methylpyrazine ^g	toffee	1077		
18	(Z)-1,5-octadien-3-one ^f	geranium-like	1080	1406	
19	benzaldehyde ^e	marzipan-like	1083	1583	
20	octanal ^e	orange-like, fatty	1086	1314	
21	acetylpyrazine ^e	popcorn-like	1139	1686	
22	3-octen-2-one ^e	nutty, fruity	1141	1440	1
23	2-isopropyl-3-methoxypyrazine ^f	earthy, pea-like	1147	1461	
24	3-ethyl-2,5-dimethylpyrazine ^e	roasty, earthy	1150	1477	
25	2-ethyl-3,5-dimethylpyrazine ^e	roasty, earthy	1157	1494	
26	1-nonen-3-one ^f	mushroom-like	1165	1432	
27	1-nonen-3-ol ^e	mushroom-like	1167	1561	
28	(E)-2-octenal ^e	fatty, nutty	1168	1467	
29	2-phenylethanol ^e	honey-like	1179	1704	
30	nonanal ^e	tallowy, fruity	1187	1420	
31	(Z)-3-nonenal ^g	cucumber-like	1190	1517	
32	2,3-diethyl-5-methylpyrazine ^e	roasty, earthy	1219	1524	
33	3,5-diethyl-2-methylpyrazine ^g	roasty, earthy	1223		
34	2-isobutyl-3-methoxypyrazine ^f	pepper-like	1240	1558	
35	3-nonen-2-one ^e	nutty, fruity	1245	1547	1
36	(Z)-2-nonenal ^f	fatty	1254	1524	
37	2-phenylethanol ^e	honey-like	1269	1978	
38	(E)-2-nonenal ^e	cardboard-like	1273	1575	
39	(E,Z)-2,6-nonadienal ^e	cucumber-like	1275	1629	
40	(E,Z)-2,6-nonadienol ^e	cucumber-like	1276	1794	
41	pentylpyridine ^e	strawy, tallowy	1279	1609	
42	3,5,5-trimethyl-2-cyclohexen-1-one ^e	nutty	1285	1661	1
43	(E,E)-2,4-nonadienal ^e	fatty	1348	1753	
44	3-methyl-2,4-nonandione ^e	strawy, fruity	1393	1764	
45	(E,Z)-2,4-decadienal ^g	deep-fried	1426	1792	
46	trans-4,5-epoxy-(E)-2-nonenal ^f	metallic	1451	1939	
47	(E,E)-2,4-decadienal ^e	deep-fried	1453	1864	
48	γ-octalactone ^e	coconut-like	1473	2000	
49	(E)-β-damascenone ^e	baked apple-like	1511	1880	
50	trans-4,5-epoxy-(E)-2-decenal ^f	metallic	1553	2061	
51	γ-nonolactone ^e	coconut-like	1586	2116	
52	γ-decalactone ^e	peach-like	1698	2231	
53	acetic acid ^e	vinegar-like		1468	
54	propanoic acid ^e	pungent		1554	
55	butanoic acid ^e	sweaty, rancid		1646	
56	3-methylbutanoic acid ^e	sweaty		1687	
57	2-methylbutanoic acid ^e	sweaty, sweet		1687	
58	pentanoic acid ^e	sweaty		1757	
59	(E)-2-butenic acid ^e	biting		1803	
60	hexanoic acid ^e	goat-like, sweaty		1867	
61	3-hydroxy-4,5-dimethyl-2(5H)-furanone ^f	seasoning-like		2205	

^a Odorants 1–52 identified in the neutral fraction, odorants 53–61 in the acidic fraction. ^b Retention indices according to Van den Dool and Kratz (1963). ^c Odor description at the GC-sniffing port. ^d Reported in the literature as volatile compound in deoiled commercial soybean lecithin. (1) Kim et al. (1984). ^e Compound identified by comparison with the reference substance on the basis of the following criteria: retention index (RI) on the capillary columns given in the table, mass spectra obtained by MS (EI), and odor quality perceived at the sniffing port. ^f Mass spectra too weak for an unequivocal interpretation. Compound identified on the basis of the remaining criteria in footnote e. ^g Compound identified by comparison with data from the library of mass spectra.

a hydrophobic filter (Schleicher & Schuell, Einbeck, Germany) (neutral/basic aroma extract).

