

USDA Dietary Supplement Ingredient Database

Release 5.0 (DSID-5)

Turmeric Dietary Supplement Study

DSID Research Summary and Results

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1. Overview

Turmeric (*Curcuma longa*) is a common spice used in food and taken as a DS for potential health benefits. The goal of this study is to evaluate the curcuminoid content in DS containing turmeric material (*Curcuma longa* dry rhizome powders and/or extracts) as a primary or the only botanical ingredient. Curcuminoids (primarily curcumin [Cur], demethoxycurcumin [DMC], bisdemethoxycurcumin [BDMC]) make up only 1-3% of the raw turmeric rhizome, and so most turmeric DS contain concentrated extracts.

Two lots of 54 commonly sold DS containing turmeric as a single or primary botanical ingredient were purchased for analysis. Curcuminoid content (including Cur, DMC and BDMC) in the DS was measured by three experienced laboratories.

We evaluated how well the various DS label formats inform consumers and researchers about the actual content of curcuminoids and piperine in these products. We compared how the required and voluntary label information predicted the measured content of total curcuminoids (TC), and how the matrix impacted TC content.

2. Sampling Plan

A sampling plan was developed to identify commonly sold products for purchase and analysis. The sampling plan was based on an evaluation of DS reported in NHANES 2013-2014 and a detailed survey of turmeric products sold via various channels including local stores, the internet and multi-level marketing companies in 2015.

A scoring system was developed to choose products for purchase from an initial pool of 197 products which fit our criteria (commonly sold DS containing turmeric material (rhizome powder and/or extract) as a single or primary ingredient). The highest scoring products (based on NHANES reporting, in-store surveys, number of websites sold, and best-seller status) were purchased for this study.

Two lots of each product (n=54) were purchased for the study. Products were purchased from the three major sales channels: mass market retail (e.g., Walmart, CVS, Target), natural and specialty retail (e.g., GNC or Whole Foods), and direct sales (products sold exclusively via the web or by multi-level marketers like Amway or Herbalife). Two DS were purchased in bulk for use as in-house control materials to monitor laboratory performance over time. Samples were repackaged and sent for laboratory analysis in defined batches.

Products with a wide range of dosage forms were purchased: hard-shell capsules (n=39), softgels (n=4), tablets (n=7), caplets (smooth-coated tablets; n=2), and powders (n=2). Dosage forms contained dry rhizome powders only, turmeric extract only or their mixtures. Thirty-eight products contained turmeric extract only; 12 products contained turmeric extract and dry rhizome powder mixtures, and 4 products contained dry rhizome powder only. Twelve products had claims for piperine in black pepper extract, and 3 listed pepper extract without a claimed level. Most products had a label claim for the amount of TC.

3. Laboratory Analysis and Quality Control

Turmeric DS were analyzed for Cur, DMC, BDMC and piperine (a constituent of black pepper extract, added to improve bioavailability) using high performance liquid chromatography (HPLC) and ultra (u)HPLC with ultraviolet (UV) detection. Samples of NIST Standard Reference Material (SRM) 3299 (turmeric rhizome powder) and SRM 3300 (turmeric extract) with known levels of curcuminoids were analyzed with each batch of samples to monitor the quality of the laboratory results. In addition, product duplicates and two in-house control materials were included in each batch. The consistent results for these quality control materials obtained from the three laboratories over the course of the study gave us confidence in the results for these constituents in the commercial turmeric DS under study.

The laboratory data were reported in mg/g and were reviewed. Samples with unusually large percentage differences from label claims or high variability among the 3 laboratories or among lots of the same product were retested. The final laboratory data were sent to our consulting statistician for statistical review.

4. Statistical Methods

Test results for individual curcuminoids, total curcuminoids (TC) and piperine were converted into mg per serving, mg per day and percentage difference from label, if applicable. The percentage difference from the label claim was calculated for each analyzed constituent in each sample: $((\text{analytical value} - \text{label value}) / \text{label value}) \times 100\%$. Least squares means and standard deviations (SD) were computed for each product using a SAS mixed model procedure.

