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Prevalence and Use Patterns of Kratom (*Mitragyna speciosa* Korth.) in a US Nationally Representative Sample

Oliver Grundmann PhD ^{a,b}, MeShell Green BS^b, Erin Berthold PhD^c, Saunjoo L. Yoon PhD^d, and Diane Ray MBA^e

^aCollege of Pharmacy, Department of Medicinal Chemistry, University of Florida, Gainesville, FL, USA; ^bCollege of Pharmacy, Department of Pharmaceutical Sciences, Midwestern University, Glendale, AZ, USA; ^cPlanted in Science Consulting, LLC, St. Augustine, FL, USA; ^dCollege of Nursing, Department of Biobehavioral Nursing Science, University of Florida, Gainesville, FL, USA; ^eResearch America Inc, Subsidiary Natural Marketing Institute, Newtown Square, PA, USA

ABSTRACT

With increasing diversity of kratom (*Mitragyna speciosa* Korth.) products containing higher amounts of alkaloids including mitragynine and 7-hydroxymitragynine, safety becomes a public concern. The study aimed to estimate the prevalence of kratom use and to examine potential benefits and adverse effects based on kratom product formulations. A cross-sectional survey utilized a non-probabilistic nationally representative sampling with a total of 11,545 respondents of which 1,049 reported current kratom use, indicating a 9.1% prevalence. The most common kratom products used in the past 30 days were pills, gummies and powder formulations. Pain relief ($n = 603$, 57.5%) was the most common condition for using kratom, followed by relaxation/stress relief ($n = 562$, 53.6%) and boost energy ($n = 520$, 49.6%). The reported benefits were increased energy from tea bags and improved sleep with leaf or extract powders. A significant positive correlation was found between the increased frequency of consuming kratom shots/extract powder and pain relief ($p = .009$ and 0.015 , respectively). A higher incidence of adverse effects was reported as the amount of kratom per dose increased with gummies/capsules/tablets/pills. The lack of standardization and consistency in kratom products results in unpredictable effects, emphasizing the need for increased research to establish reliable safety guidelines for dosage recommendations.

ARTICLE HISTORY

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KEYWORDS

Kratom; *Mitragyna speciosa*; use patterns; opioid; health impact

Introduction

The use of dried leaf material from the kratom tree (*Mitragyna speciosa* Korth., Rubiaceae) indigenous to Southeast Asia has increased in the past decade in the US (Grundmann, Hendrickson, and Greenberg 2023). Kratom preparations have diversified, with dried leaf material being the most used, whereas newer products include extracts, liquids, tinctures and isolated kratom alkaloids. Such preparations may contain the natively present alkaloids in highly concentrated amounts not found in dried leaf material (Bowdring et al. 2023). Concerns about the safety of kratom products and reports of deaths after consuming kratom, primarily as part of polydrug exposures, have led to increased scrutiny regarding regulation, state and national oversight (Ellis et al. 2024; Henningfield et al. 2024).

Kratom has been used in its natural form (i.e., fresh and dried leaves) in a traditional setting to treat diarrhea, fever, infections, pain and opium withdrawal symptoms in Southeast Asia for centuries (Brown, Lund, and Murch 2017). After its initial reports in the 1830s, researchers

isolated the indole alkaloid mitragynine unique to *Mitragyna speciosa* and discovered its dose-dependent analgesic and stimulant effects (Veltri and Grundmann 2019). In recent years, pharmacological activity has been identified for a number of kratom alkaloids, with diverse binding affinities at opioid, adrenergic and serotonergic receptors, among others (León et al. 2021; McCurdy et al. 2024). The partial agonist activity of mitragynine and its metabolite 7-hydroxymitragynine at the μ -opioid receptor raised concerns and led to the US Food and Drug Administration (FDA) classifying kratom as an opioid (FDA 2018, 2024; Tobacyk et al. 2022). Currently, kratom is regarded as a new dietary ingredient without FDA approval, and the FDA has issued statements declaring any dietary supplements containing kratom as contaminated (FDA 2019; Grundmann et al. 2023). Due to the lack of federal oversight or regulation, several US states have passed laws to regulate kratom products, which require adequate labeling and quality control measures to protect public health (Kratom Consumer Protection Act: What Is It and Why We Need It 2019). A series of

national surveys indicate that kratom prevalence appears to be dependent on the respective respondent demographic. An analysis of the 2019 National Survey on Drug Use and Health (NSDUH) found a past-year kratom use prevalence of 0.7% (Palamar 2021), while a nationally representative survey indicates a lifetime prevalence of 6.1% (Covvey et al. 2020).

