Update on Control of Olive Oil Adulteration and Misbranding in the United States

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The Food and Drug Administration has carried out a regulatory program since 1982 to control olive oil adulteration and mislabeling in the U.S. Analysis of imported and domestically packaged olive oil products and inspection of domestic packers have significantly reduced the presence of undeclared esterified olive oil in olive oil products. Undeclared esterified olive oil was present in 13% of olive oils examined in a 1985–86 survey, compared to 65% in a 1983–84 survey. Undeclared olive pomace oil and seed oils continue to require surveillance in a continuing effort to eliminate olive oil adulteration.

Olive oil, a food staple and delight to the taste in the Mediterranean region for thousands of years, is becoming more popular than ever in the U.S. In the past several years olive oil has become a favorite item on gourmet shelves, with imports of olive oil increasing steadily from 26,000 metric tons (MT) in 1981 to 42,000 MT in 1985 (1), and expected to reach 50,000 MT in 1987, according to USDA estimates (L. Hogie, Foreign Agricultural Service, USDA, March 1987 forecast). However, a survey by the Italian Experiment Station for the Fat and Oil Industry in Milan of olive oil brands purchased in 1982 in the U.S. (E. Fedeli, private communication, 1982) demonstrated that undeclared esterified oil and olive pomace (residue) oil as well as undeclared seed oils were substituted in whole or in part for olive oil in olive oil products available to U.S. consumers. These findings led to an olive oil sampling program instituted by the FDA in 1982 to take action against adulterated and misbranded olive oil products. Results of a 1983–84 survey were published recently (2). This report discusses available information on U.S. imports of olive oil products, presents the results of analysis of olive oils collected in 1985–86 (including olive oil from several California plants) and compares the 1985–86 results with results of the 1983–84 survey.

EXPERIMENTAL PROCEDURES

Olive oils were collected by FDA inspectors at points of import and from repackers, dealers, market shelves and several California plants. The products, with several exceptions, were analyzed in FDA's Boston District Laboratory.

ANALYSES

Analytical portions were analyzed by Association of Official Analytical Chemists (AOAC), International Union of Pure and Applied Chemistry (IUPAC) and Italian methods as described earlier (2). The analyses included determination of fatty acid composition and sterols (to identify seed oils), saturated fatty acids in the 2-position of the triglycerides (to identify esterified oil), triterpene diols [to identify olive pomace (residue) oil], and acidity and UV absorption (to indicate quality and distinguish refined from virgin olive oils). Chlorophyll and artificial dyes, if present, were identified by spectrophotometric measurement of a 1:1 mixture of the analytical portion in hexane, scanning between 350 and 800 nm.

RESULTS AND DISCUSSION

Current world production of olive oil is somewhat more than 1.5 million metric tons (MT), with Italy and Spain producing 50–60% of the total (3). U.S. imports of olive oil products from Italy and Spain, the two major exporting countries to the U.S., are shown in Table 1. (The other major olive oil-producing countries which export olive oil products to the U.S. are Greece, Tunisia and Turkey.) Virgin olive oil is defined as the oil obtained from the olive by mechanical or other physical means not leading to alteration of the oil; refined olive oil is obtained by refining virgin olive oil under conditions which do not lead to alteration of the initial glyceride structure; "pure olive oil" (or simply "olive oil") consists of a blend of virgin olive oil and refined olive oil; and olive pomace oil (olive residue oil) is the oil obtained by extracting with solvents the olive residue remaining after mechanical extraction of the virgin olive oil and made edible by refining methods which do not lead to alteration of the glyceride structure (4, 5). Although U.S. imports of olive oil products from Spain have remained relatively steady in recent years, imports of refined/pure olive oil and olive pomace oil from Italy have increased sharply to significant levels.

TABLE 1

U.S. Olive Oil Imports from Italy and Spain[a,b], MT × 10^3

	Virgin		Refined/pure		Pomace (residue)	
	Italy	Spain	Italy	Spain	Italy	Spain
1979	0.09	3.72	6.00	6.03	0.89	0.35
1980	0.06	2.85	5.55	5.54	0.76	0.10
1981	0.14	3.04	6.38	4.94	1.19	0.02
1982	0.33	3.10	8.69	4.55	0.84	0.08
1983	0.49	2.82	7.80	5.74	1.81	0.13
1984	0.83	3.18	13.80	5.89	4.64	0.17
1985	1.53	3.74	18.34	5.53	5.88	0.80

[a]Reference 1.