Results were calculated on a per serving and per day basis, because many of the 54 products in this study had a suggested use of more than one serving per day. Suggested use was one serving per day for 34 products, two servings per day for 10 products, three servings per day for 9 products and four servings per day for one product. If the suggested use was a range (e.g., 1-2 servings per day), the maximum number of servings per day was used. The labeled and mean measured contents for TC and piperine (if labeled) in each product are reported as per serving (Appendix Table 1) and per day (Appendix Table 2).

5. Results and Discussion

The labeled levels for turmeric material (information required by FDA) in the 54 products showed a wide range: 200-1300 mg per serving and 285-3600 mg per day (Tables 1; 2). The mean analytical results per serving of total curcuminoids (TC) also showed a wide range (8.1-1254 mg, Appendix Table 1; median= 222 mg). The product means for TC content measured per day ranged from 16.3-2328 mg (Appendix Table 2), with the median = 351 mg.

The measured TC content varied widely in products with the same labeled amount of turmeric material. At the most common labeled level (500 mg per serving and per day) of turmeric material, measured TC results ranged from 8 to 518 mg per serving (n=17) and from 16 to 554 mg per day (n=12). Even for a subset of products that included extracts only, varying amounts

of TC were found. For example, nine products labeled at 500 mg per serving of turmeric extract contained 101 to 518 mg of measured TC, and 4 products labeled at 1000 mg per serving provided from 209 to 955 mg of TC (Appendix Table 1).

Many turmeric DS voluntarily listed the amount of TC on labels. We examined the percentage differences from labels for TC content. These ranged from -34.4 to +73.3% ($7.8 \pm 16.7\%$, mean \pm SD; n=41). For 26 of 38 products (68%) the analytical results were within $\pm 10\%$ of the label claims for TC, which meets the USP recommendations from the monographs for turmeric tablets and capsules (USP43-NF38). Thirteen DS in our study had TC content more than 10% above labels and two DS were below -10% of label claims.

Thus, the voluntary label information about the TC content was more closely associated with the measured content than the FDA required information about the weights of turmeric materials.

We found that the measured TC content differed in different matrices. The TC content was much lower in products containing dry rhizome powders only than in products with turmeric extracts only. TC content in DS with extracts plus dry rhizome powders was, as expected, on average, lower than in DS with only extracts but higher than in dry rhizome powder only. Voluntary labeling of the amount of piperine on the labels was also closely associated with the actual content of piperine. The labeled levels for piperine ranged from 1.9-14.3 mg per serving and 1.9-15.1 mg per day. Measured piperine content in products having a labeled amount (n=12) ranged from 2.2 to 15 mg per serving (6.7 ± 4.3 ; mean \pm SD), and 2.2 – 17 mg per day (8.2 ± 5.3). The percentage differences from labels for piperine ranged from -3.4 to +21% ($8.3 \pm 7\%$) (Appendix Table 3).

An evaluation of measured TC content for DS with and without a claim for content shows that products with the claim were more likely to have higher amounts than those without a claim (Table 1).

Table 1. Comparison of DS with and without voluntary claims for total curcuminoid content

		Measured Total Curcuminoids (TC), mg/day		
	n	Range	Mean \pm SD	Median
DS with a label claim for total curcuminoid content	41	49 - 2328	590 \pm 499	487
DS without a label claim for total curcuminoid content	13	16 - 778	197 \pm 241	89.4

6. Conclusions

In summary, turmeric DS have a variety of label formats with a wide range of labeled weights of turmeric and labeled and measured TC concentrations. Results indicate that the FDA required information about the total weight of turmeric material may not permit accurate predictions for the content of TC. As expected, the dry rhizome powders had much lower TC content compared to the extracts. Turmeric extracts may or may not be highly concentrated

and some extracts may be microencapsulated (adds additional weight). Altogether, these factors explain the poor predictability of TC from the turmeric weight in many of these products. Products with voluntary labeling of TC and piperine content were relatively accurate (83% and 92% of tested products were within $\pm 20\%$ of label claims, respectively). Those with claims for TC content were more likely to contain higher levels of TC than DS without a claim.

Current labeling requirements for turmeric DS may be insufficient to inform researchers and consumers about the actual content of TC in DS because the extract concentrations vary widely.