The user profile of kratom has been studied in several observational surveys over the past decade, and there is general agreement that kratom products are primarily used by Caucasian white males between the ages of 30 and 50 with an annual household income of \$50,000 to \$80,000 and at least some college education (Falise et al. 2023; Garcia-Romeu et al. 2020; Grundmann et al. 2022). A recent study identified a positive association between opioid misuse with lifetime (1.72%) and past year (0.67%) kratom use (LoParco et al. 2024). Kratom might also be used by people who use methamphetamine and opioids for recreational purposes with increased likelihood of serious mental health issues and unmet mental health needs (Smith, Rogers, and Strickland 2022).

Recently, kratom products available to consumers have substantially diversified. This complicates determining the association between a product and its safety if case reports only state that a kratom product was consumed without addressing a specific type of product. Based on general toxicological principles, extracts, concentrates and isolates of kratom that contain alkaloids in an amount many times than that found in native kratom leaf material, will inherently result in a stronger pharmacological effect (Grundmann et al. 2023; Rogers et al. 2024).

This study used survey data from the general US adult population to explore an updated estimate of kratom use prevalence and to determine whether specific kratom product formulations are associated with differential benefits and/or detrimental/adverse effects.

Methods

Data collection

This survey utilized non-probabilistic based sampling through a third-party marketing company (Research America Inc.). Persons who have previously opted in to participate in surveys were invited to participate in the study as panelists. The research agency maintains proprietary and partner panels, including a combined database of millions of panel members. Panelists were randomly invited to participate in the survey by e-mail and text message, and the survey was administered online. Responses were collected from April 8, 2024, to April 22,

2024. Of 66,121 panelists randomly invited to participate 11,545 began the survey, but 10,496 (90.9%) either dropped out, did not qualify, or did not complete the survey, leaving 1,049 (9.1%) completed survey responses. Those who did not qualify were non-kratom users, and demographic data of about 1,000 non-users were captured. Respondents were not directly compensated for participation in this survey; however, there was modest compensation for overall participation in research panels.

The survey included several validation questions to ensure respondents were thoughtfully answering and not randomly clicking through and to ensure answers were not a product of artificial intelligence (AI) or digitally generated.

Because no personal information was collected and responses were anonymous, this study was exempt from Institutional Review Board (IRB) review.

Measures

The survey scope, beyond demographics and qualifying questions, included questions about the type(s) of kratom product(s) used in the past 12 months, past 30 days, ever used and used most often. The survey explored reasons for use, frequency of use, quantity used on each occasion, length of time each product has been used as well as strains used most often. Additional questions were about the perceived positive benefits of use and any negative experiences. Respondents were asked about package label information, specifically about how much kratom to consume on each occasion and product content details. Lastly, insights about how respondents first heard of kratom, where they consume the product, where they go when seeking additional information, where they shop, etc. rounded out the study.

Data analysis

The data were analyzed in Microsoft Excel for Microsoft 365 (version 2406, Microsoft, Seattle, WA) and GNU PSPP (<http://www.gnu.org/software/pspp/>, version 0.10.4-g50f7b7). Chi-square and linear-by-linear association models were used to analyze the data. Significance was set at the 0.05 level.

Results

Demographic characteristics

Respondent demographic characteristics are displayed in Table 1. More male respondents (55.3% vs. 39.9%, $p < .01$) used kratom than the non-kratom respondents. The age distribution of kratom users shifted younger,

with the majority being between 30 and 49 years old compared to the older non-kratom respondents (64.1% vs. 38.4%, $p < .01$). Kratom user and non-kratom respondents did not differ in education level. Kratom respondents had a significantly higher ($p < .01$) household income than non-kratom respondents. Out of a total sample size of 11,545 survey respondents, 1,049 were identified as active kratom users, indicating a kratom use prevalence of 9.1% among the general US adult population.

