



UCDAVIS
Innovation Institute
for Food and Health

UCDAVIS
GRADUATE SCHOOL
OF MANAGEMENT



**Barnstorm
Foundry**

THE MARKET FOR DECAFFEINATED COFFEE & COFFEE ALTERNATIVES

MARKET DISCOVERY PAPER
MARCH 2023

EXECUTIVE SUMMARY

Coffee has been consumed by humans for an extensive period of time and to this day, remains one of the most popular beverages globally. Due to coffee's prominence and history, researchers have investigated the benefits and risks of coffee consumption. Although coffee consumption provides a number of researched health benefits, studies have also highlighted potential risks stemming from its bioactive components such as caffeine and explored their impact on the human body. This report provides a summary of investigated benefits and risks associated with coffee and caffeine consumption. Type 2 Diabetes, Cardiovascular Disease and Alzheimer's Disease are three major areas of focus.

Decaffeinated coffee is consumed as a coffee alternative, particular for individuals concerned with caffeine's health impacts. This report will discuss the four common commercial methods of decaffeinating coffee and their associated benefits and risks. Solvent-based methods are still the most prevalent method due to their low cost and ease of use. Swiss water decaffeination is increasing in popularity, particularly within the organic segment but the increased costs remain a barrier for widespread adoption.

A steadily growing industry (\$1.65B with a projected Compound annual growth rate (CAGR) of 5-7% in the next decade), the decaf coffee market has several major players that dominate in terms of market share. A section of the report will discuss the state of the market, the competitors as well as the rivals that new entrants will have to face. Alternatives such as brewed teas, plant-based (chicory and dandelion) brewed coffees, and adaptogen coffees are explored and discussed as well.

Although the decaf coffee market is squarely in a Red Ocean environment, there are a few identified areas of opportunity.

The closing section of the report discusses the avenues that new entrants can investigate to ensure successful entry into the market. These areas of opportunities are based on observations of the existing competition as well as the identified coffee alternatives. Research indicates 18–24-year-olds as a potentially underserved segment and creating product features that target that segment may be beneficial. The lack of creativity in current decaf coffee product offerings also points to a potential area to explore further.

CONTENT

1	Executive Summary
6	Background and Definitions
7	Methodologies for Decaffeinating Coffee
7	Solvent-based Methods
8	Swiss Water Method
9	Carbon Dioxide (CO2) Method
9	Emerging Decaffeination Methods
11	Health Impacts of Coffee and Caffeine
12	Health Benefits of Coffee Consumption
12	Type 2 Diabetes (T2D)
13	Cardiovascular Health
14	Alzheimer's Disease and Dementia
15	Impact of Caffeine
16	Impact of Decaffeinated Coffee
17	Health Impacts: Conclusion
18	State of the Market
18	Market Size and Activity
19	Market Segmentation and Persona
22	Major Players within the Decaf Market
24	Coffee Alternatives and Other Rivals

CONTENT

24	Alternative Brewed Coffees
25	Brewed Teas
28	Adaptogen Coffees
29	Closing Summary and Recommendations
32	Contributors
33	References

BACKGROUND AND DEFINITIONS

The coffee making process begins with the *Coffea* plant. The cherry is harvested, and the seed is extracted. This seed is what the market defines as the coffee bean. There are a variety of methods that can be used to process the cherry into the dried beans, and each come with a trade-off between flavor and acidity. The dried bean is then classified as green coffee beans, which must be roasted before they can be used in making coffee.¹

Caffeine is naturally found in 28 plants including the *Coffea* plant and its variants.

Researchers have conjectured that caffeine helps the plant by acting as a natural pesticide due to its toxicity to insects in high volumes. Different individual plants contain varying amounts of caffeine.² Because of that, the average caffeine content for a standard portion of coffee can vary. According to the US Department of Agriculture (USDA), the average caffeine content for 100g of coffee is 40mg.³

Driven by public concerns regarding the effects that consuming caffeine may have on health, coffee producers developed and marketed decaffeinated coffee in an attempt to retain the taste and benefits of coffee. Ludwig Roselius is credited with developing the first commercial decaffeination process in 1905/1906.^{4,5}

The current, general definition of decaf coffee within the US market is: coffee that does not contain (or contains insignificant amounts) of caffeine. Although the federal government has not set required caffeine thresholds for decaf coffee, the USDA has issued a number of Commercial Item Descriptions (CIDs) for a variety of coffee products (Coffee, Soluble Coffee and Coffee Drink Mixes). CIDs provide a precise

definition of a commercial product and include testing details for food safety and quality, but are not commercial regulations set by the government. All 3 CIDs provide details on the tolerance level of caffeine for decaffeinated coffee in its various forms:

Decaffeinated Coffee: Shall not exceed 0.1%⁶

Soluble Coffee (Instant Coffee): Shall not exceed 0.3%⁷

Unflavored and Flavored Coffee Mix: Shall not be greater than 0.07%⁸

Methodologies for Decaffeinating Coffee

There are currently four common methods to commercially remove the caffeine from coffee. All methods decaffeinate the green coffee beans before it goes through the roasting process; decaffeinating the coffee after roasting and processing has a substantial impact on the taste of the coffee.¹³

Solvent-based Methods

The first two methods utilize chemical solvents to remove the caffeine. The direct method begins with a steaming of the green beans, which opens the pores and allows easier interaction with the solvent. Although a variety of solvents have been commercially used, the two most used ones are methylene chloride and ethyl acetate. The Food and Drug Administration (FDA) has approved the usage of methylene chloride as a decaffeination agent as long as it does not exceed a parts per million (ppm) of 0.001%. The beans are then soaked in the solvent for several hours. The caffeine is absorbed by binding to the solvent. After the soaking is complete, the beans are rinsed and steamed again to remove remnants of the solvent in the bean.^{14,15}

The second method also utilizes solvents, but in an indirect manner. The process begins by soaking the green beans in near-boiling water for a period of up to 10 hours. This draws out key components of the coffee including caffeine, oils and micronutrients that impact coffee flavor. The green beans are taken out of the mixture, and solvents are introduced into the liquid which again bond with the caffeine. This mixture is steamed and due to the solvent's lower boiling point (as compared to water), it evaporates with the bonded caffeine while leaving the oils and micronutrients. The green beans are reintroduced into this liquid to absorb what is left.¹⁵

Both above methods have raised safety concerns due to the nature of the chemicals used. In the direct method, the steaming helps to remove solvents that were introduced in the caffeine extraction process, but remnants may remain. This concern is mitigated, however, by the coffee roasting process, which adds another layer of protection for consumers. Since the solvent's boiling point is much lower than the commercial roasting temperature of coffee beans, any remaining solvents would be removed from the heat.¹⁶

Swiss Water Method

The third method is commonly known as the Swiss Water Method. This process does not use solvents and instead utilizes activated charcoal filters and temperature-induced caffeine extraction. Like the indirect method, the green beans are soaked in near-boiling water to extract the caffeine, oils and micronutrients. The green beans are taken out of the mixture and discarded. This leftover solution (called Green Coffee Extract, or GCE) is then passed through an activated charcoal filter, which removes the caffeine but leaves the rest of the liquid intact. A new batch of green beans are introduced to the liquid. Since the GCE already contains all the non-caffeine elements, it will only extract the caffeine from this new batch of beans and render it 99.99% caffeine free. The GCE can also be used multiple times before replacement or replenishment is required.^{13,15}

Carbon Dioxide (CO2) Method

The last common method is the Carbon Dioxide (CO2) process. This process is built around CO2 in its supercritical state, where it can act as a solvent and selectively extract caffeine. This is done by increasing the CO2's temperature and pressure to its critical point. The process begins in the same way – it is first steamed to increase porosity and allow caffeine to be extracted. The supercritical CO2 is then introduced into the system which extracts the caffeine from the green beans. A linked storage of water draws the caffeine from the CO2, allowing for longer periods of caffeine extraction.¹⁵

The Swiss Water and CO2 methods come with significant benefits, mostly in the form of flavor retention. Both methods also avoid the usage of chemicals, which helps to remove some consumer fears around the consumption of decaf coffee.¹⁶ The major drawback for these two alternative methods is the increased cost for producers. Both methods take a much longer period of time (24 hours and 12 hours for Swiss Water and CO2 methods, respectively) which increases production costs. A study conducted in 2017 examined the environmental impact of the CO2 method, and concluded that there are considerable environmental impacts, mostly from the transportation and steaming stages of the process.¹⁸ The study recommends modifications to the process to reduce the environmental impact.

Emerging decaffeination methods

To answer the demand for a safe, eco-friendly, and better-tasting decaffeination method, new technologies adapted to regular caffeinated beverages are being developed. An innovative product commercialized by the company *Decafino* uses polymer-containing “tea bags” acting as a magnet to trap caffeine molecules directly from the cup.^{18B} Made from food-grade ingredients that are generally recognized as safe by the FDA, these composite caffeine absorbents

can remove up ~65-80% of caffeine from a cup of coffee or tea in four to eight minutes without impacting the flavor of the beverage.

Other solutions aiming to reduce caffeine content directly from the *Coffea* plant are emerging. This includes the selection of naturally low-caffeine varieties such as *Coffea Laurina* and *Coffea Eugenioides*. However, as mentioned earlier caffeine plays an important role in the plant defenses implying some yield limitation observed in low-caffeine plants. With the recent advent in genetic engineering, current efforts using CRISPR technology focus on the development of *Coffea* plant silenced for their caffeine-making pathway in the coffee beans without affecting the leaves to minimize growth perturbation.^{18C,18D} While this strategy appears promising, genetically engineered coffee may still have to overcome public acceptance barriers.