The combined aqueous phases were adjusted to pH 2.0 with hydrochloric acid, extracted with 3 × 40 mL of diethyl ether, and dried through a hydrophobic filter (acidic aroma extract).

Finally, both aroma extracts (neutral/basic and acidic) were concentrated to 0.2 mL on a Vigreux column (40 × 1 cm) and by microdistillation.

High-Resolution Gas Chromatography (HRGC)/Mass Spectrometry (MS). HRGC/MS was performed with a

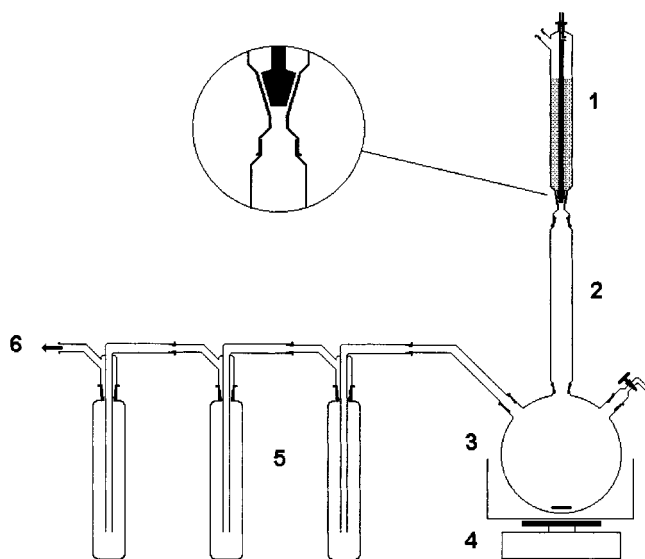


Figure 1. Apparatus for the isolation of the volatiles from soybean lecithin: (1) 100 mL dosing funnel with internal grinding; (2) falling film glass tubing; (3) three-neck flask; (4) water bath with magnetic stirrer; (5) three cooling traps; (6) vacuum pump.

Hewlett-Packard Model 5890 Series II gas chromatograph coupled with an HP 5971 A mass spectrometer run in the electron impact mode at 70 eV. The following capillaries were used: BGB-FFAP (polyethylene glycol, esterified with terephthalic acid) and BGB-1701 (14% cyanopropylphenylpolysiloxane) (each 60 m \times 0.25 mm, 0.5 μ m film thickness; BGB-Analytik, Adliswil, Switzerland). One microliter of the concentrated extracts was injected into a CIS 3 cold injection system (Gerstel, Mülheim, Germany) with nitrogen cooling. The injection temperature was -50 $^{\circ}$ C with a splitless time of 0.7 min; the temperature was then raised at 12 $^{\circ}$ C/s to 250 $^{\circ}$ C. Subsequently, two temperature programs were used: The initial oven temperature of 50 $^{\circ}$ C was held for 3 min, then raised at 5 $^{\circ}$ C/min up to 230 $^{\circ}$ C, and held for 15 min (FFAP column); the initial oven temperature of 40 $^{\circ}$ C was held for 3 min, raised at 5 $^{\circ}$ C/min to 220 $^{\circ}$ C, then raised at 20 $^{\circ}$ C/min to 280 $^{\circ}$ C, and held for 15 min (1701 column).

GC/O. The capillary columns were connected to a splitter (Graphpack-3D/2, Gerstel, Mülheim, Germany), and the effluent was split 3:1 into two uncoated deactivated restriction capillaries (50 cm \times 0.1 mm and 40 cm \times 0.1 mm) leading to the MS detector (280 $^{\circ}$ C) and to the sniff detector (250 $^{\circ}$ C, humidified, makeup gas nitrogen, Gerstel).