The most common kratom products used in the past 30 days were capsules/tablets/pills, gummies, extract powder, or leaf powder. Raw kratom leaves were used least often.

The differences in kratom amount per dose (Figure 1a) and daily frequency of use (Figure 1b) are displayed in relation to the different age groups. The largest variation in average amount of kratom per dose was observed for extract liquids, tinctures, or shots, with respondents aged 65 years and older indicating the highest amount (9.9

Table 1. Demographics of kratom and non-kratom survey respondents.

	Kratom respondents (n, %), N = 1,049	Non-kratom respondents (n, %), N = 1,000	Significance (p-value <.05)
Sex			
Male	580 (55.3%)	399 (39.9%)	p < .01
Female	464 (44.2%)	593 (59.3%)	
Transgender/Other	5 (0.5%)	8 (0.8%)	
Age (years)			
18–29	230 (21.9%)	225 (22.5%)	p < .01
30–39	403 (38.4%)	192 (19.2%)	
40–49	270 (25.7%)	192 (19.2%)	
50–64	125 (11.9%)	222 (22.2%)	
65 and older	21 (2.0%)	169 (16.9%)	
Highest level of Education			
High school graduate or less	327 (31.2%)	330 (33.0%)	p = .58
Some college, but no degree	398 (37.9%)	379 (37.9%)	
College graduate	324 (30.9%)	291 (29.1%)	
Household Income			
Less than \$30,000	240 (22.9%)	324 (32.4%)	p < .01
\$30,000 to \$74,999	422 (40.2%)	368 (36.8%)	
\$75,000 to \$149,999	274 (26.1%)	221 (22.1%)	
\$150,000 and more	105 (10.0%)	69 (6.9%)	
Decline to answer	8 (0.8%)	18 (1.8%)	
Hispanic Ethnicity			
Yes	177 (16.9%)	142 (14.2%)	p = .24
No	864 (82.4%)	849 (84.9%)	
Decline to answer	8 (0.8%)	9 (0.9%)	
Race			
White/Caucasian	809 (77.1%)	750 (75.0%)	p = .25
African-American or Black	143 (13.6%)	149 (14.9%)	
Asian	19 (1.8%)	27 (2.7%)	
American Indian or Alaska Native	33 (3.1%)	19 (1.9%)	
Pacific Islander	8 (0.8%)	8 (0.8%)	
None of the above/Other	31 (3.0%)	37 (3.7%)	
Prefer not to answer	6 (1.0%)	10 (1.0%)	
Marital status			
Married	346 (33.0%)		N/A
Never married	347 (33.1%)		
Divorced/Separated/Widowed	182 (17.3%)		
Living with a significant other	174 (16.6%)		
Employment status			
Employed full time	628 (59.9%)		N/A
Employed part time	99 (9.4%)		
Self-employed	94 (9.0%)		
Not employed, but looking for work	80 (7.6%)		
Not employed or retired	82 (7.9%)		
Student or homemaker	91 (8.7%)		
Kratom product use in past 30 days (multiple answers possible)			
Leaf powder	245 (23.4%)		N/A
Extract powder	278 (26.5%)		
Extract liquid/tincture	167 (15.9%)		
Raw leaves	115 (11.0%)		
Capsules/tablets/pills	476 (45.4%)		
Tea bags	212 (20.2%)		
Shots	224 (21.4%)		
Gummies	305 (29.1%)		