[b]In 1985 Italy exported worldwide 13,054 MT virgin olive oil, 52,400 MT pure/refined olive oil, and 16,446 MT pomace olive oil; in 1985 Spain exported worldwide 49,784 MT virgin olive oil, 24,994 MT pure olive oil, 10,308 MT refined olive oil and 2,643 MT pomace olive oil.

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In 1971, the Economic Committee of the International Olive Oil Council (IOOC) recommended that a breakdown of trade figures for different types of olive oils should be made, starting with the 1979-80 crop. Subsequently, large discrepancies were observed in U.S. Customs statistics vs those from exporting countries for nonedible olive oil imports (6). According to U.S. Customs statistics, imports of nonedible olive oil totaled 35 MT in 1980 (25 MT from Italy) and 39 MT in 1985 (34 MT from Italy). However, IOOC (6) observed that Italy has exported sizable quantities of nonedible olive oil (4,952 MT in 1980) under Common Market Tariff 15.07/130 (defined as "oil destined for industrial use not to be used for food products for human consumption") which were then diverted to illegal use by some U.S. packers. It was judged that a large proportion or all of the nonedible olive oil imported into the U.S. in recent years was esterified olive oil, banned for sale as an edible food in Italy and other Mediterranean countries but apparently freely exported. According to IOOC (6), 12 esterification plants exist in Italy alone which reesterify low grade olive oil or olive oil soapstock recovered from alkali refining of low grade virgin olive oil. Not surprisingly, esterified olive oil was found in bulk and packaged olive oil products from France, Italy and Spain in the 1983-84 FDA survey. In addition, undeclared olive pomace oil was found in products labeled to contain "virgin olive oil" as well as "olive oil" or "pure olive oil." Of 20 samples labeled "olive oil" analyzed in the 1983-84 FDA survey, 13 contained undeclared esterified olive oil and four contained undeclared olive pomace oil. It was apparent that continued surveillance was required to protect the consumer and the responsible olive oil trade.

Approximately 65 imported olive oil samples were collected and analyzed by FDA in 1985-86, comprising 26 brands from 24 firms packaging and/or distributing these products. Results of analysis of 61 olive oil samples are shown in Table 2. (The samples do not necessarily represent a cross section of olive oil products and brands available during those years.) A total of 13 of 31 samples (13 brands from 12 packers/distributors) labeled as virgin olive oil were mislabeled. Five of 31 samples labeled as virgin olive oil contained esterified olive oil as indicated by the relatively high levels (> 3%) of saturated fatty acids (16:0, 18:0) at position 2 of the triglycerides. Three of four samples of a domestic brand collected in June-July 1985 and labeled as virgin olive oil (samples 4, 5 and 11) consisted entirely or almost entirely of olive pomace oil. Two samples of the same brand collected in June 1986 (samples 24 and 25) contained approximately 50% olive pomace oil. Four additional samples of the same brand collected in July 1986 (samples 27-30) were properly labeled as virgin olive oils. Three samples labeled as virgin olive oil (samples 6, 26 and 31) also contained refined olive oil, as indicated by the specific extinction values at 268 nm.

Of 26 samples labeled olive oil (including 16 brands from 15 packers/distributors), two contained undeclared esterified oil, and five contained undeclared olive pomace oil as indicated by high (> 4%) levels of triterpene diols (Table 2, E+U) and high (> 1.10) specific extinction values at 268 nm. A domestic brand of olive oil collected in May 1985 (sample 39) consisted predominantly or entirely of esterified oil, as did samples collected in 1984. Additional samples of this brand collected in June, July and October 1985 (samples 41, 43 and 47) contained olive oil as labeled. Similarly, a second brand of olive oil imported from Italy and collected in January and July (samples 32 and 44) was substantially or entirely olive residue oil. When the second brand was resampled in March 1987, the product was olive oil as labeled. Three bulk samples declared to be type B (olive pomace) oil were correctly labeled. A fourth bulk sample declared to be olive pomace oil (sample 61) appeared to be a refined olive oil.