HEALTH IMPACTS OF COFFEE AND CAFFEINE

Coffee is consumed for a variety of reasons outside of simply boosting energy levels as a vessel for caffeine. Other health benefits include a potential reduction in risk of developing Type 2 diabetes¹⁹, increased protection against brain diseases such as Alzheimer's and dementia²⁰ as well as reduced risks of cardiovascular diseases²¹. These health benefits stem from the various bioactive components present within coffee, namely caffeine, chlorogenic acid, diterpenes and trigonelline.²⁵

For consumers who want to take advantage of the various benefits associated with coffee but not risk the impact of excessive caffeine intake, they can turn to decaffeinated coffee. An approximate 15% of consumers in the US consumed decaffeinated coffee.⁴⁷ This number is expected to grow, particularly in the specialty decaf segment. The growth trend indicates an increased interest and demand in decaffeinated coffee. Health concerns may be a key driver of this increased interest and studies have been conducted to investigate the impact of caffeine on the human body.

HEALTH BENEFITS OF COFFEE CONSUMPTION

Type 2 Diabetes (T2D)

Diabetes is becoming an increasingly common and expensive medical issue, particularly in the US. Based on the Institute of Alternative Future's projections for diabetes, between 2015 and 2030 the number of Americans with diabetes will grow to 54.9 million (54% increase from 2015) with an associated cost of more than \$622 billion by 2030.²² According to the Centers for Disease Control and Prevention (CDC), approximately 90-95% of diabetes cases are T2D.²³

With a growing number of lives at risk, solutions to reduce the impact were sought out through both pharmaceutical and nutritional routes. Due to the global, widespread consumption of coffee, researchers have investigated the impact of coffee consumption on common but debilitating health issues, including T2D. A meta-analysis²⁴ conducted in 2018 aggregated and evaluated 30 studies conducted between 2002 and 2015 and found a 30% reduction of risk in developing T2D in consumers that were regular consumers of coffee. The study explores a number of potential explanations for this, including the thermogenic and antioxidative effect of coffee.

Research into the connection between coffee and weight have found evidence that habitual consumption leads to increased energy expenditure, enhanced satiety, and thus weight-loss.²⁶ This study also highlights potential health risks of heavy caffeine consumption, particularly for cardiovascular health and expands on the possibility of other non-caffeine, bioactive compounds such as chlorogenic acid and their impact on reducing diabetes risks.

Studies have linked the reduction in T2D risks from consumption of antioxidants,^{27,28,29} and coffee in its various forms contain some of the highest antioxidants within the beverages category;³⁹ a related study also found chlorogenic acid to be the main contributor of antioxidants within coffee.³¹ Although no comprehensive study has been conducted to measure the impact of common decaf methods on chlorogenic acid content, a study³² found a 3-9% reduction in chlorogenic acid within roasted decaffeinated coffee. Interestingly, it reported a 17% increase in chlorogenic acid within decaffeinated green coffee beans.

Cardiovascular Health

In 2016, 121.5 million Americans had some form of Cardiovascular Disease (CVD) and has been the leading cause of death since 1921.⁴¹ In 2020, CVD caused 696,962 deaths.⁴² Similar to T2D, the importance of this public health issue has prompted multiple studies on the impact of coffee consumption on CVD.

A study published in 2017 concluded a 15% reduction in CVD risk in healthy individuals who habitually consume three to five cups of coffee a day.⁴³ Potential causes of this effect are the various bioactive components of coffee that provide antioxidative and anti-inflammatory effects and improved insulin sensitivity.⁴⁴ For high-risk groups such as individuals suffering hypertension, the study cautions against habitual, heavy consumption of coffee as it was linked to uncontrolled blood pressure. A separate study supported the anti-inflammatory effects of coffee consumption but highlights both the anti and pro-inflammatory effects of caffeine found in various studies. It concludes that caffeine may not be the component leading to this health benefit of coffee consumption.⁴⁵

Strokes are another major form of CVD, and a study of 2.4 million participants found a 21% reduction in risk of stroke in coffee consumers.⁴⁶ The study highlights caffeine, diterpene and chlorogenic acid as major

contributors to this effect.

Alzheimer's Disease and Dementia

Alzheimer's Disease (AD) is another growing public health problem in the US, with more than 6.5 million recorded cases and upwards of \$355 billion spent in 2021 for patient care. AD is predominantly present in people 65 and older, accounting for 94% of recorded cases.³⁴ The number of Americans with AD is projected to grow to 12.7 million by 2050 (a 95% increase), particularly due to its aging population (25% of the US population is projected to be 65 and older by 2060).³⁵ With no cure currently available for dementia, researchers have also focused on ways to reduce the risk of developing AD.

Current research on the connection between coffee consumption and risk for AD appears conflicted.³⁶ One study found a 27% reduction in AD risk when comparing participants with the highest and lowest coffee consumption.³⁶ Another, demonstrated a protective effect of caffeine for mice with AD.³⁸ Several studies however show no or negative correlation between the two and highlights the difficulty in associating specific bioactive components of coffee to their impact on the body.^{37,38} The consensus is that more clinical trials are required to confirm these potential health effects. Reduced risks of T2D as well as better cardiovascular health could also be potential explanations of these effects, due to their impact on the development of AD.^{39,40}

IMPACT OF CAFFEINE

Studies have found evidence for correlation between coffee consumption and health benefits, particularly for T2D and cardiovascular health. These studies were unable to directly attribute these effects to caffeine and insufficient evidence exists to attribute the specific bioactive components of coffee to specific health benefits. A number of published studies have also explored the various negative health effects linked to caffeine consumption, in particular anxiety, insomnia, increased blood pressure and potential for addiction.^{48,49,50}

The consensus from these studies indicates that many of these health effects are linked to or exacerbated by the excessive consumption of caffeine. Research from the 1980's and 1990's explored caffeine-induced anxiety and most linked heavy consumption of caffeine to increased anxiety and reported that the benefits of habitual, moderate caffeine outweighed the associated risks.⁴⁹ More recent studies investigated the impact of caffeine consumption on anxiety and depression, particularly for children and students.^{51,52,53} In terms of anxiety, the findings from a secondary school in England indicate no positive correlation between caffeine consumption and increased anxiety. The report does highlight heavy caffeine consumption as a predictor for high anxiety within students. A study of caffeine consumption's impact on depression in Korean middle school students found a connection between higher caffeine consumption and increased severity of depression and anxiety. Similarly, a study of caffeine intake's impact on mental health in college students at Florida State University found a positive correlation between caffeine consumption and both anxiety and depression. Both studies had small sample sizes and cannot definitively prove caffeine to be the cause of anxiety or depression.

IMPACT OF DECAFFEINATED COFFEE

A recent report published in 2020 explored the current research on decaf coffee intake and highlighted several key benefits: anti-inflammatory and antioxidants activities as well as antibacterial, antiviral and antifungal in other components of coffee.⁵⁴ In terms of the antibacterial benefits, chlorogenic acids are again found to be the leading contributor of this effect. Roasted coffee beans also contain another compound called melanoidins, which have been found to have natural antibacterial effects.⁵⁵ Both chlorogenic acids and caffeic acid (another component commonly found in coffee) have observed benefits against viruses such as herpes, hepatitis B virus and certain respiratory viruses.^{54,56}

Another study comparing the effects of caffeinated and decaffeinated coffee consumption also found that decaf coffee led to reduce waist circumference within participants.⁵⁷

HEALTH IMPACTS: CONCLUSION

Due to the widespread and habitual consumption of coffee globally, multiple studies have been conducted on its consumption and how it relates to human health. Specific studies of each bioactive component of coffee have also been conducted to explore correlations with specific health benefits. Existing research generally conclude that moderate, habitual consumption of coffee provides health benefits that can be associated with caffeine, chlorogenic acids or CA. Although no definitive link between caffeine consumption and anxiety or depression has been found, research does point towards increased risks due to heavy consumption.

Decaf coffee has also been found to have many of the benefits associated with coffee consumption. Studies on the impact of decaf consumption have not proven significant negative health effects. Methylene chloride, one of the two most common solvents used in the decaffeination process, does have harmful effects if ingested.^{58,59} The FDA allows the use of this chemical for this purpose and have set a required maximum level of 10 ppm.⁶⁰ Solvent-free methods such as CO₂ and Swiss Water decaffeination eliminate this concern.