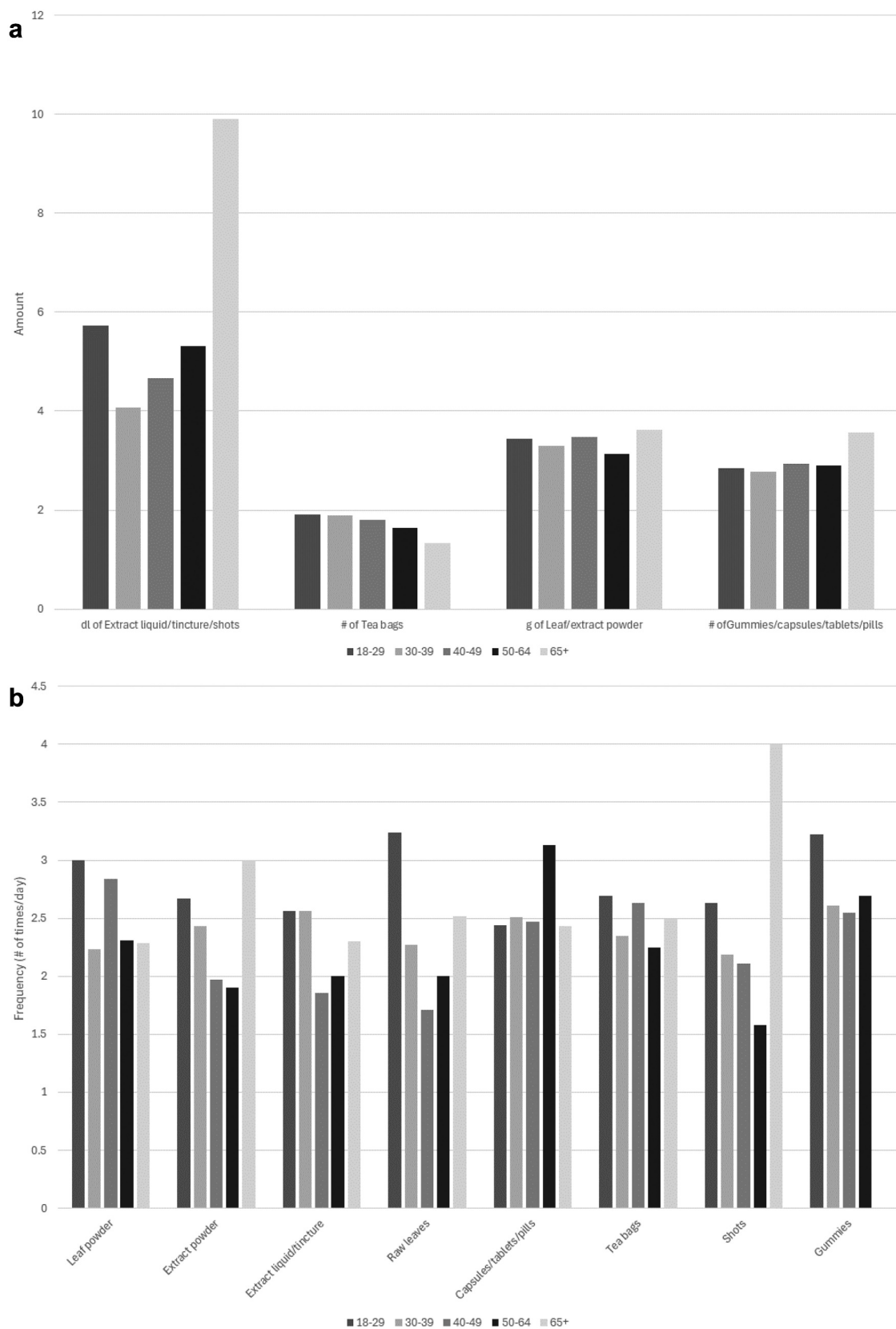


Figure 1. (a) Kratom amount/dose of different products by age group, (b) kratom frequency of use of different products by age group.

deciliter [dl] per dose) and respondents between 30 and 39 years using the lowest average kratom amount per dose (4.1 dl per dose). For amount of leaf or extract powder and amount of gummies, capsules/tablets/pills, respondents 65 years and older also consumed the highest average amount (Figure 1a).

In terms of highest daily frequency of use, raw leaf ranked highest among ages 18 to 29 (3.24 times/day); gummies for ages 30–39 years (2.61 times/day); leaf powder for 40–49 years (2.84 times/day); capsules, tablets or pills for 50–64-year-old respondents (3.13 times/day); and shots for 65 years and older respondents (4 times/day) (Figure 1b).