Additional statistical evaluation of the curcuminoid results using regression analysis is planned. The results for products with TC content claims, DS with 95% TC extract claims and those with trademarked curcumin ingredients (n=21) will be compared to products without those characteristics. The ratio of the three major curcuminoids will be compared to USP standards and products evaluated for possible adulteration.

7. Compliance with the USP Performance Standards for Dosage Forms

Compliance with the USP performance standards for DS is currently voluntary in the US. However, DSID results showing inadequate performance of green tea DS dosage forms raised concerns that DS users may not achieve health benefits expected from green tea DS (Gusev et al., 2020). The inadequate performance jeopardizes confidence in the efficacy and safety of green tea DS sold in the US and used in clinical trials.

Turmeric DS with immediate release forms were tested for dosage form performance using USP disintegration and rupture tests. Hard-shell capsules (n=39) and tablets/caplets (n=9) and were tested for disintegration and soft gels (n=4) for rupture. For each test, tablets or capsules were immersed and agitated in appropriate media and visually inspected after 15 (rupture) or 30 minutes (disintegration). A hard-shell capsule or tablet passed disintegration if there was no solid mass remaining in the vessel other than remnants of the shells or coating films. A soft gel passed the rupture test if its outer shell opened. Tablets/caplets had a 66.7% pass rate, and hard-shell capsules had an 84.6% pass rate, the rest products had inconsistent results in two lots (Table 2). All soft gels passed the rupture test (Andrews et al., 2021; Savarala et al., 2019).

Table 2: Results for disintegration testing of capsules and tablets for turmeric DS.

Dosage Form	Number of products	Pass	Fail	Mixed P/F*
Hard-shell Capsules	39	33 (84.6%)	3 (7.7%)	3 (7.7%)
Tablets/Caplets	9	6 (66.7%)	1 (11.1%)	2 (22.2%)

*In most cases, two lots of each product were tested. Mixed P/F indicates that 1 lot passed and 1 lot failed.

8. References

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Appendix Table 1. Dosage forms, turmeric material weight, *per serving* content of total curcuminoids and piperine in 54 turmeric DS: label claims and means of measured content

Product ID	Form	Matrix	Turmeric material	Total Curcuminoids			Piperine		
			mg/serving						
			Label	Label	Measured (mean)	SD	Label	Measured (mean)	SD
TR01	Capsule	turmeric extract	482	36	62.3	3.1	-	2.5	0
TR02	Softgel	turmeric extract	400	-	36	0.5	-	-	-
TR03	Capsule	turmeric extract	300	285	273.5	5.6	-	-	-
TR04	Tablet	turmeric extract	500	475	469.6	16.8	-	-	-
TR05	Capsule	turmeric extract	538	500.34	522.2	11.3	-	-	-
TR06	Capsule	turmeric extract + dry rh. powder	500	47.5	62.7	1.7	-	-	-
TR08	Capsule	turmeric extract	1000	950	922	29.5	5.7	6.2	0.2
TR09	Capsule	turmeric extract	500	-	101.2	2.1	-	-	-
TR10	Capsule	turmeric extract	900	855	852.9	12.1	4.75	5.8	0.3
TR11	Capsule	turmeric extract	450	427.5	436.7	8.4	-	4.8	0.3
TR12	Capsule	turmeric extract + dry rh. powder	500	-	55.9	0.8	-	-	-
TR13	Capsule	turmeric extract + dry rh. powder	500	47.5	48.6	1.2	-	-	-
TR14	Softgel	turmeric extract	-	48	57.5	1.2	-	-	-
TR15	Capsule	turmeric dry rh. powder	1200	-	38.5	1	-	-	-
TR16	Capsule	turmeric extract	500	475	430.7	56.6	4.75	4.6	1.1
TR19	Capsule	turmeric extract	300	285	289.2	12.6	-	-	-
TR20	Capsule	turmeric extract + dry rh. powder	500	47.5	50	2.6	-	-	-
TR22	Capsule	turmeric extract + dry rh. powder	750	47.5	31.2	20.6	4.75	5	0.4
TR23	Capsule	turmeric extract + dry rh. powder	285	-	89.4	5.4	-	-	-
TR24	Softgel	turmeric extract	750	500	556	27.5	-	-	-
TR25	Capsule	turmeric dry rh. powder	500	-	8.1	0.3	-	-	-
TR26	Capsule	turmeric extract	800	-	778.4	68.6	-	-	-
TR29	Capsule	turmeric extract	200	190	222.3	18.5	-	-	-
TR30	Capsule	turmeric extract + dry rh. powder	900	152	164.2	2.9	-	-	-
TR31	Capsule	turmeric extract	400	372	426.1	16.4	-	-	-
TR32	Capsule	turmeric extract	500	237.5	172.6	88	-	-	-
TR33	Tablet	turmeric extract	1000	950	955.3	11.1	4.75	5	0.2
TR34	Tablet	turmeric extract	450	427.5	468.8	16.4	14.25	14.2	0
TR36	Capsule	turmeric extract + dry rh. powder	600	237.5	238	9.1	-	-	-
TR37	Softgel	turmeric extract	250	-	277.2	10.3	-	-	-
TR38	Capsule	turmeric extract	500	475	463.8	5.8	-	-	-
TR39	Capsule	turmeric extract	500	475	458.4	8.5	-	-	-
TR40	Capsule	turmeric extract + dry rh. powder	500	-	30.2	1.1	2.85	3	0.1