Potent odorants occurring in the solvent extracts of soybean lecithins were perceived at the sniffing port by the following sensory methods: AEDA (Ullrich and Grosch, 1987; Holscher and Steinhart, 1992; Grosch, 1994) and modified CHARM (Acree et al., 1984; Schlüter et al., 1996; Pollien et al., 1997).

AEDA was performed by two trained and experienced sniffers. A maximum of four dilutions of the stepwise-diluted extracts (addition of diethyl ether to the extract at a ratio of 1:1, v/v) were sniffed on a single day by each subject to avoid fatigue effects. In addition, the diluted extracts were sniffed in disorder to avoid acclimatization and expectation effects.

Modified CHARM was performed by eight trained and experienced sniffers. The original extracts were diluted stepwise with diethyl ether 1:10, 1:100, and 1:1000 (v/v). Compared with AEDA, modified CHARM regarded apart from the dilution also the number of assessors who described the olfactory perception correctly and the intensity/durability of the olfactory perception.

Sensory Profiles. The sensory profiles of the lecithins were performed by 20 experienced sensory assessors. The criteria odor and taste were analyzed by determination of the intensity on a six-point scale between 0 (no taste) and 5 (very strong taste) of the attributes shown in Figures 2 and 3. The profiles

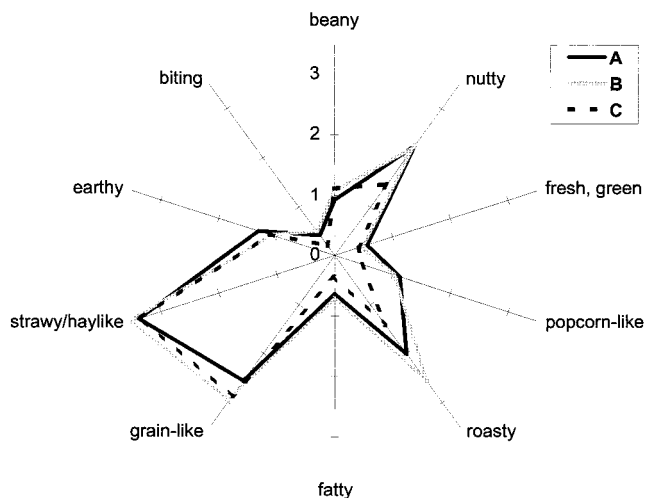


Figure 2. Odor profiles of standardized lecithin (A), enzymatic hydrolyzed lecithin (B), and deoiled enzymatic hydrolyzed lecithin (C).

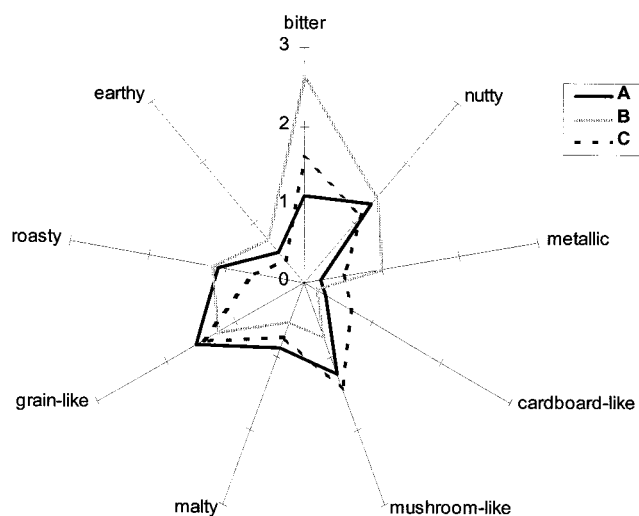


Figure 3. Taste profiles of 1% solutions of standardized lecithin (A), enzymatic hydrolyzed lecithin (B), and deoiled enzymatic hydrolyzed lecithin (C) in UHT milk with 3.5% fat content.

