Research Report on Flavoring Ingredient Around the Globe

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1. Finding Popular Flavoring Ingredients Across the Globe

The top three flavoring ingredients in each country of Brazil, China, Canada, Mexico, India, and the U.S. have been identified. The table below summarizes the major flavoring ingredients produced in each of those countries.

Table 1. Major Flavoring Ingredients Produced Around the Globe

Country	Produced Flavoring Ingredients		
Brazil	Orange	Centrifugal Sugar	Soybean Oil
China	Corn Oil	Orange Juice	Garlic Powder
Canada	Maple Syrup	Honey	Mustard
Mexico	Cilantro	Lime	Mexican Oregano
India	Chili	Ginger	Turmeric
U.S.	Soybean Oil	Non-fat Dry Milk	High Fructose Corn Syrup

1.1. Brazil

In Brazil, the top three flavoring commodities regarding production are orange, sugarcane, and soybeans. Orange can be turned into orange juice, orange zest, or orange extract. Sugarcane can be processed into sugar while the soybeans can be processed into soybean oil.

1.1.1 Oranges

Oranges are the flavoring ingredients that Brazil produces the most in volume. According to the Food and Agriculture Organization of the United Nation (2020), Brazil produces 16.7 million tonnes of oranges in 2018. The majority of oranges produced in Brazil has been exported with low domestic consumption. In 2014, nearly 69% or 12.24 million tonnes of Brazilian oranges production, which are mainly produced in São Paulo, were aimed for exports mainly for the American and European Union market (Utsumi, 2014).

The main flavors of oranges are sweet, sour, and citrusy. There are two major forms of flavor ingredients in oranges, the juice from the orange's flesh and the limonene oil from the orange's peel (Sobel, 2019). However, the orange peel can further be processed into extract.

Orange Juice. Orange juice can be extracted in a conventional way by squeezing the oranges. In commercial production of orange juice, high-pressure processing is used. Juice is then stored at 4°C or 10°C for up to 12 weeks to reduce the microbial load to nondetectable level (Bull et al., 2020; Takahashi et al., 1998).

Orange Peel. Orange peels contain abundant flavonoids such as glycosides and polyethoxylated flavones (Pereira et al., 2017). These peels can be turned into orange zest by using a zester. Apart from being orange zest, the orange peel can also be boiled at in water, and the limonene oil – orange flavoring agent – can be distilled in steam under a temperature slightly below 100°C (Royal Society of Chemistry, 2018).

Many orange varietals have been cultivated around the world. The main varietal that produces in Brazil is the navel orange (Lifestyle, 2019). The fruit has a pale yellow-orange appearance. Also, it is a seedless fruit and has 10 to 12 segments divided by thin membranes. The Brazilian Navel Orange's flavor profile has been described as sweet, tart, and tangy (Albert, n.d.). According to the Michelin Guide (n.d.), navel orange usage may have a slight bitterness compared to other orange varieties. The Brazilian Navel Orange's most significant selling point is that its zest can be made into limonene oil (orange flavoring agent) (Royal Society of Chemistry, 2018). The orange extract industry is a thriving and demanding industry. It worth 540 million US dollars in 2020 (Innovate, 2020). According to Zion Market Research (2019), the orange extract market is expected to grow at a compound annual growth rate (CAGR) of 5.4% from 2019 to 2026.

Many food companies used orange extract in beverages and bakery products. For the SWOT Analysis, the strength (S) of the orange extract, which is processed from the Brazilian Navel Orange, is the longer shelf life (typically 3-4 years). The weakness (W) of the orange extract is that it can only be used for baking, beverage, and sweet making. For opportunity (O), the orange extract manufacturers can squeeze the byproduct (orange flesh) and sell it as orange juice. Finally, the threat (T) to the orange extract industry is the COVID-19 pandemic in the short-term.

In conclusion, the significant production rate and low domestic consumption of orange in Brazil lower the navel orange price. It allows the orange extract industry to make more profit.

1.1.2 Sugarcane.

Brazil is the world's largest sugarcane producer. In the USDA-FAS Brazil Sugar Annual 2019 report, Brazil is estimated to have 9.9 million hectares of land to cultivate sugarcane for market year 2019/2020 (Barros & Berk, 2019). It is close to 2/3 of the area of Illinois (15 million ha). A 46% of the crop will be processed into sugar and 54% into ethanol (USDA-FAS, 2020). Centrifugal Sugar (raw sugar crystals and molasses) is one of the popular flavoring ingredients that derived from sugarcane.

Raw sugar crystals and molasses. Raw sugar crystal and molasses are obtained by the removal of water in sugarcane juice with centrifugation technique (Igoe, 2011, p.93). They will be added to syrup and used to produce refined cane sugar. The state of Sao Paulo and Center-

Southern Brazil are the major regions for sugarcane production in Brazil (Barros & Berk, 2019). The production of Brazilian centrifugal sugar in the market year 2019/20 is 29,925 thousand metric tons, and the exportation is about 19,300 thousand metric tons (USDA-FAS, 2020).

1.1.3 Soybean

Brazil is the largest soybean producer and exporter. In the market year of 2019/20, Brazil produced 131,000 thousand metric tons soybean, and exported about 84,000 thousand metric tons (USDA-FAS, 2020). Soybean is an excellence source for oil production. With a vast amount of soybean crop, Brazil also a leading country of soybean oil production and exportation (USDA-FAS, 2020). The production of the Brazilian soybean oil was 8,640 thousand metric tons and export was 1,050 thousand metric tons of the product (USDA, September 2020).

Soybean Oil. Soybean oil is defined as the vegetable oil that extract from the seed of the soybean legume. The oil mainly composed with approximately 86% unsaturated fatty acids (Igoe, 2011). Soybean oil is widely used in the food and restaurant industries as shortenings, margarine, salad making, and meal cooking (Igoe, 2011). To produce soybean oil, solvent extraction is performed to obtain the crude oil. It is important to go through a series of refining processing steps to convert the crude oil to edible oil. The first refining step is degumming to remove lecithin. The next step is to neutralize the oil to separate out free fatty acid. The third refining step is bleaching which will help to remove pigments of the oil. Finally, the oil is deodorized to remove volatile components (Proctor, 1997).

1.2 Canada

Canada is a large producer and exporter for several flavoring ingredients, and maple syrup, honey and mustard are three representatives among those ingredients. Maple syrup is condensed from maple sap and it is widely used as a sweetening agent. Honey often being seen as a healthy alternative to sugar. Mustard is a popular condiment largely consumed in North American.

1.2.1 Mustard

Mustard is a condiment on almost everyone's table all over the world with North America being a major consumer of mustard. There are 3 types of mustard that can be commonly found in the market, yellow (*Sinapis alba*), oriental, and brown (*Brassica juncea*) mustard. Yellow mustard is commonly found in the North American, it is milled into powder and used in condiments like salad dressings, mayonnaise, barbecue sauces. It also works great as the emulsifying agent and stabilizer for processed meat. Oriental mustard is exported to Asian countries as a condiment, while brown mustard is exported to Europe for producing specialty mustard (L'Hocine, Pitre, and Achouri, 2019). Mustard was brought to Britain by Roman and imported to the North American Continent in the mid-eighteenth century (McGuire, 2016). The mustard plant has yellow flowers and broad leaves, and it grows in cool seasons. The climate in Canada is suitable for mustard growth (McKenzie, Carcamo, 2010).

Canada is the largest exporter of mustard in the world, which takes up to 70 to 80 percent of export worldwide annually. The biggest importer of mustard is the U.S. followed by Belgium, Germany, the Netherlands, and Japan (McKenzie & Carcamo, 2010). The annual production of mustard seed in 2018 in Canada is 173,600 mt (Statistics Canada, n.d.). There was a total amount of 114,299 tonnes of mustard seed exported in 2018 (Food and Agriculture Organization of the United Nation, 2020). Saskatchewan southern prairie regions of Alberta contributes to the majority of the mustard production (McKenzie & Carcamo, 2010).

1.2.2 Maple Sap/Maple Syrup

Canada is a large exporter of a very popular flavoring ingredient - Maple Syrup. Maple Syrup is a syrup that comes from the sap in sugar maple trees; the sap from these trees is concentrated in order to make maple syrup. Before these trees are harvested, the farmers need to make sure to set up buckets near the trees in order to collect the sap, as well as cleaning all equipment necessary to produce maple syrup (Massachusetts Maple Producers Association, 2017). Harvest for these maple trees in Canada begins after winter is over. It is hard to tell exactly when sap flow is the highest; the sugar maker or the farmer will know when the time is right, and "tap" the tree, or drill a hole in the tree and collect the sap into a bucket.

Canada makes up around 71% of the maple products exported in the world. In fact, Canada exported nearly 45 million kg of maple product, which was about $381 million, in 2016 (Belliveau, 2018). The province of Quebec is where most of the maple syrup/products production comes from - nearly 92% of production (Werner, 2018). The U.S. is one of its largest importers - around 65% of the maple products get exported over (Belliveau, 2018). The average price of the Canadian maple sap is $31.00/gallon in the U.S. in 2019 (United States Department of Agriculture National Agricultural Statistics Service, 2020).

Maple syrup/sap is not only used for pancakes; it can be further processed to produce more products using its sweet flavor. Maple syrup is used in chef's kitchens and industrial food applications (Food Processing, 2008). For example, its sweet flavor can enhance the flavor of other products, such as barbeques, bakery sauces, and even ice cream.

Maple sap is the juice of maple tree. There are many maple tree varietals, such as Sugar maple, Black maple, and Red maple, are planted in Canada (Davenport & Staats, 2013). The maple sap has a clear, water-like appearance. It can be boiled into maple syrup, which is more viscous with yellow or brown color (Werner, 2006). The taste of the Canadian maple sap is sweet, and it contains different flavors depends on processing (Werner, 2006). The selling point of the Canadian maple sap is that it is widely used as a sweet flavoring ingredient (Atlantic Corporation, 2019). To turn the raw sap into a flavoring ingredient, the following steps will be taken: 1) Boiling and Evaporation; 2) Filtering; 3) Cleaning; 4) Grading and Packaging (Davenport & Staats, 2013). The maple sap is projected to worth 1.7 billion US dollars in 2023 (Atlantic Corporation, 2019). The CAGR is expected to be 7% for 2018 to 2023 period (Atlantic Corporation, 2019).