TR41	Caplet	turmeric extract	1050	997.5	1052	58.5	-	-	-
TR43	Capsule	turmeric extract	500	100	102.5	3.8	-	-	-
TR45	Tablet	turmeric extract + dry rh. powder	700	481	487.4	5.7	2.85	3.1	0
TR46	Tablet	turmeric extract	350	332.5	351.4	0.7	-	-	-
TR49	Capsule	turmeric extract + dry rh. powder	500	47.5	62.8	1.3	-	-	-
TR51	Capsule	turmeric extract	500	475	518	8.9	5.035	5.9	0.1
TR52	Capsule	turmeric extract	600	180	211.3	4.4	-	-	-
TR54	Powder	turmeric dry rh. powder	500	-	16.3	0.3	1.9	2.2	0.2
TR56	Capsule	turmeric extract	600	510	581.9	49.8	-	-	-
TR58	Capsule	turmeric extract	300	54	60.7	3.5	-	-	-
TR60	Tablet	turmeric extract	750	712.5	767	16.6	-	-	-
TR63	Powder	turmeric extract + dry rh. powder	738	42	55.8	1.7	-	12.1	0.4
TR65	Capsule	turmeric dry rh. powder	700	-	10.2	0.2	-	-	-
TR66	Capsule	turmeric extract	1000	-	209.4	5.1	-	-	-
TR67	Capsule	turmeric extract	1300	1200	1253.7	75.7	-	-	-
TR68	Tablet	turmeric extract	450	427.5	492.4	17.9	14.25	15.2	0.3
TR69	Capsule	turmeric extract	200	190	204.3	9.6	-	-	-
TR70	Capsule	turmeric extract	500	475	486.6	19.4	-	-	-
TR71	Capsule	turmeric extract	400	326.8	411.1	12.8	-	-	-
TR72	Capsule	turmeric extract	1000	-	209.2	12.5	-	-	-
TR73	Caplet	turmeric extract	1053	1000.35	1083.4	20.5	10	11.1	0.6

Appendix Table 2. Dosage forms, turmeric material weight, *per day* contents of total curcuminoids and piperine in 54 turmeric DS: label claims and means of measured content