STATE OF THE MARKET

Market Size and Activity

The global decaffeinated coffee market is valued at \$1.65B in 2019 and is expected to grow at 5-7% CAGR from 2021 to 2031. The US is estimated to hold \$433.8M of that market.^{9,10,11}

Transparency Market Research⁹

2021 - 2031: 7.9% CAGR

\$6.93B in 2021, \$14.8B in 2031

\$2.73B in Europe in 2021

Research and Markets¹⁰

\$1.6B in 2020, \$2.4B by 2027

US Market: \$433.8M

2020-2027: 5.8% CAGR

Grand View Research¹¹

\$1.65B in 2019, \$2.8B by 2027

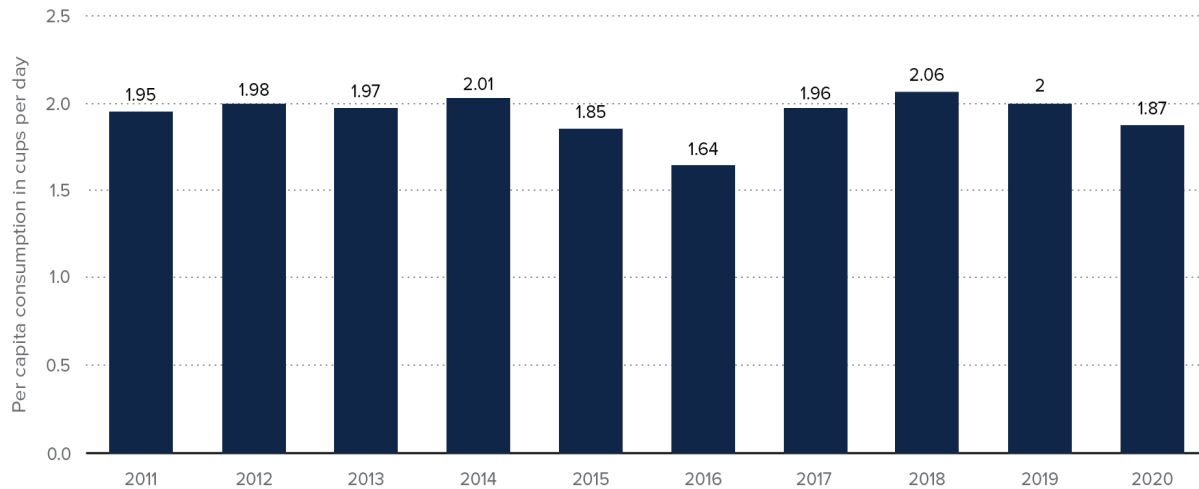
2020-2027: 7% CAGR

Raw decaf: 60% of global revenues (2019, \$1B)

Roasted: Expand fastest CAGR of 8.1% from 2020 to 2027

The market has observed considerable growth over the last decade. Although the total coffee per capita consumption in the US from 2011-2020 has remained relatively consistent (with drops in 2015 and 2016), the decaffeinated coffee per capita consumption fluctuated in the last decade, peaking in 2017 at 0.39 cups per day.¹²

Total coffee per capita consumption in the United States from 2011 to 2020 (in cups per day)

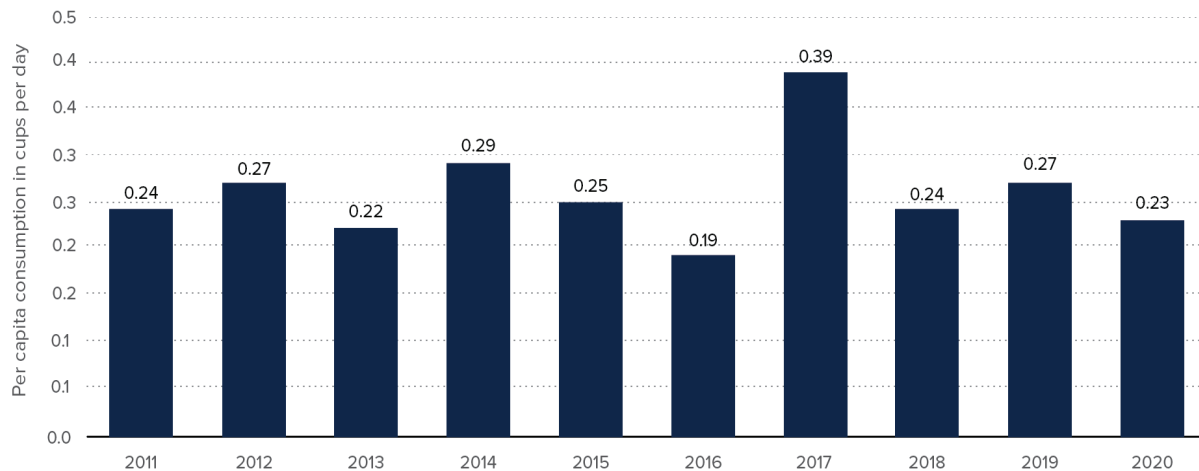


Description: In 2020, Americans drank an average of 1.87 cups of coffee per day. Between 2011 and 2020, U.S. coffee consumption per capita per day remained relatively close to two cups, with the exception of 2016, when survey respondents drank roughly 1.64 cups of coffee per day.

Note(s): January 2020; 2,838 respondents; 18 years and older; both males and females, who consumed a beverage other than tap water the day prior to being interviewed

Source(s): National Coffee Association

Decaffeinated coffee per capita consumption in the United States from 2011 to 2020 (in cups per day)



Description: In 2019, American coffee drinkers had roughly 0.23 cups of decaffeinated coffee per day. Decaffeinated coffee consumption in the United States fluctuated between 2011 and 2020, reaching its peak in 2017 when Americans drank roughly 0.39 cups of decaf per capita per day.

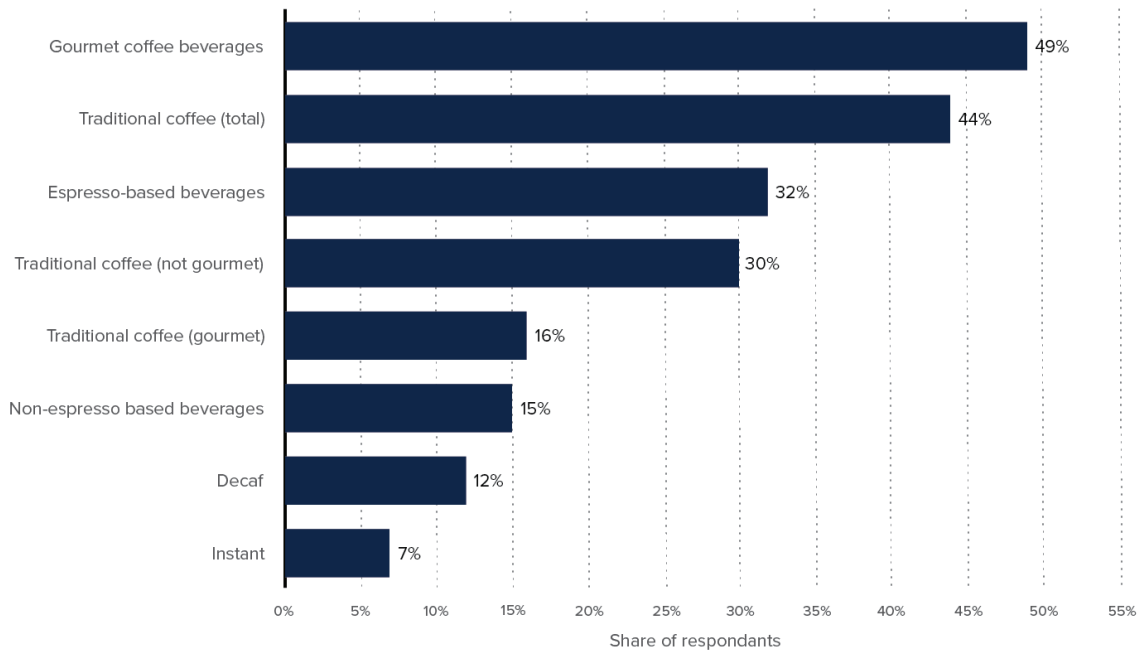
Note(s): United States, January 2020, 2,838 respondents, 18 years or older, both males and females, who consumed a beverage other than tap water the day prior to being interviewed, online survey

Source(s): National Coffee Association

Market Segmentation and Persona

Based on an online survey conducted by the National Coffee Association, Hispanic-Americans are the leading ethnicity for decaf drinkers, with 12% of their coffee consumption being decaf.

Coffee consumption share among Hispanic-Americans in the United States in 2020, by type of coffee



Source

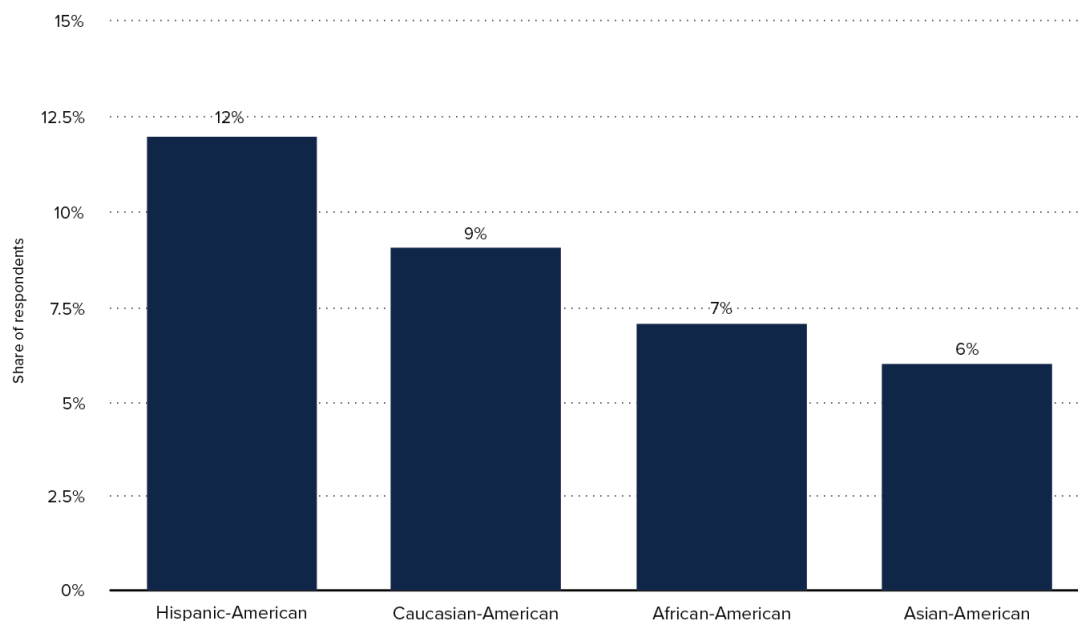
National Coffee Association
© Statista 2022

Additional Information:

United States; National Coffee Association; January 2020; 510 respondents; 18 years or older; both males and females, than tap water the day prior to being interviewed; Online survey

Decaf coffee consumption for Caucasian-Americans, African Americans and Asian-Americans account for 9%, 7% and 6% respectively.

