THE SOLUBILITY OF GASES IN EDIBLE FATS AND OILS

By FRANK C. VIBRANS

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The literature dealing with the solubility of the common gases in edible fats and oils is very limited. Lewkowitch[1] states that "carbonic acid dissolves to some extent in oils, especially under pressure. At atmospheric pressure the gas escapes with effervescence." The preparation of effervescent oils has been patented[2] and effervescent cod liver oil is supposed to be more palatable than the other cod liver oil produced for medicinal use. Ubbelohde and Svanoe[3] in an article on the hydrogenation of oils give the solubility of hydrogen in cottonseed oil at high temperature. Beyond this no references were found dealing with the solubility of gases in fats and oils. Since there is very little published information on this subject it seemed desirable that data obtained for own use should be expanded and made available for other workers in the fat field.

Data were obtained on cottonseed oil (salad oil), corn oil (salad oil), partially hydrogenated cottonseed oil shortening, and steam rendered lard made from a mixture of killing and cutting fats. All the samples were bought on the market and are representative of their class.

Solubility of Gases in Corn Oil (Salad Oil)

	At Room Temperature (23-26° C.):		At 45° C.
Air			
	7.28 cc. in 100 cc. of oil		6.98 cc. in 100 cc. of oil
	7.38		7.14
	7.30		
Average......	7.32 cc.	Average......	7.06 cc.
Oxygen			
	11.30 cc. in 100 cc. of oil		10.90 cc. in 100 cc. of oil
	11.24		11.08
	11.08		10.80
Average......	11.21 cc.	Average......	11.93 cc.
Nitrogen			
	6.38 cc. in 100 cc. of oil		6.38 cc. in 100 cc. of oil
	6.23		6.26
	6.32		6.26
			6.35
			6.40
Average......	6.31 cc.	Average......	6.33 cc.
Hydrogen			
	4.10 cc. in 100 cc. of oil		4.46 cc. in 100 cc. of oil
	4.04		4.46
	4.08		4.42
	4.10		4.45
Average......	4.08 cc.	Average.....	4.44 cc.

Solubility of Gases in Cottonseed Oil (Salad Oil)

	At Room Temperature (23-26° C.):		At 45° C.
Air			
	7.18 cc. in 100 cc. of fat		7.12 cc. in 100 cc. of fat
	7.12		6.93
	7.23		
	7.24		
	7.22		
Average......	7.20 cc.	Average.....	7.02 cc.
Oxygen			
	11.1 cc.		10.73
	11.0		10.80
Average......	11.05 cc.	Average.....	10.77 cc.
Nitrogen			
	6.06 cc.		6.06 cc.
	6.20		6.22
Average......	6.13 cc.	Average.....	6.14 cc.
Hydrogen			
	4.12 cc.		4.28 cc.
	4.32		4.22
			4.28
			4.38
Average......	4.22 cc.	Average......	4.29 cc.
Carbon Dioxide			
	140.0 cc.		105.8 cc.
	130.5		101.7
	133.0		98.9
	130.8		97.5
	135.9		101.1
			102.2
Average.......	134.0 cc.	Average.......	101.2 cc.

The gases used were: oxygen, nitrogen, hydrogen and carbon dioxide. The oxygen, nitrogen, hydrogen and carbon dioxide were bought in cylinders and used without purification.

The samples were prepared for analysis as follows: About 30 cc. of the melted fat or oil were put into a small separatory funnel and attached to the supply of gas with which the oil was to be saturated. A vacuum was produced in the separatory funnel with a Cenco-Hyvac pump for 4 or 5 minutes. During this interval the separatory funnel was shaken almost continuously to facilitate the removal of dissolved gases. Then by adjusting the stopcock a small amount of gas was bubbled through the oil while the vacuum was maintained on it. This washing process was continued for 10 or 15 minutes before the vacuum was broken. After the vacuum was broken the oil was saturated with gas by shaking the oil and gas together for 5 minutes and then bubbling the gas through it for at least 2 hours before a solubility determination was made. This procedure was assumed to completely free the oil of foreign gases and saturate it with the gas under consideration.

The Determination of Gas Dissolved in Oil

Having prepared a sample of oil saturated with gas we then determined the percentage of gas dissolved in it by shaking a known volume of oil in vacuum and measuring the quantity of gas liberated. For this purpose we used the manometric method developed by Van Slyke and his co-workers for the determination of carbon dioxide combining power, oxygen, carbon monoxide, and nitrogen in blood by measuring their respective partial pressure at arbitrary volume.[4&5] The manometric method is more accurate than the volume method since in the latter the errors in reading small volumes are from 10-100 times as great as the errors in reading barometric pressure. The manometric principle allows the gases to be expanded to a large volume and errors in the two variables, pressure and volume, are thus more nearly equalized.