Product ID	Form	Matrix	Turmeric material	Total Curcuminoids			Piperine		
			mg/day						
			Label	Label	Measured (mean)	SD	Label	Measured (mean)	SD
TR01	Capsule	turmeric extract	964	72	124.6	6.1	-	5.0	0.1
TR02	Softgel	turmeric extract	400	-	36.0	0.5	-	-	-
TR03	Capsule	turmeric extract	300	285	273.5	5.6	-	-	-
TR04	Tablet	turmeric extract	1500	1425	1408	50.4	-	-	-
TR05	Capsule	turmeric extract	538	500.34	522.2	11.3	-	-	-
TR06	Capsule	turmeric extract + dry rh. powder	500	47.5	62.7	1.7	-	-	-
TR08	Capsule	turmeric extract	1000	950	922.0	29.5	5.7	6.2	0.2
TR09	Capsule	turmeric extract	1000	-	202.4	4.3	-	-	-
TR10	Capsule	turmeric extract	900	855	852.9	12.1	4.75	5.8	0.3
TR11	Capsule	turmeric extract	900	855	873.4	16.8	-	9.6	0.6
TR12	Capsule	turmeric extract + dry rh. powder	500	-	55.9	0.8	-	-	-
TR13	Capsule	turmeric extract + dry rh. powder	500	47.5	48.6	1.2	-	-	-
TR14	Softgel	turmeric extract	-	48	57.5	1.2	-	-	-
TR15	Capsule	turmeric dry rh. powder	3600	-	115.4	3.1	-	-	-
TR16	Capsule	turmeric extract	500	475	430.7	56.6	4.75	4.6	1.1
TR19	Capsule	turmeric extract	900	855	867.5	37.7	-	-	-
TR20	Capsule	turmeric extract + dry rh. powder	500	47.5	50.0	2.6	-	-	-
TR22	Capsule	turmeric extract + dry rh. powder	1500	95	62.3	41.3	9.5	9.9	0.8
TR23	Capsule	turmeric extract + dry rh. powder	285	-	89.4	5.4	-	-	-
TR24	Softgel	turmeric extract	750	500	556.0	27.5	-	-	-
TR25	Capsule	turmeric dry rh. powder	1500	-	24.2	1.0	-	-	-
TR26	Capsule	turmeric extract	800	-	778.4	68.6	-	-	-
TR29	Capsule	turmeric extract	600	570	667.0	55.6	-	-	-
TR30	Capsule	turmeric extract + dry rh. powder	1800	304	328.3	5.7	-	-	-
TR31	Capsule	turmeric extract	1200	1116	1278	49.3	-	-	-
TR32	Capsule	turmeric extract	1000	475	345.1	175.9	-	-	-
TR33	Tablet	turmeric extract	1000	950	955.3	11.1	4.75	5.0	0.2
TR34	Tablet	turmeric extract	450	427.5	468.8	16.4	14.3	14.2	0.0
TR36	Capsule	turmeric extract + dry rh. powder	600	237.5	238.0	9.1	-	-	-
TR37	Softgel	turmeric extract	500	-	554.3	20.7	-	-	-
TR38	Capsule	turmeric extract	500	475	463.8	5.8	-	-	-
TR39	Capsule	turmeric extract	1000	950	916.8	17.0	-	-	-

TR40	Capsule	turmeric extract + dry rh. powder	500	-	30.2	1.1	2.85	3.0	0.1
TR41	Caplet	turmeric extract	1050	997.5	1052	58.5	-	-	-
TR43	Capsule	turmeric extract	500	100	102.5	3.8	-	-	-
TR45	Tablet	turmeric extract + dry rh. powder	700	481	487.4	5.7	2.85	3.1	0.0
TR46	Tablet	turmeric extract	350	332.5	351.4	0.7	-	-	-
TR49	Capsule	turmeric extract + dry rh. powder	500	47.5	62.8	1.3	-	-	-
TR51	Capsule	turmeric extract	1500	1425	1554	26.6	15.1	17.7	0.2
TR52	Capsule	turmeric extract	600	180	211.3	4.4	-	-	-
TR54	Powder	turmeric dry rh. powder	500	-	16.3	0.3	1.9	2.2	0.2
TR56	Capsule	turmeric extract	2400	2040	2327	199.3	-	-	-
TR58	Capsule	turmeric extract	600	108	121.5	7.0	-	-	-
TR60	Tablet	turmeric extract	750	712.5	767	16.6	-	-	-
TR63	Powder	turmeric extract + dry rh. powder	738	42	55.8	1.7	-	12.1	0.4
TR65	Capsule	turmeric dry rh. powder	2100	-	30.5	0.7	-	-	-
TR66	Capsule	turmeric extract	1000	-	209.4	5.1	-	-	-
TR67	Capsule	turmeric extract	1300	1200	1253	75.7	-	-	-
TR68	Tablet	turmeric extract	450	427.5	492.4	17.9	14.3	15.2	0.3
TR69	Capsule	turmeric extract	600	570	612.7	28.9	-	-	-
TR70	Capsule	turmeric extract	500	475	486.6	19.4	-	-	-
TR71	Capsule	turmeric extract	400	326.8	411.1	12.8	-	-	-
TR72	Capsule	turmeric extract	2000	-	418.4	24.9	-	-	-
TR73	Caplet	turmeric extract	1053	1000	1083	20.5	10	11.1	0.6