Maple sap is a great ingredient that many food companies use as the sweeter in their products. For the SWOT Analysis, we found that the Canadian maple sap' strength (S) is the continued increase of global consumption. The weakness (W) of maple sap is that it lacks cost-effective technologies in production. For opportunity (O), its use as a healthy functional ingredient can increase the consumption of maple sap. Finally, the threats (T) to the Canadian maple sap industry are the climate change and trade disputes.

In conclusion, the increase in global consumption of maple sap leads to market expansion. The advanced technologies used in the industry help increase the production and quality of the product. The market potential for the maple sap sued as a healthy functional ingredient is high. However, the climate change limits the collection of the maple sap.

1.2.3 Honey

Honey is one of the key agricultural commodities that are important for Canadian economy (Garden Delights Nursery, 2015). Not only is honey popular to use in many foods, such as oatmeal, smoothies, and to be used as a glaze, but it is also used in food processing. Honey can be used to extend the shelf life of many baked products; it is a healthier sugar alternative to sweeten foods, and it can be used as a humectant to add moisture to products (Garden Delights Nursery, 2015).

The beekeeping industry is one of the most important industries in Canada; the number of bee colonies has increased over the past decade, with a record high of about 796,764 in 2018. It is also apparent that the amount of beekeepers around Canada has increased too. The honey/beekeeping industry has a very promising future (Agriculture and Agri-Food Canada, 2018).

Canada produced around 9.3 million pounds of honey in 2018 and exported over $78 million worth of honey in 2017 (Agriculture and Agri-Food Canada, 2018). In addition, since the demand for honey has been increasing, the value of the honey has increased as well since 2016. The production value of honey was estimated to be around $197 million in 2018. One of the largest importers of honey is the U.S. - around 80% of all honey exports for Canada in 2008 was to the US. The prairie provinces of Alberta, Saskatchewan, and Manitoba produce over 80% of the honey and contain a high number of bee colonies and keepers (Agriculture and Agri-Food Canada, 2018).

1.3 China

In China, the top three flavoring commodities that are produced are corn, apple, and garlic. Corn can be turned into corn oil. Apple can be processed into apple juice while the garlic can be converted into garlic powder or fermented black garlic.

1.3.1 Corn

Maize or corn is the flavoring ingredients that China produces the most. China produced 257 million tonnes of maize in 2018 with majority comes from Hei Long Jiang Province (Textor, 2019). However, although they are second biggest corn producing country, China still need to import corn from other countries such as U.S. for another 1.762 million tonnes in the 2020-2021 period (Braun, 2020).

One of the possible ways to turn corn into a flavoring ingredient is corn oil. Corn oil possesses the mild almost buttery flavor and can produce distinct roasty flavor under panfrying process (Stevens, 2001). Among the vegetable oils that are available in the market, this dark yellow oil is more suitable for panfrying, making mayonnaise and baking (such as cornbread). Corn is processed into corn oil using wet or dry milling process followed by ethanal extraction. Although dry milling process is less efficient, they require fewer capital investments. As an alternative, mechanical degermination process is also used to produce corn oil (Cheryan, 2002).

1.3.2 Apple

Apple is the second mostly produced flavoring commodity in China. Based on the data from Food and Agriculture Organization of the United Nation (2020), China produces 78 million tonnes of apples in 2018. China is also the world largest apple exporting industry which the total export exceeded 1.3 million tons in 2016 with Shandong province as the highest exporting province (Tim, 2017). The biggest buyers of Chinese apple are countries of Thailand, Philippines, India, Vietnam, and Bangladesh.

One of the most feasible way to turn the apple into a flavor ingredient is the apple juice. The sweet-tart flavor of apple juice is applicable in a wide-range of foods, such as snack food, soft beverages, liquid beverages, or solid beverages (Wang, 2017). To produce apple juice, the mature apple is prepared by cutting, pulp milling, and the addition of pectinase to break down pectin in apple to increase yield and control clarity (Marketing, n.d.). The apple juice is then yielded through the extrusion process, pasteurized to kill the pathogens, and undergo ultrafiltration to create a clear apple juice (Marketing, n.d.). The flavor of apple juice could be compromised by high temperature processing steps, such as pasteurization.

1.3.3 Garlic

Garlic comes at third place in term of mostly produced flavoring ingredients in China. Based on the data from Food and Agriculture Organization of the United Nation (2020), China produces 44.6 million tonnes of garlic in 2018. In fact, China is biggest garlic producer and exporter in the world with a total export of US$ 2 billion in 2019 (Workman, 2020). These garlics are mostly produced in Shandong province and exported to other countries such as Indonesia, Vietnam, and Brazil (Textor, 2019; Observatory of Economic Complexity, n.d.). In terms of exportation, Indonesia, Vietnam, and Brazil are the major markets for the Chinese garlic. Also, the price, 0.21 USD/Kg, of the Chinese garlic is dropping because of the high production and the garlic glut in China (Sheng, 2020).

Garlic can be used as flavor ingredients in two forms, fresh garlic or garlic powder. The peeled fresh garlic are cut into thin slices and dehydrated using either conventional heated air or dehumidifier heat pump (Boonnattakorn et al., 2004). Then the dried garlic undergoes a grinding process and turned into garlic powder. In some Asian countries, fresh garlic can also be fermented at low temperature and humid condition to black garlic. Black garlic has a slightly acidic caramel candy flavor due to Milliard Reactions (Stanek, 2016) while possesses many health benefits (Yang et al., 2019).

There are over 15 garlic varietals that have been cultivated around the world. These garlic varietals usually fell into two categories: hardneck or softneck. The main varietal that produces in China is the Turban Hardneck (Max, 2020). The clove of the Turban Hardneck has a tan-colored appearance. Also, it can fill the bulb with between six and twelve evenly sized cloves. The Turban Hardneck garlic's taste has been described as hot and fiery, weak garlicy (Max, 2020). Some customers claim that if the garlic turned into garlic powders, it would lose some of the flavors. One of the Chinese Turban Hardneck garlic's selling points is that it can be processed into garlic powder. Fresh garlic cloves are peeled and cut the into slices. They are dried with a heat source, either conventional heated air or a dehumidifier heat pump. Finally, the dried garlic cloves will undergo a grinding process and turn into garlic powder (Boonnattakorn et al., 2004). The garlic powder industry is a flourishing industry. It is projected to worth 630 million US dollars in 2020 (Market Watch, 2020).

Garlic powder is widely used food industry as a spice. For the SWOT Analysis, the strength (S) of the garlic powder, which is processed from the Chinese Turban Hardneck garlic, is that it adds hot and distinct flavor to the dishes. The weakness (W) is that it is less garlicy compared to other variety. For opportunity (O), according to Market Watch (2020), the Garlic Powder Market is expected to grow at a GAGR of 3.9% from 2020 to 2025. Also, the raw materials to make garlic powder is cheap. Finally, the threat (T) to the garlic powder industry is the COVID-19 pandemic in the short-term.

In conclusion, due to the garlic glut in China, the garlic price is dropping which would allow the garlic powder producers to generate greater profit.

1.4 India

India is "the land of spice" and its unique flavoring ingredients are gradually gaining popularity around the world. Chili, turmeric and ginger are three ingredients that are largely produced and exported from India. Chili can be processed into commercial condiments like chili powder and chili sauces. Turmeric is known as "the golden spice" and it is commonly made into turmeric powder. Ginger has a pungent aroma and usually being produced and used in powder form.

1.4.1 Chili

Chili pepper (*Capsicum L.*) is the fruit part of a plant and it is considered as a spice crop. Chilies are major flavoring ingredients in cuisines worldwide. It is widely used in spice, condiment, pickles, etc. Chilies can be processed into chili powder, chili sauce, chili paste to be used in various foods and drinks.

There is a large variety of chili grown worldwide and they have different tastes and appearances. Chili is believed to be first found in Peru or Latin America regions, and it is domesticated in America at around 5000 BC (Department of Agriculture & Cooperation, 2009).

Chili was introduced to India by Portuguese in Brazil in the 17th century and Indian chilies are well known for their vibrant color and pungency level (Geetha & Selvarani, 2017). The hottest chili in the world "Naga Jolokia" is indigenous in Assam, India (Department of Agriculture & Cooperation, 2009).

India is one of the major chilies growing countries. About 36% of the total production of chilies in the world is contributed by India, and nearly 30% of chilies produced in India are traded internationally (Geetha & Selvarani, 2017). The total production of chilies is 1,008,260 tonnes between 2017 to 2018, while the Telangana state has the largest production of chilies (340,800 tonnes) among states, followed by Karnataka (260,140 tonnes) and Madhya Pradesh (244,550 tonnes) (APEDA). A 4,68,500 tonnes of chilies was exported from India during 2018-2019 and it worth 541,117.50 Rs. LAKHS (~733,890,609 USD). There is an increasing trend of chilies export since 2015-16 (Spices Board India, n.d.).

1.4.2 Ginger

Ginger (*Zingiber officinale Roscoe*) is the underground stem of the plant belonging to the Zingiberaceae family, which originated from south-eastern Asia. Ginger can be used as an ingredient for making folk medicine and it is a commonly used dried spice in baking, soft drinks, and meat industry in countries like Canada, U.K, and U.S.A. (Bag, 2018). With a pungent aroma and tangy flavor, ginger contains a high protein content (2.3%) (Kumar, Singh and Sharma, 2018). Ginger can be processed into easily preserved spice products like ginger powder, ginger syrup, and ginger oil.