Share of decaffeinated coffee consumption in the United States in 2020, by ethnicity*



Source

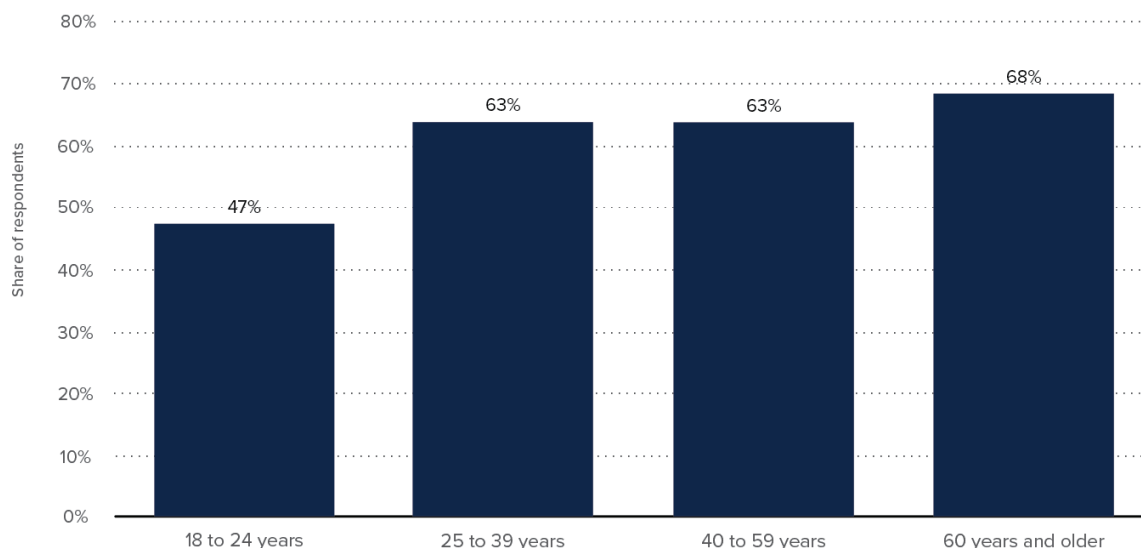
National Coffee Association
© Statista 2022

Additional Information:

United States; National Coffee Association; January 2020; 2,838 respondents; 18 years or older; both males and females, than tap water the day prior to being interviewed; Online survey

In terms of age, individuals between 18-24 account for 19% of decaf consumers and are the largest consumer group.¹¹

Share of coffee drinking consumers in the United States in 2020, by age group



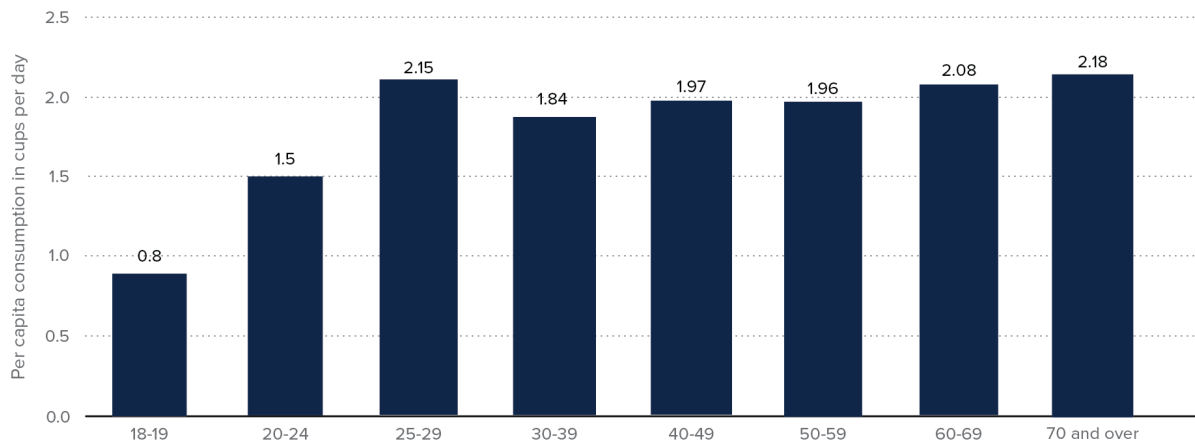
Description: In 2020 coffee was still an extremely popular beverage among Americans of all ages. Nearly half of 18 to 24-year-olds drank the beverage and almost 70 percent of seniors did as well. Not only are seniors more likely to be coffee drinkers than their younger cohorts, but they drink about three times as many cups a day as well.

Note(s): United States, January 2020, 2,838 respondents, 18 years or old, both males and females, who consumed a beverage other than tap water the day prior to being interviewed, online survey

Source(s): National Coffee Association

Articles have cited the increasing awareness and emphasis on health concerns within this age group as a leading cause of decaf popularity and growth. Interestingly, in 2020 this age group accounted for the lowest total coffee per capita consumption, and only 47% drank coffee. This indicates potential room for future growth within this specific segment of the population.

Total coffee per capita consumption in the United States in 2020 by age group (in cups per day)

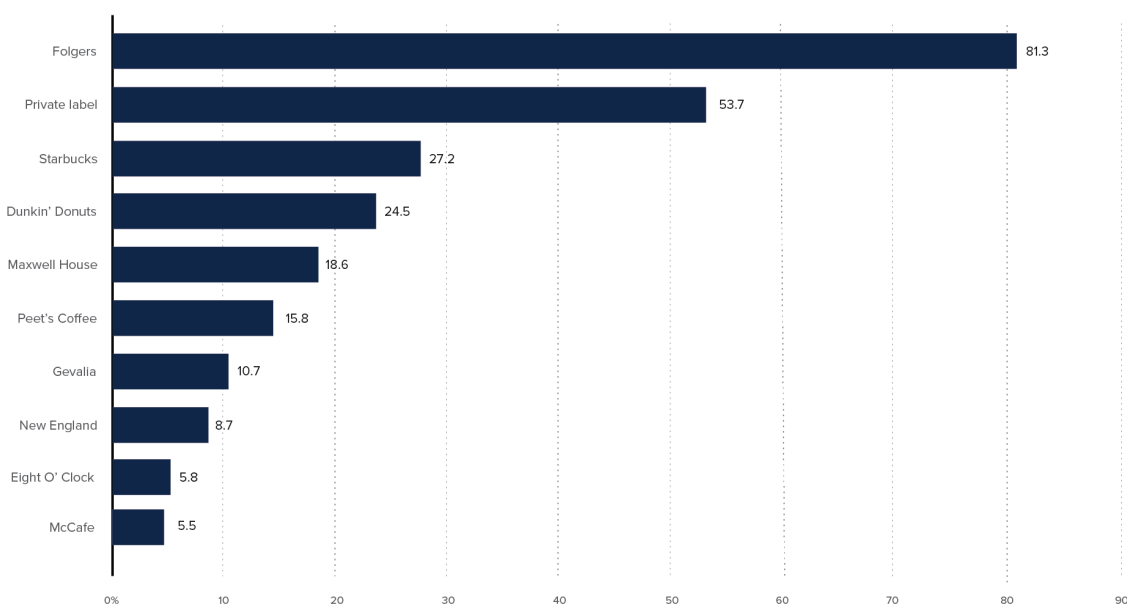


Description: In 2020, people aged 70 and over drank about 2.18 cups of coffee per capita in the United States, making it the age group that drank the most coffee on average that year. U.S. coffee consumption for respondents between the ages of 25 and 29 stood at roughly 2.15 cups a day.
Note(s): January 2020; 2,838 respondents; 18 years and older; both males and females, who consumed a beverage other than tap water the day prior to being interviewed
Source(s): National Coffee Association

Major Players within the Decaf Market

Based on a report published by Grocery Headquarters in 2017, the leading ground decaf coffee brands in the US at the time are below:

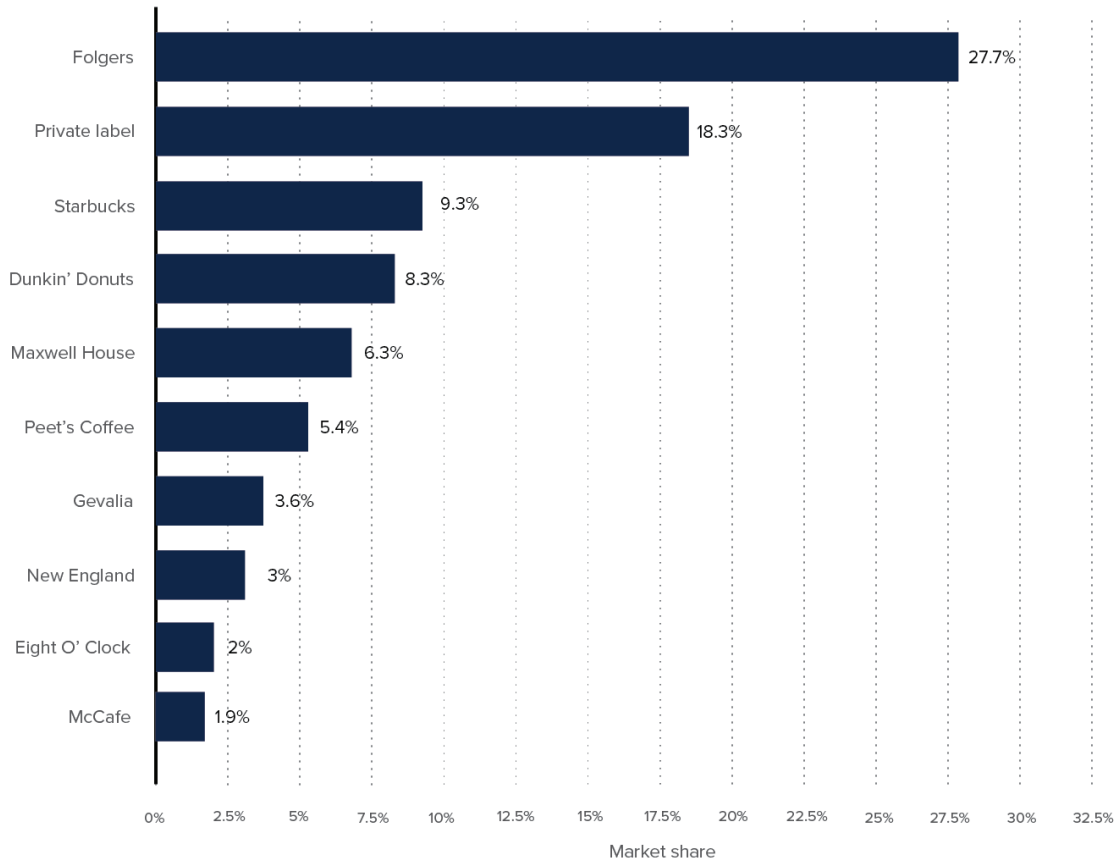
Sales of the leading ground decaffeinated coffee brands in the United States in 2017 (in million U.S. dollars)



Source
 Grocery Headquarters; IRI
 © Statista 2022

Additional Information:
 United States; IRI; 52 Weeks ended January 22, 2017

Market share of the leading ground decaf coffee brands in the United States in 2017



Source
Grocery Headquarters; IRI
© Statista 2022

Additional Information:
United States; IRI; 52 Weeks ended January 22, 2017

The Folger Coffee Co., Starbucks, Dunkin' Donuts, Maxwell House and Peet's Coffee are the top brands within the industry. Private label products also account for a significant 18.3% of the market share, while Folger's leads the market at 27.7%. Folger's is already the largest vendor of regular ground coffee⁶¹, and they have been able to leverage that to dominate the ground decaf coffee market as well.

Coffee Alternatives and Other Rivals

With additional scrutiny put on caffeine and its impact on the human body, companies have expanded into other alternatives that provide similar benefits of coffee. These include brewed “coffee” alternatives that use other base ingredients, such as chicory, cacao and dandelion. Another popular category are teas, particularly matcha and yerba mate. Lastly, adaptogen coffees combine regular brewed coffee with adaptogens such as ginseng and ashwagandha, and are increasingly popular⁶² due to additional health and energy benefits.

Alternative Brewed Coffees

Chicory, a plant within the dandelion family, is a source of various nutrients, vitamins and fiber.⁶³ Chicory coffee is made by simply brewing roasted and grinded chicory root. A study found evidence that suggest certain benefits of chicory roots for gut health and regulating blood sugar levels⁶⁴, but more research is needed to confirm the effects and identify the root cause. Chicory is also caffeine free and is thus attractive for coffee drinkers that want to reduce their caffeine consumption. Lastly, a study of bioactive components in coffee substitutes also found potentially toxic substances within chicory that could trigger allergic reactions if consumed.^{63,65} Closely related to this is dandelion coffee and it is also brewed using the roasted and grinded plant root. Its popularity stems from its closeness in terms of color and flavor to coffee, as well as benefits very similar to chicory.⁶⁶ Dandelion also contains bioactive components such as caffeic acid and chlorogenic acid, which were both discussed as potential causes of various health benefits of coffee.

Popular brands such as *Dandy Blend* combine these two roots, as well as sugar beetroot, barley and rye to create a strong coffee substitute.⁶⁸ A study published in 2014 explored the acceptability of dandelion brewed coffee and tea in Egypt and conducted a panelist taste testing experiment. It found that dandelion roots mixed with light Arabic coffee or instant coffee were most highly received and dandelion roots that were simply brewed with water were the least preferred.⁶⁹ This suggests the importance of combining these roots with a variety of other ingredients to improve taste and acceptability.

Brewed cacao is another coffee alternative with various similarities in terms of appearance and taste to coffee. The process of making brewed cacao is identical to coffee - the cacao bean is roasted and grounded before it is brewed.⁷⁰ The brew is normally made using a French press or via cold immersion to create a cold brew. The cacao itself contains antioxidants, iron as well as theobromine, a stimulant that is plentiful in cacao but not in coffee.^{71,72,73}

Brewed Teas

Teas are another vastly popular beverage that share some benefits to coffee. Due to its long association and history, a wealth of research exists on the health benefits of tea consumption. Because of its high polyphenol content and thus rich amounts of antioxidants, it has also been reported to reduce the risk of T2D and cardiovascular disease and certain cancers, as well as improved metabolic health.^{74,75}

Matcha tea is frequently highlighted as one of the best teas to consume for its health benefits. Although it comes from the same plant as regular green tea, the entire leaf is ground up and used to brew the tea. The end result is a tea that contains even higher levels of antioxidants and bioactive compounds.⁷⁶ Many of the health risks associated with consumption of tea arise from the same risks previously associated with caffeine.⁷⁷ The tea variety and preparation method impact the caffeine content, but in general caffeine content for all forms of coffee are higher than that of brewed tea. The table below compares the two beverages in its various forms:

Coffee drinks	Size in oz (mL)	Caffeine (mg)
Brewed	8 (237)	96
Brewed, decaf	8 (237)	2
Espresso	1 (30)	64
Espresso, decaf	1 (30)	0
Instant	8 (237)	62
Instant, decaf	8 (237)	2

Teas	Size in oz (mL)	Caffeine (mg)
Brewed black	8 (237)	47
Brewed black, decaf	8 (237)	2
Brewed Green	8 (237)	28
Ready to drink, bottled	8 (237)	19

Yerba mate, a plant native to South America, is another tea that has been growing in popularity, due to its energy providing benefits as well as the associated brewed tea health benefits. The yerba mate industry is expected to grow to \$316.12 million by 2025, with a CAGR of 4.50% between 2021-2025. Argentina, Brazil, Uruguay and other South American countries are expected to contribute 72% of the growth.⁷⁸ *Guayaki* is the leading yerba mate brand in the US, owning 65% of the market share for North America⁷⁹ in 2005, and had sales revenue of \$27 million in 2014.⁸⁰ The company sells both yerba mate in its tea leaf form, as well as canned carbonated yerba mate drinks and energy drinks. These three product categories remain as the dominant form of yerba mate beverages on the market.⁸¹

A study published in 2021 explored the benefits and risks of yerba mate and concludes the antioxidant, anti-inflammatory, anti cancer effects, as well as reduced risks of cardiovascular disease.⁸²

Adaptogen Coffees

Adaptogens are classified as plants and fungi that provide health benefits to humans by increasing resistance and speeding up adaptation to stress.⁸³ Adaptogens have been consumed for an extended period of time in various parts of the world, particularly in East and South Asian traditions.⁸⁴ Popular examples of adaptogens included ginseng and holy basil. Due to its long history and prevalence, studies have looked into health impacts of adaptogens such as ginseng and have been able to conclusively link their consumption to increased resistance to stress in humans.^{84,85} They also act as regulators and help the body return to proper immune responses. Other studies have highlighted reduced risks for CVD and inflammatory diseases. Adaptogen coffees are made by combining adaptogens with brewed coffee and provide benefits from both beverages, and certain adaptogens have been shown to regulate the impact of caffeine on participants.⁸⁶

Three major downsides have been identified for adaptogens; the first is the increased cost compared to regular coffee. A quick comparison of top ground coffees and top ground adaptogen coffees on Amazon showed the cost per ounce is significantly higher, with regular ground coffee averaging \$0.59 per ounce and adaptogen coffees averaging \$2.35 per ounce.

Secondly, there are also concerns regarding the regulation and safety of adaptogens. Since they are not regulated as a drug for safety or efficacy, it may be difficult to ensure consistent quality and safety for consumers. Lastly, additional research needs to be conducted to confirm and add evidence to the benefits associated with adaptogens.