Comparison of the results of analysis of olive oil samples collected in 1983-84 (2) vs results from the 1985-86 FDA survey shows an overall improvement in proper labeling of various products. Marked improvement is evident when comparing the results of analysis of samples labeled "olive oil." The majority of the 1983-84 samples (13 of 20 samples or 65%) contained undeclared esterified olive oil, but only 2 of 26 (8%) of the 1985-86 samples contained undeclared esterified olive oil. However, the same percentage (20%) of samples from both surveys contained undeclared olive pomace oil.

Use of undeclared olive pomace oil as well as substitution of seed oils for olive oil was observed in blends of olive oil and seed oils. Blends frequently include 10% or 25% olive oil admixed with soybean oil or combinations of soybean oil and vegetable oils. Verification of proper labeling included determination of fatty acid composition to estimate the levels of individual oils present in the blend and determination of sterol/triterpene diol composition to identify the presence of undeclared olive pomace oil in the blend. Inspection of domestic packing firms included collection of individual oils used to prepare blends as well as of the blended oil. When more than two component oils were present in blends, a computer program (for solving n dimensional simultaneous equations) was used to calculate the percentages of each oil present based on the fatty acid values of the relevant individual oils and the blend. For example, to analyze a 25% olive oil blend containing corn and soybean oils, samples were characterized from a domestic repacker's supplies of corn oil, soybean oil, refined olive pomace oil and the packaged blend labeled "75% Pure Vegetable Oil (Soybean Oil, Corn Oil) - 25% Pure Imported Olive Oil." The blend was determined to be a mixture of 25% olive oil, 2% corn oil and 73% soybean oil. Further analysis (sterols/triterpene diols) demonstrated that the olive oil in the blend was undeclared olive pomace oil (3% erythrodiol present in the sterol/triterpene diol fraction).

California produces only small amounts of olive oil, 3,500 tons in 1980 and less than 600 tons per year after 1983 (7). According to one plant manager, only four olive oil producers remain, all in Northern California. Samples were collected from these four plants during 1986. One of the plants prepares, for retail sale, blends of pressed (virgin) olive oil and imported Italian and Spanish refined olive oil as well as blends of olive oil and vegetable oils. A second plant processes pressed olive oil from cull olives and sells pressed and refined olive oil in bulk. A third plant produces both pressed