The largest producer of ginger in the world is India, which takes up to 65% of production. The total production of ginger is 885350 tonnes in India by 2017 to 2018. In the year of 2018, there were 20,722 tonnes of ginger exported from India, which valued 31,025k of US dollars (Food and Agriculture Organization of the United Nation, 2020). Ginger is one of the earliest recorded spices being cultivated and exported from southwest India (Münster, 2015). There are several states in India takes up the most production of ginger, such as Kerala, Karnataka, Sikkim, and other North-Eastern states (Kumar, Singh and Sharma, 2018). From 2017 to 2018, Assam state had the top production of ginger with 167,390 tonnes produced and followed by Maharashtra (140,600 tonnes) and West Bengal (130,400 tonnes) (APEDA, n.d.).

1.4.3 Turmeric

Turmeric (*Curcuma longa*) is a plant and this yellowish-brown rhizome of the plant is widely used as a spice, food preservatives, coloring material, and medicine in India and other countries. Turmeric grows seasonally from mid-February to May and mid-August to October. (Murugananthi, Selvam, 2008). Curcumin is the component providing yellow color and it has been used clinically in reducing postoperative inflammation (Chattopadhyay & Biswas, 2004). Turmeric is believed to be indigenous to South-East Asia, probably India. Multiple usages of turmeric and the potential medicinal applications of curcumin in turmeric give this spice a bright future in markets all over the world. As a flavoring ingredient, turmeric is presented in powder form to enhance flavors of foods. It is a commonly used ingredient in curries and mustards (Sirisidthi & Kosai, 2016).

India contributes approximately 78% of turmeric in total production in the world and India is one of the major countries that export turmeric (Murugananthi & Selvam, 2008). The total production of turmeric in India was 889,600 tonnes in 2017 to 2018. Telangana state had the largest production of 294,560 tonnes of turmeric among all states in India while Maharashtra

(190,090 tonnes) and Tamil Nadu (116,000 tonnes) ranked the second and third (APEDA, n.d). A 133,600 tonnes of turmeric was exported to foreign countries in the 2018-2019 period, which valued 141,616.00 Rs. LAKHS (~192,066,700 USD). The export quantity of turmeric between 2017 and 2018 increased to more than 1.5 times in the 2015-2016 period (Spices Board India, n.d). Bangladesh, Iran, Morocco, the USA, and UAE are the major markets for the Indian turmeric (Agricultural Market Intelligence Centre, 2020).

There are many turmeric varietals, such as Duggirala, Tekkurpet, Sugandham and Amalapuram, that are cultivated in India (Jayashree & Kandiannan, 2015). Turmeric, which has scientific name *Curcuma longa*, is the yellowish-brown rhizome of a plant. People usually honor it as the "Golden Spice" (Srinivasan, n.d.). The taste of the Indian turmeric has been described as earthy and bitter (Plotto, 2004). It also considers healthy to some customers. To turn the rhizome into spice, the following processing steps are followed: boiling → Drying → Polishing → Coloring → Cleaning → Grading and Packaging (Jayashree & Kandiannan, 2015). The turmeric industry is a big industry around the world. It is projected to worth 248.3 million US dollars in 2021 (Technavio Research, 2017). The CAGR is expected to over 6% for 2017 to 2021 period (Technavio Research, 2017).

For the SWOT Analysis, the turmeric's strength (S) is the low capital investment, low irrigation and low transportation loss. The weakness (W) of turmeric is that it is in traditional farming practice, and commercial farming has not been adopted. For opportunity (O), turmeric has a high exportation potential and more suppliers are needed in India. Finally, the threats (T) to the turmeric industry are the potential rhizome rot and Alternaria leaf spot disease of the plant if it was not farmed correctly.

In conclusion, the potential expansion in the global market and high turmeric production leads to higher profits for the producers. Also, there is a market potential for applying the health benefits of turmeric to food products. However, farmers in India need to adopt commercial and systemize farming practices.

1.5 Mexico

Mexico is a country with geographic diversity, which leads to an abundance/diversity of agricultural crops that can be further processed or used as flavoring ingredients. The top ingredients produced by Mexico include lime, cilantro, and Mexican Oregano.

1.5.1 Cilantro

One of Mexico's top flavoring ingredients is cilantro (*Coriandrum sativum*). It is widely used in several Mexican and other Latin American dishes. Cilantro refers to the leaves of the plant. These leaves can be used both fresh and dried. Additionally, a common spice made using cilantro is "Coriander", which is grounded cilantro seeds (Ortega, Y.& Posts, 2020). Cilantro is also commonly used in salsas and on tacos as the main garnish. Mexico is largest exporter of cilantro since its environment is perfect for the plant to grow (Ortega, Y.& Posts, 2020). In 2018, Mexico exported nearly $84.41K and 28,828 Kg of coriander seeds/cilantro/spices *(*World Integrated Trade Solution, 2018*).* The U.S. is one of the top importers of cilantro, where it is mainly used in the popular Mexican cuisine (Mexico: Exporter Guide | USDA Foreign Agricultural Service, 2020).

Cilantro is very susceptible to being contaminated by pathogens if proper agricultural practices are not enforced during and after harvest (Ortega, Y.& Posts, 2020). Cilantro is harvested in Huehuetla, Mexico, near the Gulf of Mexico and the Sierra Norte mountains (Slow Food Foundation for Biodiversity, n.d.).

1.5.2 Lime

The Mexican cuisine is rich in flavors ranging from spicy all the way to sweet. Mexican dishes are made with a diverse selection of ingredients and spices; one of the staples in many Mexican dishes is lime, also known as Limón. Several popular dishes that are not complete without lime include fruit bowls, seafood (ceviche), to tacos. The Mexican lime, also known as *Citrus aurantifolia,* is very versatile and can be used to garnish and add flavor to fish and other meats. In addition, it can also be used to add zests to drinks, and make lemonade because of its unique, sour flavor.

Mexico is one of the major countries producing, exporting, and consuming Persian and Key limes (Flores, 2019). According to the USDA's foreign agricultural service, Mexico has produced 2,199 metric tons of limes as of July 2019/20. Key limes and Persians limes are very important for Mexico's economy and its excellent climate allows an active lime production year-round (Flores, 2019). Citric acid, lime oil, and lime juice are common flavoring ingredients produced by lime. Since lime is so versatile, the demand for limes from Mexico is expected to grow in the coming years (Market Growth, 2019). Several states in Mexico are involved in harvesting and producing limes: Colima, Guerrero, Michoacán, and Oaxaca. However, the major lime producing state would be Veracruz, making up 61% of the production of limes (Market Growth, 2019). Mexico is the biggest producer and exporter in the world of Key Lime and Persian Lime. The primary production place of the Mexican limes is Veracruz, Southern Mexico. The main export destinations for Mexican limes are the USA and Canada. Key Lime and Persian

Lime have many differences. For Key Lime, it can be described as having a juicy green pulp and unique acidic flavor. It is the widely cultivated lime in Mexico (Flores, 2019). On the other hand, the Persian Lime is seedless, bigger, thicker, and has less aromatic skin than the key lime (Flores, 2019). Both of the limes are used for food products like citric acid, lime juice, and lime oil (Mordor Intelligence, n.d.).

The lime business is economically important for Mexico (Flores, 2019). COVID-19 and the drought disturbed the supply chain (Flores,2019) The production and exportation of both Key Lime and Persian Lime are decreased. The harvest areas are expected to reduce by 8% due to the drought and virus. Producers are planning to abandon harvest and replant trees. These events led to the shot-up of lime's price and caused lime producers to try to leave the country (Flores,2019). Fortunately, the lime demand in the US is expected to remain stable.

For the SWOT Analysis, the strength (S) of the Mexican lime is that the trade between the U.S. & Mexico remains stable. And the weakness (W) is that the lime producers may leave the market due to COVID-19 and drought. For opportunity (O), the Key Lime has a long shelf life. The producers are expected to have more harvests. Finally, the most significant threats (T) to the Mexican industry are the unknown extent of damage due to COVID-19.

In conclusion, although COVID-19 and droughts have had a considerable impact on the lime market, stable demand and exports to the U.S. have supported the market back in Mexico.

1.5.3 Mexican Oregano

The Mexican cuisine uses a variety of spices that add flavor to many of the dishes we love. One of the top flavoring ingredients popular worldwide is Mexican oregano, also known as

Lippia graveolens. It has a pungent oregano/earthy aroma, and intense flavor. Mexican oregano is popular for its use as a spice in Mexican and Latin American dishes; the dry and fresh leaves can be used as seasoning for a variety of foods such as fish, sauces, and other meats. In addition, Mexican oregano extract can also be added to relishes or other food products (Plant Use, 2018). Mexican oregano is a member of the mint family, and the most common strain is rich in fragrance and taste (Igoe, 2011). This flavor ingredient is mainly exported by Mexico, which is near 3,000 tons. About 2,000 tons is exported to the U.S. (Plant Use, 2018).

Mexican oregano plant can be cultivated in various states across Mexico, including Durango, Guanajuato, Zacatecas; however, it is mostly cultivated in northern Jalisco (Flores, 2019). It grows well under the sun and is able to survive both wet and frosty conditions (Plant Use, 2018). The peak season for harvest lasts between July to September.

1.6. United States of America (U.S.)

The U.S. is one of the major agricultural commodities production and exportation countries in the world. It also has a thriving food ingredient processing industry. The top three flavoring ingredients in the U.S. are high fructose corn syrup (HFCS), soybean oil, and non-fat dry milk, which are produced from corn, soybean, and milk, respectively.

1.6.1 Corn

According to the *Food and Agriculture Organization of the United Nations (FAO) (2020),* both production and exportation volumes of corn ranked number one among all the U.S. agricultural commodities. In the U.S., the main usage of corn is for livestock feeding and a small portion (10 to 20%) is exported worldwide (USDA-ERS, 2020). Corn can be processed into sugar, flour, oil, cereal, and sweetener such as HFCS, which is one of the top U.S. exportation products (FAO, 2020). HFCS is the product of the isomerization of glucose to fructose in corn syrup by isomerase (Igoe, 2011). The sweeter HFCS is widely used in soft drinks, candy, fruit juices, etc. The fructose content in HFCS is either 42% (HFCS-42) or 55% (HFCS-55) (U.S. Food & Drug Administration, 2018). The U.S.'s productions of HFCS-42 and HFCS-55 in 2019 were 2,211 thousand short tons (1 short ton = 0.907 metric ton) and 5,653 thousand short tons, respectively. Together, the U.S. exported 1,250 thousand short tons of HFCS in 2019.