Kratom use for health conditions

The use of kratom for various health conditions, together with other substances, is displayed in Supplementary Table S1. The most common health condition kratom was used for by respondents was pain relief ($n = 603$, 57.5%) followed by relaxation and stress relief ($n = 562$, 53.6%) and to boost energy ($n = 520$, 49.6%). When kratom was endorsed to treat a condition, its use was almost always different (either more/less; higher/lower) than the other substances endorsed to treat that same condition. For example, more people used prescription drugs and kratom to treat opioid withdrawal than prescription drugs alone, while fewer people used kratom for relief of depression

together with prescription medicines than just prescription medicines alone. The two substance categories that were least different for each kratom use condition were over-the-counter medications and other substances. In contrast, respondents who did not use anything to treat a condition or who indicated not managing or treating the condition were less likely to use kratom.

Correlation of kratom use frequency and amount with beneficial effects

A linear-by-linear regression model was used to correlate frequency of daily use or amount per dose to the self-perceived beneficial effects of kratom for various conditions (Table 2). For kratom extract powder and shots, daily use frequency was positively correlated to self-treat pain relief, i.e., that higher frequency of use was rated as more beneficial. Euphoria and opioid withdrawal assistance were positively correlated with the use of capsules/tablets/pills. In contrast, both the use of leaf powder for relaxation and stress relief and the use of raw leaves for improved sleep were negatively correlated with frequency of use, i.e., that higher frequency of use was rated as less beneficial in self-treating these conditions.

For kratom amount per dose, only two positive correlations were identified (Table 3). Higher amounts of tea bags were rated as being more beneficial for boosting energy and higher amounts of leaf or extract powders

Table 2. Daily kratom use frequency correlation significance (p-values <0.05) with beneficial and adverse effects.

	Leaf powder	Extract powder	Extract liquid/tincture	Raw leaves	Capsules/tablets/pills	Tea bags	Shots	Gummies
Beneficial effects								
Pain relief	0.125	0.015*	0.912	0.859	0.842	0.822	0.009*	0.314
Boost energy	0.834	0.431	0.687	0.152	0.413	0.391	0.417	0.465
Relieve depression	0.751	0.154	0.996	0.884	0.574	0.668	0.347	0.242
Elevate mood	0.493	0.613	0.981	0.252	0.899	0.864	0.796	0.452
Decrease anxiety	0.663	0.555	0.450	0.556	0.892	0.240	0.513	0.704
Relaxation and stress relief	0.018#	0.349	0.124	0.082	0.411	0.687	0.459	0.907
Improved focus	0.356	0.149	0.371	0.238	0.190	0.788	0.721	0.181
Improve sleep	0.189	0.855	0.775	0.045#	0.463	0.441	0.116	0.251
Euphoria	0.551	0.205	0.613	0.610	0.041*	0.576	0.122	0.197
Opioid withdrawal assistance	0.469	0.342	0.957	0.321	0.004*	0.157	0.276	0.741
Adverse effects								
Anxiety and irritability	0.045#	0.669	0.162	0.532	0.164	0.547	0.081	0.302
Constipation	0.130	0.154	0.067	0.702	0.187	0.784	0.005#	0.339
Hallucination	0.536	0.960	0.833	0.369	0.881	0.863	0.270	0.407
Nausea	0.647	0.936	0.789	0.183	0.782	0.951	0.230	0.117
Vomiting	0.932	0.319	0.686	0.731	0.560	0.415	0.251	0.146
Dizziness	0.977	0.684	0.486	0.409	0.534	0.035#	0.125	0.005#
Drowsiness	0.740	0.119	0.970	0.118	0.055	0.972	0.523	0.285
Sleep disturbances	0.704	0.964	0.004*	0.020*	0.804	0.860	0.022*	0.333
Nervousness or restlessness	0.830	0.691	0.597	0.895	0.301	0.884	0.397	0.782
Slowed breathing	0.196	0.785	0.015*	0.516	0.631	0.406	0.821	0.899
Sweating	0.087	0.601	0.334	0.538	0.041#	0.738	0.044#	0.327
Weight loss over time	0.702	0.023*	0.927	0.378	0.994	0.607	0.062	0.073
Abnormal heart rhythms	0.159	0.530	0.486	0.629	0.282	0.884	0.019#	0.001#
Loss of appetite	0.751	0.386	0.908	0.665	0.523	0.634	0.114	0.324

* = significant positive correlation between increased amount/dose and greater beneficial/adverse effects, # = significant negative correlation between increased amount/dose and greater beneficial/adverse effects.