CLOSING SUMMARY AND RECOMMENDATIONS

Coffee will continue to be one of the major beverages consumed globally by consumers primarily due to its energy-boosting properties, as well as the associated health benefits. Although there is a body of evidence that suggests potential negative health impacts from the consumption of caffeine, particularly in cases of heavy consumption, there is currently insufficient evidence to conclusively make that claim. With that said, consumers have started to explore coffee alternatives that do not contain caffeine and the market has seen increased demand for these beverages. Many of these alternatives contain the same health benefits that coffee provides.

The decaf coffee market continues to grow, particularly within the 18-24 age range. Evidence suggests this trend stems from a more health conscious population who are increasingly careful with their consumption of caffeine. Research also indicates that the majority of health benefits of coffee remain after the decaffeination process. The decaffeination method makes an impact on the taste and potential health risks of the coffee and methods such as the CO₂ and Swiss water methods alleviate many of these drawbacks at the cost of increased production expenses. The popularity of the discussed coffee alternatives may force companies to use these more expensive methods to ensure minimal reduction in taste and health benefits from consumption.

New entrants into the decaf market will be facing a steep, uphill battle. They are entering a steadily growing, yet saturated market where major players have had a long-standing dominance of market share.

Developed partnerships in transportation, production and distribution of these players allow them to take advantage of economies of scale that smaller entrants may not have. The current supply chain issues plaguing global logistics and transportation will exacerbate this situation and increase startup and setup costs for small-scale new entrants. Rival products, in particular adaptogen-based beverages, will also need to be carefully considered and their associated health benefits researched. New decaf coffee products will have to showcase their superior value in terms of health benefits or price when compared to these growing alternatives.

With that in mind, there are a few areas of opportunity within this market: all of the popular decaf coffee products are simply decaffeinated versions of flagship coffee beans (such as Starbucks' house blend, or Folgers' classic) instead of specialty beans grown specifically for decaf purposes. In addition, companies still tend to use solvent-based methods to decaffeinate their coffee beans (Folgers uses ethyl acetate for their Classic Decaf Ground Coffee while Starbucks' uses methylene chloride for the majority of their decaf coffee) which not only retains the health risk associated with the solvents, but also created coffee with subpar tastes. New entrants should investigate both of these areas further.

Secondly, previously cited research showed a potentially underserved market for decaf coffee: 18-24 year olds. Current offerings from major decaf brands generally have dated packaging and design (in particular Maxwell House and Folgers). The growing popularity of small-scale, private label coffee brands indicate consumers' interest and willingness to purchase them for a variety of social, financial or environmental reasons. A cursory look at popular private label coffee brands show packaging that is sleeker, more modern and minimalistic. The marketing aspect is another area of consideration and potential differentiation for new entrants to seriously consider.

Lastly, new product offerings should also consider combining decaf coffee with other materials with health benefits, such as adaptogens or other herbs and plants discussed above. Since decaf coffee is observed to retain many health benefits of coffee without the risk of caffeine consumption, it should remain as a base component; but since reduced taste tends to be a common aftereffect of the decaffeination process, combining decaf coffee with natural flavor enhancers or plants may help alleviate this drawback. The increased health benefits of this concoction may also be another product differentiator.

CONTRIBUTORS

Antoine Abrieux

Strategic Research Associate, Innovation Institute for Food and Health

Mary Avilla

Program Manager, Innovation Institute for Food and Health

Tana Hernandez Barrueta

Science Communication Fellow, Innovation Institute for Food and Health

Ash Bagla

MBA Student, UC Davis Graduate School of Management

Mariana Barboza

Research Program Manager, Innovation Institute for Food and Health

Gordon Chang

MBA Student, UC Davis Graduate School of Management

Robby Divine

Postdoctoral Researcher, UC Davis

Lucas Haskins

MBA Student, UC Davis Graduate School of Management

Dana Armstrong Hughes

Talent Development Coordinator, Innovation Institute for Food and Health

Veronica Keys

Program Assistant, Innovation Institute for Food and Health

Nathaniel Morrison

MBA Student, UC Davis Graduate School of Management

Prasad Naik

Professor, UC Davis Graduate School of Management

Marissa Pickard

Lead Community Coordinator, Innovation Institute for Food and Health

Justin B. Siegel

Associate Professor of Chemistry, Biochemistry & Molecular Medicine,
UC Davis

Faculty Director, Innovation Institute for Food and Health

Wesley Wilson

Executive Chair, Innovation Institute for Food and Health

REFERENCES

- 1 Jones, Keiran. “Coffee Processing Methods – from Cherry to Green Bean.” Coffe Rambler, Coffe Rambler, 9 July 2018, <https://www.coffe Rambler.com/post/coffee-processing-methods-from-cherry-to-green-bean>.
- 2 Nathanson, James A. “Caffeine and Related Methylxanthines: Possible Naturally Occurring Pesticides.” *Science*, vol. 226, no. 4671, 1984, pp. 184–87. JSTOR, <http://www.jstor.org/stable/1693475>.
- 3 FNDDS, USDA. “Fooddata Central Search Results.” FoodData Central, <https://fdc.nal.usda.gov/fdc-app.html#/food-details/1104137/nutrients>.
- 4 “Understanding the Weird History of Decaffeinated Coffee and How It’s Made.” Compass Coffee, 7 Dec. 2020, <https://www.compasscoffee.com/blogs/daily-grind/understanding-the-weird-history-of-decaffeinated-coffee-and-how-it-s-made>.
- 5 Fabricant, Florence. “A Coffee Drinker’s Guide to Decaffeinated Brands.” *The New York Times*, The New York Times, 1 Aug. 1984, <https://www.nytimes.com/1984/08/01/garden/a-coffee-drinker-s-guide-to-decaffeinated-brands.html#:~:text=The%20first%20commercial%20decaffeination%20process,the%20French%20%27%27sans%20caffeine>.
- 6 USDA. “CID Coffee - Agricultural Marketing Service.” Commercial Item Description - Coffee, 17 Aug. 2004, <https://www.ams.usda.gov/sites/default/files/media/CID%20Coffee.pdf>.
- 7 USDA and Department of Health and Human Services. “Dietary Guidelines for Americans 2020-2025.” <https://www.dietaryguidelines.gov/resources/2020-2025-dietary-guidelines-online-materials>.
- 8 “CID Coffee - Agricultural Marketing Service.” Commercial Item Description - Drink Mixes, Coffee (Unflavored and Flavored), 16 May 2013,
- 9 “Decaffeinated Coffee Market.” Transparency Market Research, <https://www.transparencymarketresearch.com/decaffeinated-coffee-market.html>.

- 10 Research and Markets. “Decaffeinated Coffee - Global Market Trajectory & Analytics.” Research and Markets - Market Research Reports - Welcome, <https://www.researchandmarkets.com/reports/5303025/decaffeinated-coffee-global-market-trajectory>.
- 11 “Decaffeinated Coffee Market Size Worth \$2.8 Billion by 2027.” Grand View Research, <https://www.grandviewresearch.com/press-release/global-decaf-coffee-market>.
- 12 “Coffee Market in the U.S.” Statista, <https://www.statista.com/study/12878/us-coffee-market-statista-dossier/>.
- 13 “How Do You Decaffeinate Coffee?” BBC Future, BBC, 18 Sept. 2018, <https://www.bbc.com/future/article/20180917-how-do-you-decaffeinate-coffee>.
- 14 “Decaffeination Process: Essential Facts.” SoloEspresso.net, 13 Dec. 2020, https://soloespresso.net/the-decaffeination-process/#Decaffeination_Where_it_all_started.
- 15 “How Is Decaffeinated Coffee Made? the Chemistry of Coffee Decaffeination.” Compound Interest, 26 Sept. 2018, <https://www.compoundchem.com/2018/09/26/coffee-decaffeination/>.
- 16 Buckingham, Cheyenne. “One Major Side Effect of Drinking Decaf Coffee.” Yahoo!, Yahoo!, 6 Apr. 2021, <https://money.yahoo.com/one-major-side-effect-drinking-203513110.html>.
- 17 “Decaffeinated Coffee: Swiss Water Process.” Coffee Review, <https://www.coffeereview.com/coffee-reference/coffee-categories/decaffeinated-coffee/swiss-water-process/>.
- 18 De Marco I., Riemma S., Iannone R., 2017, Supercritical Carbon Dioxide Decaffeination Process: a Life Cycle Assessment Study, Chemical Engineering Transactions, 57, 1699-1704.
- 18B Decafino website: <https://www.decafino.com/technology>
- 18C (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9133285/> ;
- 18D <https://slate.com/technology/2023/01/decaf-coffee-genetic-engineering.html>).
- 19 Carlström, Mattias, and Susanna C Larsson. “Coffee consumption and reduced risk of developing type 2 diabetes: a systematic review with meta-analysis.” Nutrition reviews vol. 76,6 (2018): 395-417. doi:10.1093/nutrit/nuy014
- 20 Qing-Ping Liu, Yan-Feng Wu, Hong-Yu Cheng, Tao Xia, Hong Ding, Hui Wang, Ze-Mu Wang, Yun Xu, Habitual coffee consumption and risk of cognitive decline/dementia: A systematic review and meta-analysis of prospective cohort studies, Nutrition, Volume 32, Issue 6, 2016, Pages 628-636, ISSN 0899-9007, <https://doi.org/10.1016/j.nut.2015.11.015>.