The apparatus consists of a reaction chamber, mechanically shaken, a calibrated mercury barometer connected directly to the reaction chamber, a mercury leveling bulb, and the necessary stopcocks. To make the determination, a sample of oil saturated with gas is measured directly into the reaction chamber with a rubber tipped Ostwald pipette. A vacuum is produced by lowering the mercury leveling bulb and then the oil is shaken for about 5 minutes. The gas liberated is measured by reading the pressure exerted by it when its volume is set arbitrarily at 2 cc. in the reaction chamber. After the reading is made the gas is expelled from the apparatus, a vacuum is again produced and the operation repeated. This repetition is continued until there is no change in pressure on two consecutive readings. From these readings the total volume of gas liberated from the oil is calculated. This calculation can be easiest illustrated by taking a set of original data. A 5 cc. sample of corn oil when shaken in vacuum liberated air which when measured at 2cc. volume gave the following pressure readings. These consecutive pressure readings are represented by P_1, P_2, P_3, P_4, etc.

	mm.at 23° C.
P_1	191.0
P_2	98.2
P_3	76.9
P_4	75.7
P_5	73.0
P_6	73.0

Subtracting P_6 from each of the other pressure readings we have:

118.0 mm
25.2
3.9
2.7

149.8 mm

The total air liberated from 5cc. of oil equals 2 cc. measured at 149.8 mm. This is reduced to 0° C. and 760 mm. Hg as follows:

$$\text{Vol. at } 0^\circ \text{ C. and 760 mm. Hg.} = 2 \times \frac{149.8}{760} \times \frac{273}{296} = 0.364 \text{ cc. or 7.28 cc. per 100 cc. of oil.}$$

Following the procedure regularly used in determinations of this type a drop of caprylic alcohol was added to the reaction chamber to prevent an emulsion from being formed and to keep the mercury from breaking up into little globules.

To eliminate the possibility of error due to the different amounts of moisture that might be present in the samples of fat and oils used, 2 cc. of water were added to the reaction chamber and kept there throughout the period of this investigation. Then since all readings were made in the presence of water no correction for water vapor was necessary.

In order to make determinations on hydrogenated shortening and lard, both of which are solid at room temperature, 12 cc. of air free toluene were added to the reaction chamber for each determination. This dissolved the fat and no stearine separated.

In determining the solubility of gases in fats and oils at 45° C. a temperature at which both the hydrogenated shortening and lard were liquid, the fat or oil was saturated with the gas in an air oven set at 45° ± 2°. The pipette with which the oil was to be measured was also put in the oven and when used for measuring a sample of fat the operation was carried out as quickly as possible. Once the sample of fat was transferred to the reaction chamber of the Van Slyke apparatus the remainder of the determination was carried out at room temperature. The first gas reading was not made until the apparatus had had time to come to constant temperature after the warm sample had been added to it.

Using this technique we obtained the following data shown on these pages.

	Solubility of Gases in Hydrogenated Cottonseed Oil Shortening at 45° C.	Solubility of Gases in Lard at 45° C.
Air		
	7.20 cc.	7.22 cc.
	7.36	7.13
	Average...... 7.28 cc.	Average...... 7.17 cc.
Oxygen		
	11.36 cc.	11.32 cc.
	11.08	10.78
	11.12	11.14
	11.28	11.44
	Average...... 11.21 cc.	Average..... 11.17 cc.
Nitrogen		
	6.60 cc.	6.23 cc.
	6.62	6.22
	6.76	
	6.84	Average...... 6.22 cc.
	Average...... 6.70 cc.	
Hydrogen		
	4.24 cc.	4.16 cc.
	4.36	4.24
		4.26
	Average...... 4.30 cc.	4 43
		Average...... 4.27 cc.
Carbon Dioxide		
		100.4 cc.
		101.0
		102.8
		100.4
		102.6
		Average.......101.4 cc.

Tabulating the average of the above determinations, we have:

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		CC. of Gas (Calculated to 0° C. and 760 MM. Hg.) That Dissolved in 100 CC. of Fat or Oil				
Fat or Oil	Temperature C.	Air	Oxygen	Nitrogen	Hydrogen	CO_2
Corn oil (salad oil)....	Room (23-26°)	7.3	11.2	6.3	4.1	...
Corn oil (salad oil)....	45° ± 2°	7.1	10.9	6.3	4.4	...
CSO oil (salad oil)....	Room (23-26°)	7.2	11.1	6.1	4.2	134.
CSO oil (salad oil)....	45° ± 2°	7.0	10.8	6.1	4.3	101.
Lard (bleached)	45° ± 2°	7.2	11.2	6.2	4.3	102.
Hyd. CSO shortening..	45° ± 2°	7.3	11.2	6.7	4.3	...

These data are accurate to within about 4%.

REFERENCES

[1] Lewkowitsch, 5th ed. Vol. 1, page 62.
[2] German Patent 109,446 (1899).
[3] Zeitschrift für angewandte Chemie 32, (1), 257 (1919).
[4] Journal of Biological Chemistry 61, 523 (1924).
[5] Ibid. 61, 575 (1924).

Peppermint Oil in Better Demand

American peppermint oil, the most important essential oil produced in the United States, has enjoyed better demand abroad since the beginning of 1934, due in part to increased activity among consuming industries and in part to more favorable exchange, according to C. C. Concannon, Chief of the Commerce Department's Chemical Division.

Exports of this flavoring material amounted to 168,000 pounds, valued at $449,000, during the first eight months of the year, compared with 158,000 pounds, valued at $375,000, for the corresponding period of last year. American peppermint oil is known the world over for its high quality and superior flavor, Mr. Concannon declared, and is regularly exported to more than forty foreign markets.

Although peppermint oil is produced in England, Continental Europe and elsewhere, the United States is by far the principal world source.