Table 3. Amount of kratom per dose correlation significance (p-values <0.05) with beneficial and adverse effects.

	Extract liquid/tincture/shots	Tea bags	Leaf/extract powder	Gummies/capsules/tablets/pills
<i>Beneficial effects</i>				
Pain relief	0.285	0.200	0.623	0.889
Boost energy	0.373	0.028*	0.76	0.329
Relieve depression	0.356	0.569	0.685	0.595
Elevate mood	0.092	0.273	0.075	0.326
Decrease anxiety	0.065	0.748	0.584	0.775
Relaxation and stress relief	0.659	0.766	0.861	0.172
Improved focus	0.175	0.219	0.403	0.652
Improve sleep	0.263	0.782	0.020*	0.079
Euphoria	0.155	0.493	0.308	0.169
Opioid withdrawal assistance	0.649	0.972	0.779	0.572
<i>Adverse Effects</i>				
Anxiety and irritability	0.053	0.753	0.169	0.367
Constipation	0.109	0.272	0.043*	<0.01*
Hallucination	0.144	0.106	0.105	0.099
Nausea	<0.01*	0.690	0.479	<0.01*
Vomiting	0.491	0.293	0.159	<0.01*
Dizziness	0.253	0.735	0.619	0.807
Drowsiness	0.759	0.861	0.425	0.498
Sleep disturbances	0.075	0.239	0.429	<0.01*
Nervousness or restlessness	0.276	0.784	0.692	0.760
Slowed breathing	0.619	0.079	0.293	0.187
Sweating	0.866	<0.01*	0.428	<0.01*
Weight loss over time	0.830	0.170	0.132	0.119
Abnormal heart rhythms	0.016#	0.01*	0.807	0.253
Loss of appetite	0.352	0.501	0.259	0.547

* = significant positive correlation between increased amount/dose and greater beneficial/adverse effects, # = significant negative correlation between increased amount/dose and greater beneficial/adverse effects.

for improved sleep. No negative correlations between kratom amount per dose and health conditions were identified.

Correlation of kratom use frequency and amount with adverse effects

Similar to beneficial effects, linear-by-linear regression models were used to correlate kratom use frequency or amount per dose with adverse or detrimental effects (Tables 2 and 3). Interestingly, less frequent use of kratom was more often associated with adverse effects than increased frequency of use (Table 2). Less frequent use of leaf powder was correlated with more anxiety and irritability. Constipation was more commonly reported with a lower frequency of kratom shot consumption. Similarly, less frequent use of tea bags and gummies was correlated with higher reports of dizziness. More frequent use of kratom shots and extract liquids or tinctures were correlated with sleep disturbances, as were extract powder use with weight loss over time. The decreased frequency of kratom shot or capsules/tablets/pills use was correlated with sweating, while the decreased frequency of kratom shot or gummy use was correlated with abnormal heart rhythm.

For kratom amount per dose, almost all correlations were positive, i.e., higher amounts of kratom per dose

led to a higher likelihood of adverse effects (Table 3). The most common dosage forms that were correlated with increased adverse effects, in particular constipation, nausea, vomiting, sleep disturbances and sweating, were gummies and capsules/tablets/pills. Increased leaf or extract powder amounts were only positively correlated with constipation, whereas more tea bags led to increased sweating. The only negative correlation was identified between extract liquid or tinctures and abnormal heart rhythm.

Concern of kratom dependence with frequency and amount of use

Average kratom frequency per day and amount per dose were compared with the degree of concern for kratom dependence (Table 4). The average frequency of use per day ranged from 1.8 times for extract powder to 3.4 times for gummies with no significant differences in frequency of use for any product formulation. However, the average amount used per dose was significant for all product formulations. For extract liquids, tinctures and shots, the lowest average amount per dose was correlated with “very concerned” by respondents. The opposite was the case for tea bags, leaf or extract powder and gummies/capsules/tablets/pills where increased amounts per dose correlated with increased concern

Table 4. Average amount of kratom per dose and daily kratom frequency by level of concern for dependence.