1.6.2 Soybean

The U.S. is one of the leading soybean production countries. According to the FAO *(2020),* both production and exportation volumes of soybean ranked number two, only behind maize, among all the U.S. agricultural commodities. In 2018 alone, the U.S. produced 123,664,230 tonnes of soybeans and exported 464,153,33 tonnes of them (FAO, 2020).

Soybean is the legume that contains about 40% protein and 18% oil (Igoe,2011). The Upper-Midwest produced most of the soybean in the U.S. It takes up 81% of the total soybean production in the U.S. (USDA-ERS, 2020). With the high soybean production, the U.S. manufactures many soy products, such as soymilk, Tofu, and soybean oils. Among them, soybean oil is the dominant one. To turn the soybean into oil, the following processing steps are taken: Cleaning and Sorting → Dehulling → Softening → Flaking → Solvent Extraction → Oil Pressing (Serrato, 1981). Soybean oil is composed of majorly unsaturated fatty acids (85%) and it is widely used in shortening, margarine, salad, and cooking (Igoe, 2011). The U.S.'s soybean oil production volume is 11,315 thousand metric tons in the 2019/20 market year, and the exportation volume is 1,179 thousand metric tons (USDA-FAS, 2020). Soybean oil contributes to 90% of the U.S. vegetable oil in the market (USDA-ERS,2020). The price of American soybean oil is competitive. It is about 645 US dollars/metric ton during the 2019/2020 market year (USDA-FAS, 2020). However, the USDA projected soybean oil at a higher price because of the higher demand but lower supply in the coming year (USDA-ERS, 2020). According to the market report from Beroe Advantage Procurement (n.d.), the soybean oil market and supply is growing steady because of the increase of population and demand of biodiesel.

For the SWOT Analysis, the strength (S) of the U.S. soybean oil is its large and stable production, leading to lower prices. The weakness (W) is that the large domestic consumption will lower the soybean oil's export volume. For opportunity (O), with the increase of biodiesel production and population, demand of soybean oil is going to increase. Finally, the most significant threats (T) to the U.S. industry are the trade war with China and the expansion of Brazil and Argentina's soybean industry. In addition, the soybean oil production face criticism of deforestation of the woods, and the heath problem concerned like obesity and diabetes (Wexler, 2019).

In conclusion, the U.S.'s large soybean production led to the high and stable output of soybean oils at a lower price. However, the U.S. soybean oil industry may face difficulties because of the trade war with China and the competition from Brazil and Argentina.

1.6.3 Milk

The U.S. has a flourishing dairy industry. Dairy products provide nutritional and economic benefits to the Americans. The U.S produced 96,890,477 tonnes of cow milk in 2018 (FAO, 2020). According to the data from the USDA-ERS, more than 50% of U.S. milk are produced in the states of California, Wisconsin, Idaho, New York, and Texas (USDA-ERS, 2020). Beside fluid milk, cheese, butter, and non-dry fat milk are the top three dairy products consumed by American. Although cheese's production is much higher than non-fat dry milk, the U.S. still needs to import cheese because of the domestic consumption. On the other hand, about two-third of the non-fat dry milk can be exported after supplying the U.S. market.

Non-fat dry milk is the flavorful and nutritious milk solid containing more than 1.5% of fat and less than 5% moisture. The non-fat dry milk has the ability to bind water, serve as emulsifier and foam builder (Igoe,2011). It is a significant ingredient for dessert, baking goods and ice cream. In 2019, U.S. produced 1,099 thousand metric tons and exported total of 701 thousand metric tons of non-fat dry milk (USDA-FAS, 2020).

1.7 Conclusion

In conclusion, our research successfully identified the top three flavoring ingredients manufactured in Brazil, China, Canada, Mexico, India, and the U.S. They are correlated to the high production of the agricultural commodities used to produce the country's ingredients. After carefully reviewed all the top three ingredient industries in each country, we found out that the orange extract industry in Brazil, garlic powder industry in China, turmeric industry in India, maple sap industry in Canada, lime industry in Mexico, and the soybean oil in the U.S. are thriving and growing because of the large and stable production of the raw materials in each country. Each industry has its unique strength and weakness. However, most of the six countries' flavoring ingredient industries face the same threats: the COVID-19 pandemic. Like Canadian maple sap and Mexican lime, a few of them face the challenges of climate change and natural disasters.

2. Chemical Characteristics and Parameters that Affect the Quality of Various Flavoring Ingredients

2.1. Caffeine

2.1.1 Introduction

Caffeine is considered one of the world's most consumed psycho agent, as it is a chemical substance that interacts with the central nervous system causing shifts in mood, behavior, or perception. The most popular source of caffeine is through coffee, to help us stay alert and boost productivity. Caffeine can also be found in plants such as tea, cacao beans, yerba matte, and guarana berries. Caffeine can be added to many beverages, such as sodas, energy drinks, energy shots, etc. and it is commonly used as an energy booster in most foods.

2.1.2 Metabolism & Chemical Characteristics

Not only has caffeine consumption has remained a great source for energy, it has also been proven to have several health benefits. The chemical name for caffeine is methylxanthine (1,3,7-trimethylxanthine), and research has shown that caffeine-containing products include several phytochemicals, such as polyphenols and melanoidins (brown pigment during roasting), as well as magnesium, potassium, etc. (Food Insight, 2019). Pure caffeine is white crystal at room temperature. It is also odorless and has a bitter taste. The boiling point of caffeine is 352 ˚F/178 ˚C, the melting point is 460 °F/ ~238.0 °C, and the pH is 6.9 (PubChem, n.d.).

Caffeine can be absorbed by the body after 45 minutes of ingesting it, making blood levels peak at around 15 minutes (PubChem, n.d.). The consumption of caffeine makes people alert, because it can block the reaction of adenosine. Adenosine increases drowsiness and inhibits arousal. Since the chemical structure of caffeine is similar to adenosine, caffeine is able to bind to adenosine receptors, block adenosine, and stop its effects (PubChem, n.d.).

2.1.3 Processing/Extraction of Caffeine

Caffeine is classified as a Generally Recognized as Safe (GRAS) ingredient by the USDA. It is required to be listed on the ingredients list in the food and beverage product labels, sometimes even the amount of caffeine in the product. Caffeine can be extracted from both roasted coffee beans and raw beans. However, the extraction methods and time at low temperatures are different between these two types of beans.

One of the most common methods for extracting caffeine from coffee beans is organic solvent extraction, which uses organic solvent, such as dichloromethane or ethyl acetate, to wash the beans (Irimia & Gottschling, 2018). During the organic solvent extraction, the coffee beans are moistened or steamed in a rotating drum for about 30 minutes to open their pores. Then, they can be rinsed for hours with organic solvents that are approved by the USDA to extract caffeine (Irimia & Gottschling, 2018). Eventually, the solvent is saturated with caffeine. Finally, the coffee beans are steamed to evaporate the solvent, leaving caffeine in a white powder form.

Another common method is the water process method (Gillespie, 2019). During this method, coffee beans are placed in water and they are heated until reaching the boiling point. This process removes both flavors and caffeine from the coffee beans. Then, an organic solvent, such as dichloromethane or ethyl acetate, is added to the water-coffee mixture. The solvent will be absorbed by the coffee beans and will later be removed by evaporation (Gillespie, 2019).

Supercritical carbon dioxide method is also commonly used to extract caffeine. When temperature and pressure are both raised, carbon dioxide can be changed into a supercritical liquid, which is a mixture of both liquid and gas (Gillespie, 2019). Coffee beans are rinsed with this supercritical liquid to be able to extract the caffeine. This liquid can be recycled to use it repeatedly in the extraction process.

The yield of caffeine from these common methods was not comparable. However, the type of bean roasting (medium roast & dark roast) and semi-dry processing may influence the caffeine content/yield (Rodriguez, Y. F. B., 2020). Different methods were used to find different ways of extracting caffeine and to find which one yielded the most caffeine; the type of coffee bean also influenced the caffeine levels, where the green coffee bean processed using a wet method also yielded low amounts of caffeine (Rodriguez, Y. F. B., 2020). Overall, the coffee beans with darker roasts yield the lowest amount of caffeine (Rodriguez, Y. F. B., 2020).

2.1.4 Impact of Climate Conditions on Quality of Caffeine from Coffee and Green Tea

The quality of caffeine in coffee can vary depending on climate conditions during harvest. Caffeine is one of the main chemicals in coffee beans that contribute to the bitterness (Irimia & Gottschling, 2018). Caffeine is formed in immature coffee seeds and accumulates as the seed develops (Irimia & Gottschling, 2018). This accumulation is affected by environment conditions. For example, in C. arabica coffee strains, the amount of caffeine can be increased if the plant is exposed to more shade. In addition, the altitude of where the coffee beans are harvested can influence caffeine quality and content. However, it is yet to be confirmed that temperature influences caffeine concentration since the caffeine content in many C. arabica strains remain stable in different environments (Irimia & Gottschling, 2018).

Green tea leaves are another common source of caffeine. Soil conditions and soil quality can impact the level of caffeine in green tea leaves. For example, with increased nitrogen in the soil by soil nitrogen fertilization, the caffeine content found in the leaves increased at first (when exposed to more light) then decreased as the leaves grow and develop (Irimia & Gottschling, 2018). Fertilizing the soil with nitrogen leads to significant increase in tea yield and the levels of amino acids and caffeine until later development of tea leaves. However, after one month of reasonable nitrogen treatments a decrease in phenol ammonia was observed. Therefore, these lower levels of phenol ammonia will yield better tea quality and higher caffeine content (Irimia & Gottschling, 2018).

2.2 Garlic

2.2.1 Introduction

Garlic (*Allium sativum* L.) is an essential Allium species known for its therapeutic and flavoring functions. Chinese have been using this commodity in cooking to avoid food poisoning, such as when consuming fresh seafood, for thousands of years (Reyzelman, 2015). The quality of garlic is evaluated based on their health benefits and sensory characteristics, such as color and pungency or flavor intensity. The ideal fresh garlic cloves should be white with intensive flavors.