- 21 Stevens, Laura M et al. "Association Between Coffee Intake and Incident Heart Failure Risk: A Machine Learning Analysis of the FHS, the ARIC Study, and the CHS." *Circulation. Heart failure* vol. 14,2 (2021): e006799. doi:10.1161/CIRCHEARTFAILURE.119.006799
- 22 Rowley, William R et al. "Diabetes 2030: Insights from Yesterday, Today, and Future Trends." *Population health management* vol. 20,1 (2017): 6-12. doi:10.1089/pop.2015.0181
- 23 Type 2 Diabetes. Centers for Disease Control and Prevention, 16 Dec. 2021, <https://www.cdc.gov/diabetes/basics/type2.html>.
- 24 Mattias Carlström, Susanna C Larsson, Coffee consumption and reduced risk of developing type 2 diabetes: a systematic review with meta-analysis, *Nutrition Reviews*, Volume 76, Issue 6, June 2018, Pages 395–417, <https://doi.org/10.1093/nutrit/nuy014>
- 25 Nuhu, Abdulmumin A. "Bioactive micronutrients in coffee: recent analytical approaches for characterization and quantification." *ISRN nutrition* vol. 2014 384230. 22 Jan. 2014, doi:10.1155/2014/384230
- 26 James A Greenberg, Carol N Boozer, Allan Geliebter, Coffee, diabetes, and weight control, *The American Journal of Clinical Nutrition*, Volume 84, Issue 4, October 2006, Pages 682–693, <https://doi.org/10.1093/ajcn/84.4.682>
- 27 Jukka Montonen, Paul Knekt, Ritva Järvinen, Antti Reunanen; Dietary Antioxidant Intake and Risk of Type 2 Diabetes . *Diabetes Care* 1 February 2004; 27 (2): 362–366. <https://doi.org/10.2337/diacare.27.2.362>
- 28 Quansah, Dan Yedu et al. "Associations of Dietary Antioxidants and Risk of Type 2 Diabetes: Data from the 2007-2012 Korea National Health and Nutrition Examination Survey." *Molecules (Basel, Switzerland)* vol. 22,10 1664. 5 Oct. 2017, doi:10.3390/molecules22101664
- 29 van der Schaft, N., Schoufour, J.D., Nano, J. et al. Dietary antioxidant capacity and risk of type 2 diabetes mellitus, prediabetes and insulin resistance: the Rotterdam Study. *Eur J Epidemiol* 34, 853–861 (2019). <https://doi.org/10.1007/s10654-019-00548-9>
- 30 Yashin A, Yashin Y, Wang JY, Nemzer B. Antioxidant and Antiradical Activity of Coffee. *Antioxidants (Basel)*. 2013;2(4):230-245. Published 2013 Oct 15. doi:10.3390/antiox2040230
- 31 W. Mullen, B. Nemzer, B. Ou, A. Stalmach, J. Hunter, M. N. Clifford, and E. Combet. The Antioxidant and Chlorogenic Acid Profiles of Whole Coffee Fruits Are Influenced by the Extraction Procedures. *Journal of Agricultural and Food Chemistry* 2011 59 (8), 3754-3762 DOI: 10.1021/jf200122m

- 32 Adriana Farah, Tomas de Paulis, Daniel P. Moreira, Luiz C. Trugo, and Peter R. Martin. Chlorogenic Acids and Lactones in Regular and Water-Decaffeinated Arabica Coffees. *Journal of Agricultural and Food Chemistry* 2006 54 (2), 374-381. DOI: 10.1021/jf0518305
- 33 “2021 Alzheimer's disease facts and figures.” *Alzheimer's & dementia : the journal of the Alzheimer's Association* vol. 17,3 (2021): 327-406. doi:10.1002/alz.12328
- 34 “When Alzheimer's Symptoms Start before Age 65.” Mayo Clinic, Mayo Foundation for Medical Education and Research, 29 Apr. 2022, <https://www.mayoclinic.org/diseases-conditions/alzheimers-disease/in-depth/alzheimers/art-20048356>.
- 35 Vespa, Jonathan. “The U.S. Joins Other Countries with Large Aging Populations.” *Census.gov*, 13 Mar. 2018, <https://www.census.gov/library/stories/2018/03/graying-america.html>.
- 36 Qing-Ping Liu, Yan-Feng Wu, Hong-Yu Cheng, Tao Xia, Hong Ding, Hui Wang, Ze-Mu Wang, Yun Xu, Habitual coffee consumption and risk of cognitive decline/dementia: A systematic review and meta-analysis of prospective cohort studies, *Nutrition*, Volume 32, Issue 6, 2016, Pages 628-636, ISSN 0899-9007, <https://doi.org/10.1016/j.nut.2015.11.015>.
- 37 Larsson SC, Orsini N. Coffee Consumption and Risk of Dementia and Alzheimer's Disease: A Dose-Response Meta-Analysis of Prospective Studies. *Nutrients*. 2018;10(10):1501. Published 2018 Oct 14. doi:10.3390/nu10101501
- 38 Eskelinen, Marjo H. and Kivipelto, Miia. ‘Caffeine as a Protective Factor in Dementia and Alzheimer’s Disease’. 14 Apr. 2010 : S167 – S174.
- 39 Eskelinen, Marjo H. et al. ‘Midlife Coffee and Tea Drinking and the Risk of Late-Life Dementia: A Population-Based CAIDE Study’. 1 Jan. 2009 : 85 – 91.
- 40 Budson, Andrew E. “What's the Relationship between Diabetes and Dementia?” *Harvard Health*, Harvard Medical School, 12 July 2021, <https://www.health.harvard.edu/blog/whats-the-relationship-between-diabetes-and-dementia-202107122546>.
- 41 American Heart Association. “Nearly Half of All Adult Americans Have Cardiovascular Disease.” *ScienceDaily*, ScienceDaily, 31 Jan. 2019, <https://www.sciencedaily.com/releases/2019/01/190131084238.htm>.
- 42 FASTSTATS - Deaths and Mortality. Centers for Disease Control and Prevention, [https://www.cdc.gov/nchs/fastats/deaths.htm#:~:text=Number%20of%20deaths%20for%20leading,Accidents%20\(unintentional%20injuries\)%3A%20200%2C955](https://www.cdc.gov/nchs/fastats/deaths.htm#:~:text=Number%20of%20deaths%20for%20leading,Accidents%20(unintentional%20injuries)%3A%20200%2C955).

- 43 Fernando Rodríguez-Artalejo and Esther López-García. Coffee Consumption and Cardiovascular Disease: A Condensed Review of Epidemiological Evidence and Mechanisms. *Journal of Agricultural and Food Chemistry* 2018 66 (21), 5257-5263. DOI: 10.1021/acs.jafc.7b04506
- 44 “Good News for Coffee Lovers: Daily Coffee May Benefit the Heart.” American College of Cardiology, 24 Mar. 2022, <https://www.acc.org/About-ACC/Press-Releases/2022/03/23/17/55/Good-News-for-Coffee-Lovers-Daily-Coffee-May-Benefit-the-Heart>.
- 45 CLRS Paiva, BTS Beserra, CEG Reis, JG Dorea, THM Da Costa & AA Amato (2019) Consumption of coffee or caffeine and serum concentration of inflammatory markers: A systematic review, *Critical Reviews in Food Science and Nutrition*, 59:4, 652-663, DOI: 10.1080/10408398.2017.1386159
- 46 Chuan Shao, Hui Tang, Xiaoya Wang, Jiaquan He, Coffee Consumption and Stroke Risk: Evidence from a Systematic Review and Meta-Analysis of more than 2.4 Million Men and Women, *Journal of Stroke and Cerebrovascular Diseases*, Volume 30, Issue 1, 2021, 105452, ISSN 1052-3057, <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105452>. (<https://www.sciencedirect.com/science/article/pii/S1052305720308703>)
- 47 Wallengren, Maja. “Decaf Coffee: Strong Consumer Growth; New Health Focus.” *STiR Coffee and Tea Magazine* | Global Business Insight on Coffee and Tea, 19 Oct. 2021, <https://stir-tea-coffee.com/features/decaf-coffee-strong-consumer-growth-new-health-focus/>.
- 48 “9 Side Effects of Too Much Caffeine.” Healthline, Healthline Media, <https://www.healthline.com/nutrition/caffeine-side-effects>.
- 49 A. Smith, Effects of caffeine on human behavior, *Food and Chemical Toxicology*, Volume 40, Issue 9, 2002, Pages 1243-1255, ISSN 0278-6915, [https://doi.org/10.1016/S0278-6915\(02\)00096-0](https://doi.org/10.1016/S0278-6915(02)00096-0). (<https://www.sciencedirect.com/science/article/pii/S0278691502000960>)
- 50 Kumar, Vikas, et al. "Caffeine: A Boon Or Bane." *Nutrition and Food Science*, vol. 48, no. 1, 2018, pp. 61-75. ProQuest, <https://www.proquest.com/scholarly-journals/caffeine-boon-bane/docview/2001127240/se-2?accountid=14505>, doi:<https://doi.org/10.1108/NFS-05-2017-0100>.
- 51 Richards, Gareth, and Andrew Smith. “Caffeine consumption and self-assessed stress, anxiety, and depression in secondary school children.” *Journal of psychopharmacology* (Oxford, England) vol. 29,12 (2015): 1236-47. doi:10.1177/0269881115612404
- 52 Jin, Mi-Joo et al. “The Relationship of Caffeine Intake with Depression, Anxiety, Stress, and Sleep in Korean Adolescents.” *Korean journal of family medicine* vol. 37,2 (2016): 111-6. doi:10.4082/kjfm.2016.37.2.111