Appendix Table 3. Mean percentage differences from labels for total curcuminoid and piperine content in turmeric DS

Product ID	Form	Matrix	Total Curcuminoids		Piperine	
			Percentage Differences from Label			
			Mean	SD	Mean	SD
TR01	Capsule	turmeric extract	73.1	8.5	-	-
TR03	Capsule	turmeric extract	-4.0	2.0	-	-
TR04	Tablet	turmeric extract	-1.1	3.5	-	-
TR05	Capsule	turmeric extract	4.4	2.3	-	-
TR06	Capsule	turmeric extract + dry rh. powder	32.0	3.5	-	-
TR08	Capsule	turmeric extract	-2.9	3.1	8.1	3.7
TR10	Capsule	turmeric extract	-0.2	1.4	21.0	6.7
TR11	Capsule	turmeric extract	2.2	2.0	-	-
TR13	Capsule	turmeric extract + dry rh. powder	2.4	2.5	-	-
TR14	Softgel	turmeric extract	19.7	2.5	-	-
TR16	Capsule	turmeric extract	-9.3	11.9	-3.4	22.2
TR19	Capsule	turmeric extract	1.5	4.4	-	-
TR20	Capsule	turmeric extract + dry rh. powder	5.2	5.5	-	-
TR22	Capsule	turmeric extract + dry rh. powder	-34.4	43.4	4.3	8.4
TR24	Softgel	turmeric extract	11.2	5.5	-	-
TR29	Capsule	turmeric extract	17.0	9.8	-	-
TR30	Capsule	turmeric extract + dry rh. powder	8.0	1.9	-	-
TR31	Capsule	turmeric extract	14.6	4.4	-	-
TR32	Capsule	turmeric extract	-27.3	37.0	-	-
TR33	Tablet	turmeric extract	0.6	1.2	4.6	3.7
TR34	Tablet	turmeric extract	9.7	3.8	-0.4	0.1
TR36	Capsule	turmeric extract + dry rh. powder	0.2	3.8	-	-
TR38	Capsule	turmeric extract	-2.4	1.2	-	-
TR39	Capsule	turmeric extract	-3.5	1.8	-	-
TR40	Capsule	turmeric extract + dry rh. powder	-	-	6.0	3.7
TR41	Caplet	turmeric extract	5.5	5.9	-	-
TR43	Capsule	turmeric extract	2.5	3.8	-	-
TR45	Tablet	turmeric extract + dry rh. powder	1.3	1.2	10.1	1.0
TR46	Tablet	turmeric extract	5.7	0.2	-	-
TR49	Capsule	turmeric extract + dry rh. powder	32.3	2.7	-	-
TR51	Capsule	turmeric extract	9.1	1.9	16.9	1.3
TR52	Capsule	turmeric extract	17.4	2.4	-	-
TR54	Powder	turmeric dry rh. powder	-	-	15.1	11.6
TR56	Capsule	turmeric extract	14.1	9.8	-	-
TR58	Capsule	turmeric extract	12.5	6.5	-	-
TR60	Tablet	turmeric extract	7.7	2.3	-	-
TR63	Powder	turmeric extract + dry rh. powder	32.8	4.0	-	-

TR67	Capsule	turmeric extract	4.5	6.3	-	-
TR68	Tablet	turmeric extract	15.2	4.2	6.6	1.8
TR69	Capsule	turmeric extract	7.5	5.1	-	-
TR70	Capsule	turmeric extract	2.5	4.1	-	-
TR71	Capsule	turmeric extract	25.8	3.9	-	-
TR73	Caplet	turmeric extract	8.3	2.1	11.4	6.3