Garlic possesses various biological functions such as hypocholesterolemic and antidiabetic. These biological actions were due to compounds, such as thiosulfinates and polysulfides, present in garlic oil. These products result from the degradation of cysteine derivatives in garlic (S-alkyl cysteine sulfoxides) by alliinase (Augusti KT, 1996).

Fresh garlic possess a unique flavor because of sulfur-containing volatiles, such as alliin. By the action of alliinase enzyme, alliin is converted to allicin and eventually disproportionately to thiosulfinates and disulfides (Carson, 1967).

2.2.2 Effect of Processing on Garlic's Quality

In ancient times, people used fresh garlic as flavoring ingredients without any processing steps. As technology advances, garlic is further processed for longer shelf-life, easier of use, or the incorporation of new flavor; however, processing methods affect the quality of garlic. Garlic is most commonly processed into garlic powder.

To produce garlic powder, fresh garlic is cut, dried, and grinded into powder. The flavor of garlic powder is milder compared to fresh garlic due the evaporation of flavor compounds (sulfur-containing volatiles) at high temperature during the drying process (Pezzutti & Crapiste, 1997). Furthermore, converting garlic into garlic powder also reduces its biological benefits and flavor since these sulfur-containing volatiles are evaporated due to high-temperature during the drying process. With lower temperature of the drying process in making the garlic paste, the biological activity and intensity of flavor of garlic paste is stronger than garlic powder.

Raw garlics can also be fermented into black garlics. To ferment raw garlic into black garlic, garlic bulbs are fermented for several weeks at high humidity (80% RH) and high temperature (70°C) for 30 days (Zhang et al., 2016). Compared to fresh garlic, black garlic does not release a prominent off-flavor. This reduction of off-flavor is due to the reduced amount of allicin that got converted into antioxidant compounds – bioactive alkaloids during fermentation (Kimura et al., 2017). The fermentation environment also facilitates the Maillard reaction, in which amino acids react with reducing sugars in the garlic, forming inky black pigment in the cloves. In the meantime, a stickier texture develops, and a sweeter taste along with the deep taste of seared meat and fried onions produces (Stanek, 2016).

2.2.3 Climate Condition Impact on Garlic Quality

Soil conditions can affect garlic quality. Garlic grows best on slightly acidic soil with a pH range 6.0 to 7.5 (The Spruce, 2019). Although garlic may grow on more acidic soil, garlic will turn yellow, which is not favorable (Evans, 2019). Nitrogen, phosphorus, potassium nutrients are required in the soil to promote the initial growth, to optimize root development, and to form healthy bulbs, respectively (Spruce, 2019). Sulfur content in the soil would positively affect the level of sulfur-containing compounds in garlic, which improve garlic's biological properties and flavor (Spruce, 2019).

In addition to pH and nutrients in the soil, other environmental conditions also affect the levels of sulfur-containing compounds in garlic. To achieve the maximum concentration of sulfur-containing compounds in garlic, garlic should grow under full sun exposure with cool temperature ranging from 0℃ to 10℃ in the earlier growth stage, because cool temperature is vital in establishing an extensive root system (Albert, n.d). Although mature garlic is not heavily affected, if younger garlic plants grow under than 0℃, the color of garlic could turn yellow (Evans, 2019). Therefore, in the countries like U.S. and China, it is the best practice to plant garlic in the spring and fall seasons, which after 8 months garlic will be matured and ready to be harvested during summer (Green, n.d.).

2.3 Vanilla

2.3.1 Introduction

Vanilla extract is one of the most popular flavoring ingredients world-wide (Brownell, 2011). It is widely used in dairy products, bakery products, and chocolate. Vanilla is extracted from the cured vanilla bean (Igoe, 2010). The vanilla quality is significantly influenced by the chemical characteristics of the vanilla bean, processing methods, and the climate conditions in growing the vanilla bean.

2.3.2 Chemical characteristics

Cured vanilla beans contain more than 600 phytochemicals, and vanillin is the major contributor to the flavor strength of vanilla products (Havkin-Frenkel, 2018). The quality of vanilla is related to the concentration of vanillin in the cured vanilla beans (Ranadive, 2011). How vanillin is biochemically synthesized by the vanilla beans are not well understood. A possible biosynthesis pathway has been proposed. L-phenylalanine ammonia-lyse (PAL) converted L-phenylalanine to vanillin β-D-glucoside in green vanilla beans (Podstolski, 2011). Then, during the curing process, the vanillin β-D-glucoside are converted to vanillin by hydroxylation (Lindsay,2017). Other than natural vanillin produced from the vanilla beans, synthetic vanillin from lignin, guaiacol and eugenol are also commonly seen on the market. The synthetic vanillin is often used to fortify the natural extracts and flavoring (Ranadive, 2011). The vanillin content in the cured vanilla beans varies depending on the genetic origins of the vanilla beans. For example, a cured pod of vanilla planiflolia approximately contains 1.0 to 8.0 % of vanillin in dry weight. In contrast, a cured pod of Vanilla tahitensis only has 0.5 to 2.0 % of vanillin in dry weight (Havkin-Frenkel, 2018). In addition, vanillin content in the cured vanilla beans differs if the beans are from different geographic origins and cured using different processing methods (Ranadive, 2011).

Other chemicals, such as resin and organic acids, as well as the soluble solid content in the vanilla beans also affect the vanilla quality (Havkin-Frenkel 2018). If the vanilla beans had a higher resin content, the processed vanilla extract would be cloudier (Havkin-Frenkel, 2018). If the soluble solid content in a vanilla extract is lower than 0.2 g per 100 mL for a single-fold of extract, then the vanilla bean extracts should not be considered as a good quality extract (Ranadive, 2011). The content of organic acids in the vanilla extract is the purity indicator and is expressed as the "lead number". One-fold of pure vanilla extract should have a minimum lead number of 0.7 (Havkin-Frenkel, 2018).

2.3.3 Curing of vanilla beans and extraction

To obtain high quality of vanilla extract, manufacturers need to ensure that the quality of the raw material is consistent. One of the critical processing steps is the curing process of the beans after harvesting. Failure to perform proper curing process will result in a loss of tremendous amount of vanillin content from the vanilla beans (Havkin-Frenkel, 2018). If a six-months long traditional curing process is applied, a vast amount of vanillin content in the vanilla beans will be lost. The traditional curing process includes several steps such as killing, sweating, drying, and conditioning. The killing process is to end the vanilla bean's vegetative life with heat, such as sun and oven. Sweating is to put the killed beans under high humidity and temperature condition to develop the vanilla flavor, aroma, and color. The third step is to dry the beans with heat to prevent spoilage. The final step is conditioning, which is to further dry the beans and allow flavor development by the enzymatic and non-enzymatic oxidative reactions

(Frenkel et al, 2011). Only 2.5 to 4.5% of vanillin on dry weight basis can be recovered (Havkin-Frenkel, 2018). The significant loss is due to the evaporation of vanillin-water molecules from the green bean in high-temperature conditions. In contrast, 7 to 8% vanillin on dry weight basis can be recovered from the mechanical maceration curing process (12 to 24 hours) of sun-dried green vanilla beans (Havkin-Frenkel, 2018).

In addition, vanillin can be extract from the beans with ethyl acetate in both acid and alkaline conditions. First, beans are soaked in water and then grinded. Then, vanillin is extracted from water using ethyl acetate. The last step is to evaporate ethyl acetate and filter out the vanillin. However, to maintain the consistent quality of the extract, the manufactures have to follow the proper procedures: 1) the quality of raw materials should be consistent, 2) the manufacturing process should follow best practices, and 3) the operators are well trained (Ranadive, 2011).

2.3.4 Impact of climates on the quality of vanilla

The impact of climate is essential toward the quality of the vanilla beans. The best place for the vanilla bean to grow on the earth is the tropical lands where they are 20 degree northern or southern of the equator (Exley, 2011). Vanilla beans should be planted in the area with around 24 ºC, ~80% relatively humidity, average annual precipitation around 1,200 to 2,000 mm, and well-drained and rich soil during March to June (Ranadive, 2011). The optimal growing conditions vary depending on the species of the vanilla beans.

3. Customer Perception on Caffeine and Vanilla Extracts Survey Report

3.1 Introduction

Caffeine is one of the popular consumed stimulants which are produced out of coffee beans commonly produced in Brazil (Statista, 2020). On the other end, vanilla extract is one of the most popular flavoring ingredients that are commonly produced in Mexico (Future Market Insight, 2020). Therefore, we conducted this survey with the main purpose to determine if consumers cared about the origin of their caffeine & vanilla products and the determining factors when purchasing them.

3.2 Method

Qualtrics was used to implement the 14-question online survey (Appendix A). The survey was advertised through the University of Illinois at Urbana-Champaign's E-week (staff and faculty members across campus) and Listserv (undergraduate students, graduate students, staff, and faculty in the Department of Food Science and Human Nutrition at the University of Illinois at Urbana-Champaign). After approximately one week (October 9, 2020 – October 16, 2020), data was obtained from 161 participants. The data was later analyzed using both Friedman Test and Chi Square Test (Appendix B).

3.3 Results and Discussions

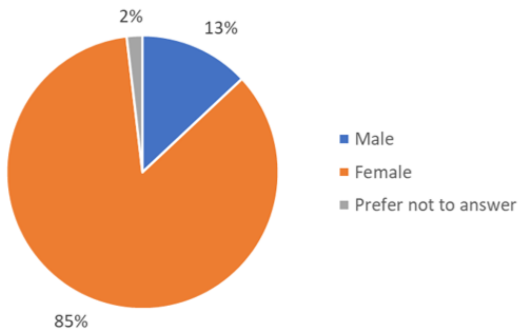

Figure 1: Gender Demographics Data.