- 53 Bertasi, Raphael A O et al. "Caffeine Intake and Mental Health in College Students." *Cureus* vol. 13,4 e14313. 5 Apr. 2021, doi:10.7759/cureus.14313
- 54 Raffaella Colombo & Adele Papetti (2021) Decaffeinated coffee and its benefits on health: focus on systemic disorders, *Critical Reviews in Food Science and Nutrition*, 61:15, 2506-2522, DOI: 10.1080/10408398.2020.1779175
- 55 José A. Rufián-Henares and Silvia P. de la Cueva, *Journal of Agricultural and Food Chemistry* 2009 57 (2), 432-438, DOI: 10.1021/jf8027842
- 56 Muhammad Naveed, Veghar Hejazi, Muhammad Abbas, Asghar Ali Kamboh, Ghulam Jilany Khan, Muhammad Shumzaid, Fawwad Ahmad, Daryoush Babazadeh, Xia FangFang, Faezeh Modarresi-Ghazani, Li WenHua, Zhou XiaoHui, Chlorogenic acid (CGA): A pharmacological review and call for further research, *Biomedicine & Pharmacotherapy*, Volume 97, 2018, Pages 67-74, ISSN 0753-3322, <https://doi.org/10.1016/j.biopha.2017.10.064>. (<https://www.sciencedirect.com/science/article/pii/S0753332217339963>)
- 57 Ramli NNS, Alkhalidy AA, Mhd Jalil AM. Effects of Caffeinated and Decaffeinated Coffee Consumption on Metabolic Syndrome Parameters: A Systematic Review and Meta-Analysis of Data from Randomised Controlled Trials. *Medicina (Kaunas)*. 2021;57(9):957. Published 2021 Sep 11. doi:10.3390/medicina57090957
- 58 Eske, Jamie. "Is Decaf Coffee Bad for You? Caffeine Content and Health Benefits." *Medical News Today*, MediLexicon International, 18 June 2019, <https://www.medicalnewstoday.com/articles/325502#bad-for-health>.
- 59 "Methylene Chloride." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 2 Nov. 2018, <https://www.cdc.gov/niosh/topics/methylenechloride/>.
- 60 "CFR - Code of Federal Regulations Title 21." US Food and Drug Administration, <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=173.255>.
- 61 "Leading Regular Ground Coffee Vendors, 2017." Statista, Apr. 2017, <https://www.statista.com/statistics/188313/leading-regular-ground-coffee-vendors-in-the-united-states-in-2011/>.
- 62 "3 Reasons Why Adaptogen Drink Is Now a Trend." Rootastes, 28 Oct. 2021, <https://www.therootastes.com/blogs/food-trends/3-reasons-why-adaptogen-drink-is-now-a-trend>.
- 63 "Chicory Coffee: A Healthy Alternative to Coffee?" Healthline, Healthline Media, <https://www.healthline.com/nutrition/chicory-coffee#nutrition>.

- 64 Nishimura, Mie et al. "Effects of the extract from roasted chicory (*Cichorium intybus* L.) root containing inulin-type fructans on blood glucose, lipid metabolism, and fecal properties." *Journal of traditional and complementary medicine* vol. 5,3 161-7. 20 Jan. 2015, doi:10.1016/j.jtcme.2014.11.016
- 65 Zawirska-Wojtasiak, Renata et al. "Bioactivity of selected materials for coffee substitute." *PloS one* vol. 13,11 e0206762. 15 Nov. 2018, doi:10.1371/journal.pone.0206762
- 66 Baird, Sarah. "Demystifying Dandelion Coffee, the Hippest New Health Drink." *Eater, Eater*, 30 June 2015, <https://www.eater.com/drinks/2015/6/30/8871449/demystifying-dandelion-coffee-the-hippest-new-health-drink>.
- 67 Staughton, John. "3 Proven Benefits of Dandelion Coffee." *Organic Facts*, 3 Sept. 2020, <https://www.organicfacts.net/dandelion-coffee.html>.
- 68 Corsillo, Liza. "I Quit Coffee with the Help of This Dandelion Powder." *The Strategist*, 26 Jan. 2021, <https://nymag.com/strategist/article/dandy-blend-review.html>.
- 69 Abdel-Moemin, Aly & Aboraya, Alaa. (2014). Innovative beverages of coffee and tea based on dandelion (*Taraxacum officinale*) roots and leaves. *Agricultura University of Maribor*. 11. 1-10.
- 70 Reinagel, Monica. "Brewed Cacao: Your New Afternoon Pick-Me-up?" *Food & Nutrition Magazine*, 13 Feb. 2017, <https://foodandnutrition.org/blogs/stone-soup/brewed-cacao-your-new-afternoon-pick-me-up/>.
- 71 Beckett, Alex. "Meet Cold Brew Cocoa, the next Cold Drink Innovation." *Mintel*, 9 Aug. 2017, <https://www.mintel.com/blog/drink-market-news/meet-cold-brew-cocoa-the-next-cold-drink-innovation>.
- 72 "Theobromine - an Overview | ." *ScienceDirect*, <https://www.sciencedirect.com/topics/neuroscience/theobromine>.
- 73 "'Caffeine and Theobromine Content in Coffee, Tea and Instant Cocoa Mixes'." *Bioprofile Testing Laboratories, LLC*, <https://www.bioprofilelabs.com/TheobromineContentCoffeeTeaInstantCocoa.htm>.
- 74 Khan, Naghma, and Hasan Mukhtar. "Tea and health: studies in humans." *Current pharmaceutical design* vol. 19,34 (2013): 6141-7. doi:10.2174/1381612811319340008
- 75 "An Overview of Research on the Potential Health Benefits of Tea." *TeaUSA News*, <https://www.teausa.com/14852/an-overview-of-research-on-the-potential-health-benefits-of-tea>.

- 76 “7 Proven Health Benefits of Matcha Tea.” Healthline, Healthline Media, <https://www.healthline.com/nutrition/7-benefits-of-matcha-tea#7.-Matcha-tea-is-very-easy-to-prepare>.
- 77 “Side Effects of Tea: 9 Reasons Not to Drink Too Much.” Healthline, Healthline Media, <https://www.healthline.com/nutrition/side-effects-of-tea#5.-Heartburn>.
- 78 “Yerba Mate Market to Grow at a CAGR of 4.50% from 2020 to 2025: 72% of Growth to Originate from South America: 17000+ Technavio Reports.” Technavio Reports, 20 Dec. 2021, <https://www.prnewswire.com/news-releases/yerba-mate-market-to-grow-at-a-cagr-of-4-50-from-2020-to-2025-72--of-growth-to-originate-from-south-america17000-technavio-reports-301448080.html>.
- 79 Guayakí. “Leading Yerba Maté Brand Gets Boost by Partnering with Oasis Sales and Marketing.” New Hope Network, 7 Mar. 2005, <https://www.newhope.com/supply-news-amp-analysis/leading-yerba-mat-brand-gets-boost-partnering-oasis-sales-and-marketing>.
- 80 Hennessy, Maggie. “If You Survive, You Thrive: Guayaki Yerba Mate's Slow-Burning Success.” Foodnavigator, 27 Oct. 2015, <https://www.foodnavigator-usa.com/Article/2015/10/27/If-you-survive-you-thrive-Guayaki-yerba-mate-s-slow-burning-success>.
- 81 Espinal, Nelson. “The Rise of Yerba Mate.” UCSD Guardian, 1 Mar. 2020, <https://ucsdguardian.org/2020/03/01/the-rise-of-yerba-mate/>.
- 82 Gawron-Gzella, Anna et al. “Yerba Mate-A Long but Current History.” *Nutrients* vol. 13,11 3706. 21 Oct. 2021, doi:10.3390/nu13113706
- 83 Ducharme, Jamie. “What Are Adaptogens? Healing Herbs for Stress and Fatigue.” *Time*, Time, 28 Feb. 2018, <https://time.com/5025278/adaptogens-herbs-stress-anxiety/>.
- 84 Panossian, Alexander G et al. “Evolution of the adaptogenic concept from traditional use to medical systems: Pharmacology of stress- and aging-related diseases.” *Medicinal research reviews* vol. 41,1 (2021): 630-703. doi:10.1002/med.21743
- 85 Qi, H-y Li, L, and Ma, H. Cellular stress response mechanisms as therapeutic targets of ginsenosides. *Med Res Rev.* 2018; 38: 625– 654. <https://doi.org/10.1002/med.21450>
- 86 Boolani, Ali et al. “Caffeine-Containing, Adaptogenic-Rich Drink Modulates the Effects of Caffeine on Mental Performance and Cognitive Parameters: A Double-Blinded, Placebo-Controlled, Randomized Trial.” *Nutrients* vol. 12,7 1922. 29 Jun. 2020, doi:10.3390/nu12071922
- 87 Anderson, Elisabeth, and Jinpeng Li. “Trending – Adaptogen Ingredients.” Center for Research on Ingredient Safety, 1 Mar. 2021, <https://www.canr.msu.edu/news/adaptogen-ingredient>.