of odor were examined on the origin sample, and the profiles of taste were studied as solutions of 1:100 (v/v) in ultrahigh temperature milk (UHT milk) with a fat content of 3.5%. The taste was studied in solution because of the viscous, sticky consistency and the strong bitter taste, especially of hydrolyzed lecithins. The milk medium was used because of its ability to disperse and/or emulsify all of the different investigated lecithins. The interactions between lecithin and milk protein were accepted and desired. UHT milk was examined in the same way as the lecithins by providing sensory profiles. In the taste profiles, shown in Figure 3, the UHT milk intensities of the sensory attributes were subtracted from the total intensities of the lecithin solutions.

RESULTS AND DISCUSSION

Sensory Profiles. To date, there have been neither studies to describe objectively the flavor of soy lecithins in a sensory analytical way nor analytical chemical investigations to find out the causes of their odor. To elucidate the odor of soy lecithins and their off-odor problems in some applications, it was necessary to record first their nasal and retronasal olfactory. The odor and taste (including retronasal odor) profiles of the lecithins were determined by the general perceptions

Table 2. Potent Odorants (FD > 8; CHARM > 10) of Standardized (A), Hydrolyzed (B), and Oil-Free (C) Commercial Soybean Lecithin

no. ^a	odorant	odor ^b	FD factor ^c			CHARM value ^d		
			A	B	C	A	B	C
45	(<i>E,E</i>)-2,4-decadienal	deep-fried	2048	1024	1024	736	1592	1159
49	(<i>E</i>)- β -damascenone	baked apple-like	1024	4096	128	1481	6305	419
32	2,3-diethyl-5-methylpyrazine	roasty, earthy	1024	4096	64	4032	7934	178
38	(<i>E</i>)-2-nonenal	cardboard-like	1024	1024	2048	360	870	907
50	<i>trans</i> -4,5-epoxy-(<i>E</i>)-2-decenal	metallic	1024	1024	512	701	907	649
26	1-nonen-3-one	mushroom-like	1024	1024	512	32	117	123
25	2-ethyl-3,5-dimethylpyrazine	roasty, earthy	1024	1024	16	1564	1778	28
15	1-octen-3-one	mushroom-like	512	256	1024	637	753	1212
44	3-methyl-2,4-nonandione	strawy, fruity	512	256	256	100	96	113
41	pentylpyridine	strawy, tallowy	256	128	16	56	40	12
53	acetic acid	vinegar-like	128	128	64	196	186	101
43	(<i>E,E</i>)-2,4-nonadienal	fatty	128	128	64	10	13	10
18	(<i>Z</i>)-1,5-octadien-3-one	geranium-like	128	64	64	123	105	125
55	butanoic acid	sweaty, rancid	128	64	32	254	85	67
21	acetylpyrazine	popcorn-like	128	32	<1	79	58	<3
56/57	2-/3-methylbutanoic acid ^e	sweaty, sweet	64	64	32	30	137	98
20	octanal	orange-like, fatty	64	64	32	12	10	15
34	2-isobutyl-3-methoxy-pyrazine	pepper-like	64	64	16	28	42	12
39/40	(<i>E,Z</i>)-2,6-nonadienal/-ol ^e	cucumber-like	64	32	64	25	36	14
24	3-ethyl-2,5-dimethylpyrazine	roasty, earthy	64	32	2	8	10	<3
12	diethyl disulfide	sulfury	64	16	32	64	35	51
61	3-hydroxy-4,5-dimethyl-2(5 <i>H</i>)-furanone	seasoning-like	64	16	16	137	17	11
30	nonanal	tallowy, fruity	64	16	16	19	11	9
51	γ -nonalactone	coconut-like	32	128	16	69	326	35
48	γ -octalactone	coconut-like	32	128	16	41	142	18
7	hexanal	green	32	32	64	42	25	61
23	2-isopropyl-3-methoxy-pyrazine	earthy, pea-like	32	32	8	28	45	7
36	(<i>Z</i>)-2-nonenal	fatty	32	32	4	66	23	<3
13	2-acetyl-1-pyrroline	popcorn-like	32	32	4	48	66	<3
4	2-methylbutanal	strawy	32	32	4	40	59	7
1	methylpropanal	malty, pungent	32	32	4	15	21	5
46	<i>trans</i> -4,5-epoxy-(<i>E</i>)-2-nonenal	metallic	32	16	4	<3	<3	<3
37	2-phenylethanol	honey-like	32	16	<1	49	40	<3
31	(<i>Z</i>)-3-nonenal	cucumber-like	32	8	1	10	4	<3
11	(<i>Z</i>)-4-heptenal	fishy	32	1	16	54	<3	21
59	(<i>E</i>)-2-butenoic acid	biting	16	16	16	30	20	33
58	pentanoic acid	sweaty	16	16	8	12	32	15
3	3-methylbutanal	malty, strawy	16	8	8	9	11	11