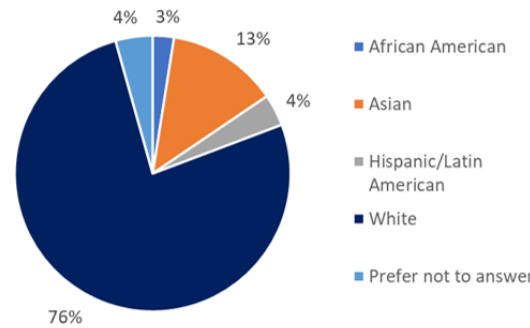

Figure 2: Ethnicity Demographics Data

Figure 1 and 2 above showed that our survey data best represents the white female population in the Urbana-Champaign area. This claim was based on most panelists were white and woman (Figure 1 and 2), and this survey was conducted on Urbana-Champaign area. Also, chi square test was used to analyze the data and proved that the data on Figure 1 and 2 are not randomized.

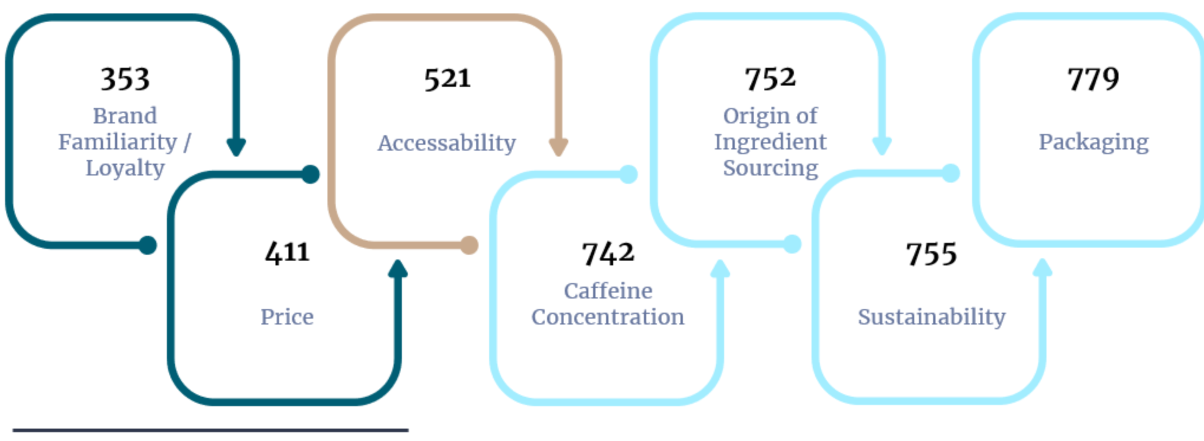

Figure 3: Customer Determining Factor in Buying Caffeine Containing Products

Friedman Test was used to analyze the data and showed that results in Figure 3 were not randomized; however, the yardstick in the graph shows that the factors above the sticks are not significantly different from each other. The number in the figure shows the importance of each factor. The number was calculated by multiplying the average rank value (rank 1 as one value, and rank 7 as seven value) by the number of panelists who answered the question. The smaller the number the more important the factor. The most important determining factors in customers buying the caffeine containing products are the brand familiarity/loyalty and the price. Most customers were not able to distinguish the quality variation of coffee beans based on the country of origin, and some of their purchases were deemed as status symbol (Samoggia & Riedel, 2019; 2018).

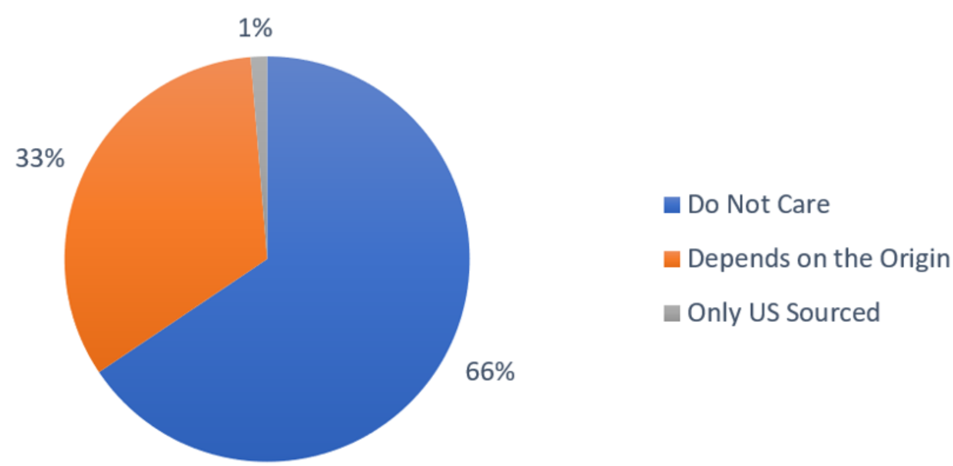

Figure 4: Customer Preferences in Origin of Caffeine in Caffeine Containing Products

Figure 4 showed that most customer (66%) did not care where the caffeine- containing product was sourced from. Among the panelists who have a preference on the country of origin of the caffeine- containing product (34 %), they preferred to have their caffeine containing products sourced from the U.S. (Figure 5) although the U.S. did not product much caffeine.

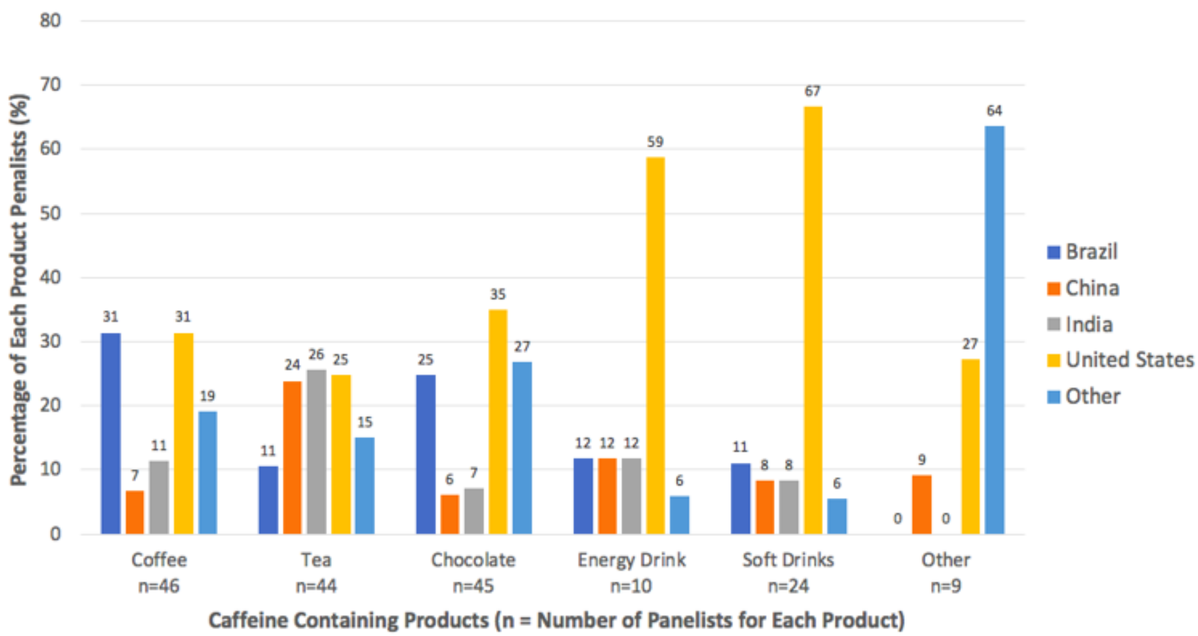

Figure 5: Caffeine Product Country of Origin Preferences Data

This preference toward the U.S. was because people tend to favor products from their home country, the U.S. (Gudero, 2009). Also, there was a positive correlation between the higher the economy of a country, the higher the customer's value perception toward their products (Eliott & Carmeron, 1994).

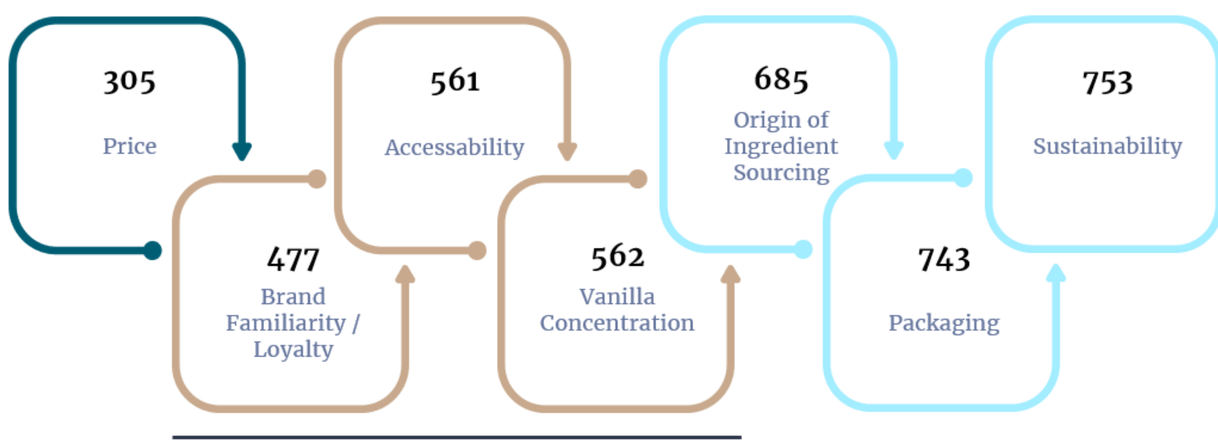

Figure 6: Customer Determining Factor in Buying Vanilla Containing Products

Figure 6 shows that the most important determining factor in customers buying the vanilla containing products is the price. The number in the figure shows the importance of each factor. The number was calculated by multiplying the average rank value (rank 1 as one value, and rank 7 as seven value) by the number of panelists who answered the question. The smaller the number the more important the factor. This price sensitivity was well reflected on how food and beverage makers took wait-and-see attitude toward the fluctuation price of vanilla before finally making purchases (Siengner, 2019). However, in term packaging, there is a limitation in our survey questionnaire which natural ingredient label in the packaging was not mentioned. Therefore, to gather a more insight, the “natural label packaging” wording should be used instead of “packaging” in the future surveys. According to April Rae Parker (2003), labelling or packaging was one of the most important factors, although not as important as price, more people are now driven toward natural trends.