TABLE 2

Analytical Results: Olive Oil Samples Collected by FDA in U.S. in 1985–86

Sample	Label declaration	% of total fatty acids		% at position-2 triglycerides		% of sterols + triterpene diols					K_{232}	K_{268}	ΔK	Finding[b]
		16:0	18:0	16:0	18:0	Camp-esterol	Stig-masterol	β-Sit-osterol	Δ5-Avena-sterol	E+U[a]				
1	Virgin olive oil	13.2	1.4	2.7	tr	3.3	0.7	80.8	14.2	0.0	2.45	0.19	0.00	A
2	Virgin olive oil	11.0	2.8	0.4	0.4	3.0	1.1	71.4	22.0	1.3	–	0.09	0.01	A
3	Virgin olive oil	10.7	2.8	1.0	0.6	2.8	1.5	82.5	11.8	1.4	–	0.18	0.01	A
4	Virgin olive oil[c]	9.5	2.8	1.3	0.5	5.1	2.7	71.2	3.2	13.7	3.30	0.90	0.13	C
5	Virgin olive oil[c]	9.7	2.8	2.7	0.5	5.3	2.9	71.9	2.2	13.6	3.75	1.45	0.20	C
6	Virgin olive oil	11.3	2.8	0.7	0.3	3.7	1.2	81.8	12.1	1.0	3.25	0.40	0.05	D
7	Virgin olive oil	11.5	2.6	3.9	tr	3.8	0.7	85.8	7.4	2.3	2.24	0.15	0.00	B
8	Virgin olive oil	10.5	3.2	6.7	2.0	3.1	1.1	89.1	4.5	2.2	2.17	0.74	0.13	B
9	Virgin olive oil	8.1	3.3	4.2	tr	3.0	0.8	91.6	4.6	tr	2.92	0.14	0.00	B
10	Virgin olive oil	9.3	3.3	1.6	0.5	2.9	1.3	84.3	9.7	1.8	–	0.22	0.02	A
11	Virgin olive oil	9.5	2.7	tr	tr	5.4	3.0	70.9	1.6	15.0	3.70	1.35	0.16	C
12	Virgin olive oil	10.6	3.0	0.8	0.4	3.1	1.2	84.1	10.3	1.2	–	0.19	0.01	A
13	Virgin olive oil	10.6	3.0	0.6	0.2	3.0	1.4	83.5	9.3	1.2	–	0.17	0.01	A
14	Virgin olive oil[d]	9.5	3.2	2.2	1.2	3.1	0.6	85.2	10.2	0.8	–	0.20	0.02	A
15	Virgin olive oil	12.5	2.9	1.0	0.3	3.0	0.4	87.9	8.1	0.0	–	0.25	0.02	A
16	Virgin olive oil[e]	15.3	2.5	4.2	0.9	3.2	0.9	84.6	10.2	0.9	–	0.18	0.01	B
17	Virgin olive oil[e]	9.2	3.3	1.4	0.7	3.4	1.0	87.9	6.6	1.0	–	0.13	0.00	A
18	Virgin olive oil[e]	12.2	3.0	3.5	1.1	3.2	1.0	85.0	8.8	1.6	–	0.20	0.02	B
19	Virgin olive oil[e]	12.1	3.0	2.2	0.4	3.5	1.1	83.4	10.1	1.2	–	0.18	0.01	A
20	Virgin olive oil[e]	12.2	3.0	1.7	1.0	3.4	1.1	82.4	9.9	1.8	–	0.23	0.02	A
21	Virgin olive oil[e]	12.2	3.0	1.4	0.6	3.6	1.2	82.5	10.0	1.8	–	0.22	0.02	A
22	Virgin olive oil	12.2	3.0	1.4	0.9	3.5	1.1	83.1	10.1	1.1	–	0.18	0.01	A
23	Virgin olive oil	10.0	3.0	1.0	0.6	3.4	1.4	84.3	9.2	1.0	–	0.13	0.01	A
24	Virgin olive oil[c]	10.5	2.8	1.4	0.8	3.6	2.0	79.5	5.3	6.4	3.16	0.50	0.06	C
25	Virgin olive oil[c]	10.6	2.8	2.2	0.9	3.7	2.1	78.0	4.8	7.2	3.38	0.66	0.13	C
26	Virgin olive oil	11.5	3.0	0.8	0.6	3.8	2.2	82.3	9.1	1.4	2.94	0.82	0.13	D
27	Virgin olive oil[c]	10.0	3.0	–	–	3.6	1.1	83.6	8.5	0.8	–	0.13	0.01	A
28	Virgin olive oil[c]	10.0	3.0	–	–	3.5	1.4	83.5	8.6	1.2	–	0.13	0.01	A
29	Virgin olive oil[c]	10.0	3.0	–	–	3.4	1.4	83.4	8.8	0.9	–	0.13	0.01	A
30	Virgin olive oil[c]	10.0	3.0	–	–	4.3	1.9	81.4	9.3	1.6	–	0.17	0.01	A
31	Virgin olive oil	11.7	2.6	1.2	0.4	3.8	1.6	85.9	8.2	0.6	2.60	0.76	0.13	D
32	Olive oil	10.9	2.8	1.4	tr	3.8	1.6	66.8	6.1	15.0	3.63	1.43	0.21	C
33	Olive oil	12.9	2.7	1.3	0.6	3.2	1.2	84.8	8.1	2.8	2.27	0.70	0.10	A
34	Olive oil	13.0	2.7	1.4	0.4	5.0	1.7	82.6	8.6	1.9	1.42	0.78	0.12	A
35	Olive oil	11.1	2.6	1.8	1.1	2.7	0.5	80.6	14.6	1.6	0.92	0.43	0.08	A