^a Continuous numbers of odorants according to Table 1. ^b Odor description at the GC-sniffing port. ^c Flavor dilution (FD) factors of the neutral fraction determined on BGB-1701, of the acidic fraction on BGB-FFAP. ^d CHARM values of the neutral fraction determined on BGB-1701, of the acidic fraction on BGB-FFAP. ^e Compounds have the same RI on the column used for sniffing. Olfactory sensation measured as total perception of both odorants.

of the sensory panel and are shown in Figures 2 and 3. In addition to the known attributes beany and hay-like (Kim et al., 1984; Sessa, 1985), the following attributes have proved useful for the objective description of soy lecithin odor (Figure 2): strawy, grain-like, roasty, nutty, and earthy. Attributes with the highest intensity of the retronasal sensations are, apart from the nasal sensations grain-like, roasty, nutty, and earthy, the attributes cardboard-like, malty, mushroom-like, and metallic (Figure 3).

The sensory profiles enable, on the one hand, a preview of which functional classes of substances are possibly responsible for the characteristic attributes of the odor and, on the other hand, a direct sensory comparison of flavor impressions between different lecithins.

The differences in the odor profiles (Figure 2) of the investigated lecithins are based essentially on the olfactory attributes roasty and nutty. The roasty and grain-like sensations increase through enzymatic hydrolysis, whereas roasty, nutty, and popcorn-like sensations decrease through the process of acetone deoiling. The taste profiles (Figure 3) are characterized mainly by the bitterness of nonvolatiles in hydrolyzed lecithins. Furthermore, the retronasal sensations metallic, roasty,

and earthy increase through hydrolysis, whereas the attributes mushroom-like and malty decrease. Acetone deoiling lessens the retronasal attributes of metallic, nutty, roasty, and earthy and intensifies mushroom-like and cardboard-like taste.

Isolation Technique. The apparatus for the isolation of the volatiles from soybean lecithins (Figure 1) is constructed similar to that of Guth and Grosch (1989). Because of the extremely viscous and sticky consistency, lecithin isolation requires two fundamental modifications: a dosing funnel with an internal grinding and a falling film glass tubing. The internal grinding of the funnel prevents clogging of the dosing system and guarantees that no lecithin plug is formed. The falling film glass tubing encourages an increase of the surface of the lecithin, which is necessary for a high release of odorants.

GC/O. The volatile fractions isolated from standardized (A), hydrolyzed (B), and deoiled hydrolyzed (C) lecithins were screened for potent odorants by AEDA and modified CHARM. Table 1 shows an overview of the 61 odorants that were perceived at the sniffing port and also identified as described in the footnotes of Table 1. Fifty-three of the 61 odorants identified in the present

work had not been reported previously in different treated commercial soybean lecithins.