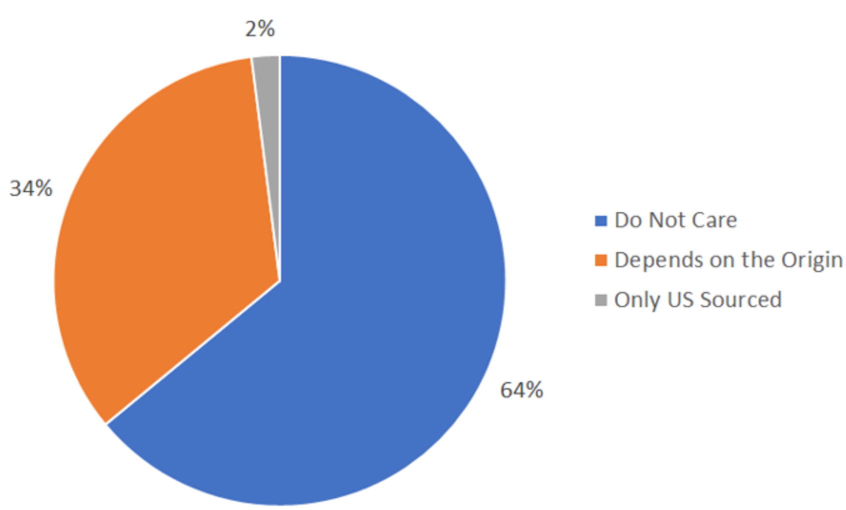

Figure 7: Customer Vanilla Origin Preferences in Vanilla Containing Products

Figure 7 and 8 above showed that most customer (64%) did not care where their vanilla was sourced from. Among the panelists who have a preference on the country of origin of the vanilla (36 %), they preferred vanilla from Mexico rather than China (Figure 8).

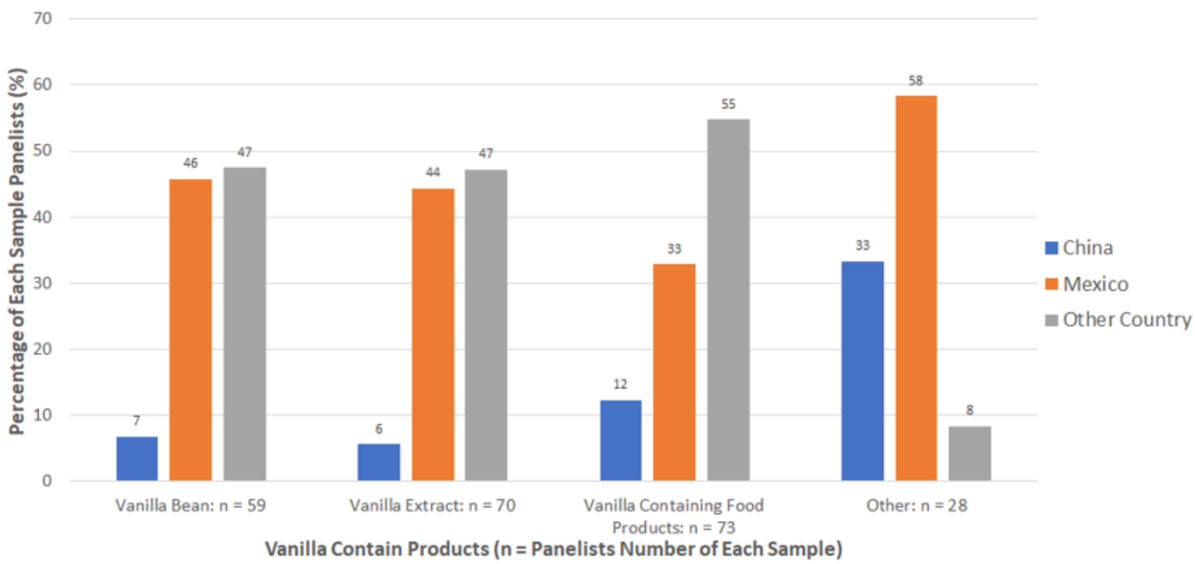

Figure 8: Caffeine Product Country of Origin Preferences Data

This low bar value in China was because people had a bad perception on Chinese products (Andersson, 2015). China also started their vanilla late; therefore, their quality was still not comparable to Mexico, but China is rapidly growing quantitatively and qualitatively (Landau, 1998). On the other end, tendency to favor Mexican Vanilla Extract was because Mexican Vanilla Extract was heavily advertised as a very high-quality vanilla extract (Rain, 2019). However, unlike the increasing demand, the production rate of the Mexican Vanilla Extract was reducing which creates new room for other vanilla extract producer, such as China, to fill in (Future Market Insight, 2020).

3.4 Conclusion

In term of caffeine, our survey showed that the most important determining factor in customer buying caffeine-containing products were both brand familiarity and price with majority of them not considering the origin country of caffeine. This survey also revealed a potential opportunity to win the caffeine market if the company focuses more on both brand familiarity and price.

In term of vanilla, our survey showed that the most important determining factor in customer buying caffeine-containing products were price with majority of them not considering the origin country of caffeine. This survey also revealed a potential opportunity to create a big profit if the company could shift to China's production surplus as opposed to sticking with Mexican declining production rate.

4. Caffeine and Vanilla Samples Lab Analysis

4.1 Introduction

Caffeine and vanilla are two popular flavoring ingredients used all over the world. Caffeine is usually presented as a white fine powder. Vanilla extract is presented as a liquid with different variations of brown colors (Ranadive, 2011). In order to analyze properties of caffeine and vanilla, the pH, refractive index and specific gravity of 1) caffeine powder, 2) Mexican vanilla extract, and 3) Tahiti vanilla extract, which are provided by Bell Flavors, were evaluated.

4.2 Sample Information

Table 2 summarized the information of samples that were evaluated. The extracts of Tahitian vanilla & Mexican vanilla are both from Nielsen-Massey. Due to campus health and safety requirements in respond to COVID-19, we were not able to conduct tasting without masks. The flavor profile of Tahiti and Mexican vanilla extracts are from the Nielsen-Massey's website (Nielsen-Massey, n.d.).

Table 2. Sample Information Table

Sample	Catalog Number	Sensory Characteristics		
		Appearance	Smell	Flavor Profile
Caffeine	NONSTOCK – 004601	White Fine Powder	Subtle Chocolatey Aroma	N/A
Tahiti Vanilla	NONSTOCK – 001303	Very Dark Brown Liquid	Very Strong Sweet Vanillin Aroma	Floral, Fruity, Anise- and Cherry- like
Mexican Vanilla	NONSTOCK – 010175	Medium Brown Liquid	Medium Sweet Vanillin Aroma	Deep, Creamy, Spicy-Sweet Character

4.3 Method

The pH of the Tahitian Vanilla was measured in triplicate and the temperature of the sample was recorded. The pH meter (Hanna Instrument, HI 99163) was calibrated using buffer solutions with pH 4, 7, and 10 following the manual. For the Mexican Vanilla, the pH strips were used to estimate the pH value in triplicate because there was not enough sample for the immersion of the pH meter probe. The temperature of the sample was recorded. For the pH of the caffeine powder, the powder was diluted into caffeine aqueous solution (concentration of 10 mg/mL) and was measured using the pH meter in triplicates. The temperature of the sample was recorded. A calibrated Brix Refractometer was used to measure the refractive index of the Tahitian Vanilla, Mexican Vanilla, and caffeine solution in triplicates.

All samples' specific gravity was measured indirectly by dividing the mass of the samples over the mass water at the same temperature. The water density at a particular temperature was obtained from the reference (Plymouth State University, n.d.). An analytical scale was used to get the mass of the samples and the water. Since there was only a little amount of Tahitian Vanilla, the masses of 1 mL of the extract and 1 mL of water were measured in separate beakers on the analytical scale to calculate the Tahitian Vanilla's specific gravity. Then, the calculation was made. Similarly, the amount of Mexican Vanilla sample were extraordinarily little, so the masses 0.1 mL of the extract and 0.1 mL of water were measured for the specific gravity calculation. For the caffeine's specific gravity, 50 mL of the caffeine solution and 50 mL of water were weighted for the calculation. The specific gravity calculations of all samples were measured in triplicates.

4.4 Results

Table 3. The pH, Refractive Index and Specific Gravity of Caffeine Solution, Mexican Vanilla Extract, and Tahiti Vanilla Extract. Values are expressed as average ± standard deviation (SD) for n = 3.

Sample names	pH	Brix (%)	Specific Gravity
Caffeine solution	7.913 ± 0.071	2.00 ± 0.00	0.01001 ± 0.00011
Mexican vanilla	4.633 ± 0.032	23.00 ± 0.87	0.8347 ± 0.0015
Tahiti vanilla	4.00 ± 0.00	18.00 ± 0.00	0.800 ± 0.010

The raw data of the analysis is in Appendix C. From the Table 3, Caffeine is a slightly basic flavoring agent with a very low specific gravity value and low sugar content. Tahitian

Vanilla and Mexican Vanilla are a slightly acidic flavoring agent with a low specific gravity value and high sugar content.

4.5 Discussions

The pH of the aqueous caffeine solution (10 mg/mL) is different than the reference value of caffeine - 6.9 (Science Encyclopedia, n.d.). The concentration of the caffeine solution would differ in pH. The Mexican Vanilla is more acidic than the Tahitian vanilla, with a pH of 4.00 and 4.63, respectively. The brix scale relates the refractive index to sugar concentration, measuring % dissolved sugars (Paar, n.d.). The caffeine has quite a low % dissolved sugar, whereas Tahitian vanilla has a very high amount of % dissolved sugar, with an average of 23, and Mexican vanilla follows up with an average % Brix of 18. In addition, the average specific gravity of Tahitian vanilla, 0.834, compared to that of Mexican Vanilla (0.80) & caffeine (0.0100) indicates that the Tahitian Vanilla has the highest sugar concentration out of all the samples. Small SD on the results shows that these values were precise since the values did not deviate much from the average.