TABLE 2

Analytical Results: Olive Oil Samples Collected by FDA in U.S. in 1985–86

Sample	Label declaration	% of total fatty acids		% at position-2 triglycerides		% of sterols + triterpene diols					K_{232}	K_{268}	ΔK	Finding[b]
		16:0	18:0	16:0	18:0	Camp-esterol	Stig-masterol	β-Sit-osterol	Δ5-Avena-sterol	E+U[a]				
36	Olive oil	11.3	2.9	1.8	2.0	3.0	0.7	86.9	5.3	1.8	2.53	1.01	0.18	A
37	Olive oil	12.9	2.1	1.8	0.4	3.1	0.7	88.2	6.1	1.8	1.67	0.76	0.10	A
38	Olive oil	12.4	3.1	1.3	0.4	3.3	2.5	77.9	8.8	2.0	2.97	0.74	0.12	A
39	Olive oil[d]	9.5	3.1	8.1	2.3	4.1	1.4	89.4	0.0	5.2	4.78	0.74	0.11	B
40	Olive oil	11.8	2.7	1.9	0.4	2.8	1.4	86.9	7.4	1.5	3.83	0.90	0.11	A
41	Olive oil[d]	8.7	3.1	0.6	0.2	3.5	1.2	88.1	3.0	0.7	2.44	0.64	0.11	A
42	Olive oil	12.9	2.1	4.9	tr	3.0	1.7	89.2	4.9	1.1	2.61	0.32	0.04	B
43	Olive oil[d]	8.9	3.1	1.4	0.7	3.1	1.9	88.1	3.3	1.2	2.75	0.82	0.13	A
44	Olive oil	10.3	2.2	1.8	0.3	3.5	1.7	69.7	3.6	14.7	4.22	1.46	0.20	C
45	Olive oil	10.2	2.8	0.9	tr	3.0	1.1	75.8	18.1	1.6	2.64	0.87	0.16	A
46	Olive oil	9.1	2.6	0.7	tr	3.3	1.2	84.1	7.0	1.8	1.92	0.87	0.16	A
47	Olive oil[d]	11.4	2.9	0.8	0.3	3.4	1.1	88.1	5.4	0.9	2.71	0.82	0.14	A
48	Olive oil	11.0	2.8	1.6	0.6	4.4	3.1	77.2	8.3	0.0	1.46	0.88	0.15	A
49	Olive oil	10.3	2.6	1.8	0.5	2.5	0.8	88.8	5.0	0.0	1.96	0.38	0.06	A
50	Olive oil	10.8	3.1	1.1	0.2	4.1	1.9	86.8	5.9	0.0	1.90	1.20	0.22	A
51	Olive oil	9.2	3.6	0.6	0.2	5.3	tr	86.9	7.1	0.0	–	0.10	0.00	E
52	Olive oil	7.4	2.7	0.8	0.7	4.6	1.8	80.2	6.2	4.1	3.00	1.05	0.13	F
53	Olive oil	11.4	2.7	1.5	0.5	3.8	3.0	75.0	3.5	8.9	4.30	1.42	0.21	C
54	Olive oil	9.9	3.3	0.6	0.2	3.8	1.5	84.0	5.9	1.8	–	0.14	0.01	E
55	Olive oil	10.6	3.0	–	–	4.3	3.1	78.2	3.0	4.5	4.53	1.45	0.14	C
56	Olive oil	10.5	3.0	–	–	4.3	3.0	79.3	3.0	4.6	4.63	1.40	0.20	C
57	Olive oil	12.5	2.1	0.7	0.1	3.0	1.5	76.2	17.7	0.2	1.80	0.15	0.01	E
58	Type B (olive pomace oil)	9.3	2.7	1.7	0.4	5.6	2.8	73.0	0.0	16.4	4.10	1.56	0.19	A
59	Type B (olive pomace oil)	10.7	2.8	1.9	tr	4.7	2.2	70.0	3.8	12.5	4.69	1.51	0.20	A
60	Type B (olive pomace oil)	10.7	3.0	–	–	3.1	2.4	77.3	2.1	10.0	5.14	1.51	0.22	A
61	Type B (olive pomace oil)	11.2	2.5	1.1	0.4	–	–	85.9	2.5	1.0	3.20	1.38	0.21	F

[a]E+U, erythrodiol + uvaol (triterpene diols).

[b]A, sample appears to be properly labeled; B, sample contains or consists entirely of esterified olive oil; C, sample contains or consists entirely of olive pomace (residue) oil; D, sample is a blend of pressed and refined olive oil; E, sample is pressed (virgin) olive oil; F, sample is refined olive oil.

[c]Various samples of one brand (Firm A) collected in June 1985 (samples 4, 5); July 1985 (samples 10, 11); March 1986 (samples 24, 25), and July 1986 (samples 27–30).