<i>Amount of kratom per dose</i>						
	Not at all concerned	Not very concerned	Neither concerned nor unconcerned	Somewhat concerned	Very concerned	Significance (p-value)
Leaf/extract powder (in g)	3.35	3.28	3.31	3.17	3.8	.007
Extract liquid/tincture/shots (in dL)	5.71	4.80	5.51	4.18	3.14	.005
Gummies/capsules/tablets/pills (#)	3.00	2.72	2.60	2.80	3.29	.003
Tea bags (#)	1.66	1.64	1.79	1.95	2.15	.002
<i>Daily kratom use frequency (# of times)</i>						
	Not at all concerned	Not very concerned	Neither concerned nor unconcerned	Somewhat concerned	Very concerned	Significance
Tea bags	2.46	2.31	2.33	2.56	2.68	.993
Capsules/tablets/pills	2.65	2.53	2.62	2.58	2.41	.854
Gummies	3.40	2.25	2.68	2.66	2.87	.756
Raw leaves	1.86	2.00	2.00	3.00	2.75	.405
Leaf powder	3.00	2.41	2.05	2.42	2.63	.404
Extract liquid/tincture	2.11	2.00	2.00	2.50	2.55	.370
Shots	2.57	1.83	2.32	1.90	2.36	.226
Extract powder	1.97	1.80	2.13	2.86	2.62	.068

for dependence. For all three product categories, the highest average amount per dose was in the “very concerned” category (Table 4).

Discussion

Consistent with findings from other studies, the kratom users in this investigation were predominantly middle-class, middle-aged, Caucasian, non-Hispanics. Notably, the reported lifetime prevalence in this study was approximately 9.1% (1,049 active kratom users out of a total sample of 11,545 respondents), reflecting a steady increase from previous data (Covvey et al. 2020; Palamar 2021). Respondents primarily cited pain relief ($n = 603$), relaxation and stress relief ($n = 562$) and energy enhancement ($n = 520$) as their main motivations for kratom use. A significant positive correlation was observed between the increased frequency of consuming kratom shots and extract powder with pain relief ($p = .009$ and 0.015 , respectively). This antinociceptive effect may be attributed to the activation of opioid receptors by mitragynine and its active metabolite 7-hydroxymitragynine. Additionally, a significant positive correlation was found between increased intake of kratom in the form of capsules/tablets/pills with the assistance of opioid withdrawal ($p = .004$), further suggesting the harm reduction effects of kratom and mitragynine through partial agonism of μ -opioid receptors.

The variation in adverse reactions experienced across different kratom dosage forms aligns with previous

findings, further indicating that certain kratom products may pose fewer issues for consumers (Rogers et al. 2024; Smith et al. 2024). Survey respondents reported a higher incidence of adverse effects as the amount of kratom per dose increased when using gummies, capsules, tablets, or pills. This may be due to higher extract concentrations or the ease of consumption associated with these forms, and by circumventing the unpleasant taste of unflavored kratom powder. Similar to findings from other self-reported surveys, respondents indicated experiencing symptoms of withdrawal, including gastrointestinal upset, restlessness, anxiety, irritability, sweating and dizziness – with increased frequency of kratom consumption (Grundmann et al. 2023; Rogers et al. 2024). Interestingly, kratom users in this survey reported greater concern for dependency associated with increased amounts per dose rather than with increased frequency of use. This contrasts with a study conducted by Rogers and colleagues (2024), which found a stronger relationship between frequency of use and kratom use disorder symptoms compared to amount consumed per dose (Rogers et al. 2024).

Overall, the reported effects of the various kratom products differ, which may be attributed to variations in the quantities of active alkaloids, the frequency of use, or the amount consumed per specified dose. The absence of standardization and consistency in kratom products results in fairly unpredictable effects, emphasizing the need for increased research to establish reliable safety guidelines for dosage recommendations.

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ORCID

Oliver Grundmann PhD  <http://orcid.org/0000-0003-2302-8949>

Data availability statement

The data that support the findings of this study are available from Research America Inc. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of Research America Inc.

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