The odorants are distributed in the following classes of substances: 20 aldehydes, 11 ketones, 11 nitrogen compounds, 8 acids, 4 alcohols, 3 lactones, 2 sulfur compounds, and 2 furans.

In previous studies Kim et al. (1984) found only two aldehydes to be present in deoiled lecithins. Jewel and Nawar (1980) explained the absence of aldehydes in phospholipids by spontaneous reaction of aldehydes with the basic amino function of phospholipids, especially of ethanolamine. This thesis is not correct for the commercial lecithins under investigation. On the contrary, there are a high number of aldehydes in these lecithins; moreover, (*E,E*)-2,4-decadienal (**47**) and (*E*)-2-nonenal (**38**) have the highest FD factors and CHARM values (Table 2).

On the basis of both olfactory methods, AEDA and modified CHARM, a preliminary selection of important odorants of lecithins was carried out. The compounds 2,3-diethyl-5-methylpyrazine (**32**) and (*E*)- β -damascenone (**49**) are, on the basis of the FD factors and CHARM values, important odorants, especially in hydrolyzed lecithins. Furthermore, the ketones 1-octen-3-one (**15**), 1-nonen-3-one (**26**), and 3-methyl-2,4-nonanedione (**44**), the aldehydes (*E,E*)-2,4-decadienal (**47**), (*E*)-2-nonenal (**38**), and *trans*-4,5-epoxy-(*E*)-2-decenal (**50**), and the pyrazine 2-ethyl-3,5-dimethylpyrazine (**25**) have FD factors ≥ 1024 and CHARM values > 500 . In contrast to stored soybean oil, in which 3-methyl-2,4-nonanedione (**44**) is a beany, grassy-smelling character impact compound formed during flavor reversion (Guth and Grosch, 1989, 1990a,b), in soybean lecithins odorant **44** is only one of a multiplicity of odorants that are responsible for the general lecithin aroma.

The results of AEDA and modified CHARM analysis are in good correlation; for example, the odorants **32**, **49**, **15**, **47**, **38**, **50**, and **25** are nearly equally important when the results of both methods are compared. The odorants **26** and **44** have a lower importance in CHARM analysis than in AEDA on the level of the CHARM values of (*Z*)-1,5-octadien-3-one (**18**), acetic acid (**53**), and butanoic acid (**55**). However, the sensory characterization with both olfactory methods offers the possibility of recording the important odorants of soybean lecithin. Modified CHARM analysis offers the measurement of the dilution value combined with the number of assessors who recognize the olfactory perception and the entire elution time of the compound, whereas AEDA determines simply the maximum dilution value.

Due to the process of enzymatic hydrolysis there is—on the basis of both olfactory methods used—only an increase of the potent odorants **32**, **49**, **48**, and **51** and a decrease of compounds **11** and **31**. These changes are slight, so that only minor differences in odorant concentrations are expected. This conclusion correlates with the results of the odor profiles of the investigated standardized and hydrolyzed lecithins. Acetone deoiling mainly effects a high decrease of the nitrogen-containing compounds **21**, **24**, **25**, **32**, and **41** with predominantly roasty odor.

CONCLUSION

This study has revealed the potent odorants that are responsible for the aroma of different treated soybean lecithins. The olfactory methods AEDA and modified CHARM indicated the different importance of the 61

identified odorants and their various intensities in standardized, hydrolyzed, and deoiled lecithins. Through the established sensory profiles with their characteristic nasal and retronasal descriptions of potent lecithin criterion attributes it was possible to trace back systematically different perceptions of lecithin flavor to particular odor-active compounds. The roasty perception was mainly caused by 2,3-diethyl-5-methylpyrazine (**32**) and 2-ethyl-3,5-dimethylpyrazine (**25**). This perception is intensified through hydrolysis, whereas the processes of deoiling lessen the roasty odor. To substantiate the results of both olfactory analyses, the quantification and the determination of odor-active values of the odorants identified in this study will be very useful.

ACKNOWLEDGMENT

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