[d]Samples of another brand (Firm B) collected in May 1985 (sample 39) and June–October 1985 (samples 14, 41, 43, 47).

[e]Samples of a third brand (Firm C) collected in March 1986.

TABLE 3

Analytical Results: Olive Oil Samples from California Collected by FDA in 1986

Sample	Firm	Label declaration	% of total fatty acids		% at position 2 of triglycerides		% of sterols + triterpene diols								
			16:0	18:0	16:0	18:0	Campesterol	Stigmasterol	β-Sitosterol	Δ5-Avenasterol	E+U[a]	K_{232}	K_{268}	ΔK	Finding[b]
1	I	Olive oil[c]	13.0	2.7	1.2	0.4	3.5	2.6	83.4	3.9	3.7	3.30	1.21	0.22	A
2	I	Olive oil[d,e]	11.6	3.5	0.7	0.2	2.8	3.1	88.3	5.2	0.0	1.31	0.36	0.04	B
3	II	Olive oil	11.3	2.4	1.2	0.3	4.1	2.9	73.7	5.8	9.8	4.57	1.75	0.26	C
4	II	Olive oil	12.4	2.5	1.7	0.4	4.0	2.9	77.6	5.1	7.6	4.34	1.58	0.25	C
5	III	Olive oil	12.4	2.9	1.4	0.3	2.6	3.5	90.5	2.9	0.2	1.92	0.88	0.16	A
6	III	Virgin olive oil[d]	11.3	3.2	0.9	0.3	2.9	2.6	87.4	4.6	1.7	4.06	0.76	0.10	A
7	IV	Virgin olive oil	8.6	2.8	0.8	0.4	3.0	0.9	88.5	6.5	0.0	-	0.13	0.01	A
8	IV	Virgin olive oil	9.3	2.7	0.5	0.2	3.0	0.8	88.3	6.1	0.8	-	0.09	0.00	A
9	IV	Virgin olive oil	9.9	2.6	0.8	0.2	2.9	0.8	91.0	4.8	0.0	-	0.13	0.00	A

[a]E+U, erythrodiol + uvaol (triterpene diols).
[b]A, sample appears to be properly labeled; B, sample is a pressed (virgin) olive oil; C, sample contain or consists entirely of olive pomace (residue) oil.
[c]Product is a blend of California and Spanish olive oil.
[d]Product is a poor quality pressed (virgin) olive oil with free acidity (as % oleic acid) of ca. 4%.
[e]Collected from unlabeled bulk tank.

and refined olive oil, and the fourth plant produces virgin olive oil from two varieties of olives and packages it for retail sale. Another plant in northern California that produced olive pomace oil (hexane extraction process) stopped production in 1986 due to wastewater disposal problems. Results of analysis of nine olive oil samples collected from the California plants are shown in Table 3. Sample No. 2, collected from an unlabeled bulk tank, was a poor quality pressed olive oil (acidity 3.9% expressed as oleic acid). Sample 3, collected from an unlabeled metal drum and described as refined olive oil, consisted in part of olive pomace oil, as indicated by the relatively high level of triterpene diols. Sample 4, collected from an unlabeled plastic container and described by the firm management as virgin olive oil, also contained olive pomace oil.

The current survey supports earlier observations that continuous vigilance is required to control adulteration of olive oil products and protect the consumer and the responsible olive oil trade. The 1985-86 FDA sampling program resulted in a sharp decline in the misuse of esterified olive oil and a modest decrease in the use of undeclared olive pomace oil in olive oil and olive oil blends. Effective control of olive oil adulteration also requires tighter control by exporting countries, a set of universally accepted definitions for olive oil products, and uniform labeling regulations. According to the current International Olive Oil Agreement (4), the product "olive oil" or "pure olive oil" is defined as a blend of virgin olive oil and refined olive oil. No minimum or maximum level of virgin olive oil is specified for such a blend. Accordingly, a blend containing 0.1% virgin olive oil could be designated as "olive oil," provided that the UV specific extinction values fall within accepted limits. Internationally approved definitions for olive oil products should include a definition for "olive oil" specifying a minimum level of virgin olive oil in the product. Also required is a method to determine the proportions of virgin and refined olive oil in a blend.

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