However, there were some limitation in the measurement of pH on the caffeine solution in this experiment. Potential sources of error include not too steady reading on the pH meter. When determining the specific gravity, reading on the weight scale was not too steady.

4.6 Conclusions

Our testing methods can be replicated to measure the chemical characteristics on vanilla extracts and caffeine powders with proper instruments. The test results of the pH, %Brix, and specific gravity are precise because the C.V. values are under 0.05. Bell Flavor can use our chemical characteristics (pH, %Brix, and specific gravity) data in their internal research and product development of Caffeine Solution Extract, Tahiti Vanilla Extract, and Mexico Vanilla Extract.

5. Recommendations Based on Caffeine and Vanilla Market and Trends

5.1 Caffeine

5.1.1 Introduction

Caffeine is a popular flavoring ingredient that is considered to be one of the world's most consumed psycho agents, as it causes shifts in mood, behavior and increases concentration (Gillespie, 2019). One of the most popular sources of caffeine is from coffee, which is consumed primarily to boost productivity and keep us alert. There are many other popular sources of caffeine such as tea and cacao beans (Food Insight, 2019). Caffeine can be added to a variety of foods and beverages; for example, sodas, energy drinks, energy shots, pre-work out, etc. However, since the supply chain has been disrupted by the COVID-19 pandemic, which has also caused anti-Chinese sentiment in the U.S., it is recommended that companies should source these ingredients from other countries.

5.1.2 Supplier Qualification

According to the survey we conducted throughout the campus, we found that the majority of people (66%) did not care for where their caffeine originated from. This finding is similar to the study that we found that country of origin is not a determinant since most customers cannot differentiate the quality based on the country origin (Samoggia & Riedel, 2019; 2018). However, the key determining factor of their purchases was both brand familiarity and price since customers identify brands as status symbols (Samoggia & Riedel, 2018). These customer behavior surveys showed that the most viable business model for this industry is to find a good quality and cost-friendly coffee beans supplier and to sell the caffeine extract to well-known companies. In this case, we believe that Brazil matches our expected supplier qualifications.

5.1.3 Brazil as an Alternative Supplier

In terms of choosing the ideal coffee bean supplier, the coffee bean quality is the most important factor. Brazil has remained the leading producer and exporter of coffee for over 150 years with a total production of 3.7 metric tonnes in 2020 (Alves, 2020). Not only in terms of quantity, but Brazilian coffee beans also have a superior quality and are considered as one of the world's finest coffee beans for their both Arabica and Robusta coffee beans. This high quality of coffee is made possible by Brazil's geographical location with optimal surface area for plantation and the best climate to grow high quality coffee beans (Bizvibe, 2017).

In term bilateral trade, the US is currently in a good trade agreement with Brazil. This good trade agreement is reflected in how the US imports most of their coffee beans from Brazil (24% of total coffee import) (USDA, 2020). Apart from its good quality, Brazil also offers their coffee beans at a very competitive price, especially their Robusta coffee. In Brazil, robusta coffee costs 0.88 USD/Kg, whereas the general price of robusta coffee is 1.87 USD/Kg, which proves its competitive price in the coffee market (Statista, 2020; Gomes, Teixeira, 2020). Also, Brazil is located near the US (4537 miles apart), which allows a cheaper transportation cost compared to most other coffee-producing countries (Distance From To, n.d.).

In order to source coffee beans from another country, it is necessary to contact top suppliers in Brazil; the top Brazilian coffee bean suppliers/manufacturers include companies such as EISA-Empressa Interagricola S.A., Terra Forte Exportacao E Importacao De Cafe Ltda, and Cooperative Regional Cafeicultores Guaxupe Ltda (Panjiva, n.d.).

5.1.4 Quality Control and Manufacturing Process

Brazil produces two types of coffee, Arabica and Robusta coffee. To process them into caffeine extracts, Robusta coffee is preferred because they cost almost half the price and contain almost twice the caffeine content of the Arabica coffee (The Roasters Pack, 2014).

In order to extract caffeine from coffee beans, there are different methods that can be used, but the most common method used is the Direct Organic Solvent Extraction since it can be used on both coffee beans and liquid coffee (Gillespie, 2018). The most common method of extracting caffeine from coffee beans is the direct organic solvent extraction, where the coffee beans are moistened or steamed in a rotating drum, followed up with rinsing them with dichloromethane, then you steam the beans a second time to evaporate the solvent, leaving only the caffeine behind in white powder form (Gillespie, 2018).

5.1.5 Conclusion

Consumers are interested in caffeine containing products from well-known companies for accessible prices. Based on the information gathered, the best recommendation would be to source caffeine from Brazil since they have suppliers that will provide these companies high quality beans, with a high content of caffeine for a cheaper price. To be exact, the best type of coffee bean to extract caffeine from would be Brazilian Robusta coffee beans since it is much cheaper and has a higher caffeine content. Finally, the best method to extract the caffeine from robusta coffee beans would be the organic solvent extraction. Thus, Brazil would be the most convenient choice.

5.2 Vanilla

5.2.1 Introduction

Vanilla extract is one of the most popular flavoring ingredients worldwide (Brownell, 2011). It is widely used in dairy products, bakery products, and chocolate. According to the Food and Agriculture Organization of the United Nations (FAO) (2020), mainland China is the fourth largest vanilla production country globally. It produced around 459 tonnes of vanilla in 2018 (FAO, 2020). Although China has become one of the leading suppliers of vanillin, the COVID-19 pandemic and the Sino-U.S. trade war have disrupted the supply chain and generated anti-Chinese sentiment in the U.S. Many ingredients manufacturers, like Bell Flavors, are seeking vanilla outside of China with the current circumstances.

5.2.2 Supplier Qualifications

Based on our team's consumer perception survey, the survey takers, white-female Americans, thought the price is the most important customer determining factor in buying vanilla containing products. Therefore, it is crucial to select an alternative supplier that will sell vanilla to Bell Flavor at a friendly price. Also, the survey takers who care about their vanilla products selected Mexico as the origin of their vanilla containing products over China. Overall, consumers tend to have negative perceptions of all Chinese products (Andersson, 2015). The result implies that some of the consumers have knowledge about the quality of the vanilla. Therefore, it is essential to choose an alternative supplier with high-quality vanilla, too. According to our team's research and consumer perceptions, we found that Mexico will be the best alternate vanilla supplier for Bell Flavor to make up the lost portion from China.

5.2.3 Mexico as an Alternative Supplier

Mexico is the birthplace of vanilla beans. It has a long history of vanilla bean cultivation and exportation. The indigenous groups in Mexico have used vanilla beans for flavoring and medicine dating back to the pre-Hispanic Mesoamerica era. Mexico was the only country that could export vanilla beans before the 20th century (Hernandez-Hernandez, 2011). Although Mexico lost its monopoly on vanilla, it is still one of the leading countries in vanilla production and exportation. According to the Food and Agriculture Organization of the United Nations (FAO) (2020) database, Mexico is the third-largest vanilla production country globally. Its vanilla production, 495 tonnes, suppressed the Chinese in 2018 (FAO,2020). Besides the advantage of quantity, Mexican vanilla is highly marketed. The Mexican vanilla extract is considered one of the top five vanilla extracts in the international market (Future Market Insight, 2020). If Bell Flavor increased its vanilla bean imports from Mexico, it could market its vanilla-related ingredients as high quality.

The U.S. is the largest consumer of vanilla in the world and approximately 40% of the world's annual production of vanilla is imported by the US (Calva-Estradaa & Mendozab, 2017). The price of Mexican Vanilla beans is 5,000 pesos, which is about US$282 per kilogram (Navarro, 2017). Mexican Vanilla shows no difference in price compared to other production countries like Madagascar, although Mexican Vanilla may appear to have higher quality (Hernandez-Hernandez, 2011).

In Mexico, most of the vanilla beans are primarily cultivated in Papantla and Gutierrez Zamora of the state of Veracruz, about 70% of the nation's production, and San Jose Acateno of the State of Puebla, about 30% of the nation's production (Hernandez-Hernandez, 2011). In addition, the city of Papantla and the town of San Jose Acateno are the curing and trading centers of the Mexican Vanilla beans (Corell, 1953). We recommend Bell Flavor to get in touch with the local dealers in Papantla and San Jose Acateno for best vanilla bean supply.

5.2.4 Quality Control and Manufacturing Process

The quality of vanilla can be determined from several parameters, including aroma, moisture content, vanillin content and microbial limit (Ranadive, 2011). Vanillin content of vanilla beans can be varied based on cultivation, curing practices and origins, it can go up to 3% of weight. Higher vanillin content results in stronger flavor (Ranadive, 2011). For measuring vanillin content, liquid chromatography like HPLC and HP-TLC, isotopic methods like stable isotope ratio analysis (SIRA) are methods tested to be effective in separating and examining the vanillin and 3 other vanilloid compounds. Gas chromatography methods can be used to examine the flavor and aroma of vanilla (Hoffman & Zapf, 2011). Strictly applying microbial limit for vanilla is important for preventing possible contaminations, recommended limit of microbial contaminants for each gram of vanilla are 1000-10,000 total plate counts, less than 10 counts of yeast, less than 1 count of mold, negative on salmonella and less than 3 counts of E. coli 3 Tube MPN. The vanilla beans for extraction should have 20 to 25% of moisture content and high moisture content ones will have better appearance and aroma. Moisture content can be tested using physical methods such as Hot Oven Method and Vacuum Oven Method, or chemical methods including Karl Fischer method (Ranadive, 2011).

To extract vanillin from the cured beans, the producers need to grind the beans and soak them in water first. Then, the extraction of the vanillin from water using ethyl acetate in acidic condition is required. The last step is to evaporate and filter out the vanillin. The vanillin will be stored with alcohol as the vanilla extract. To maintain the consistent quality of the extract is very important, too. The manufacturers must follow the proper procedures: 1) the raw materials have to be consistent, 2) the manufacturing process needs to be sound/scientific, and 3) the operators are trained well (Ranadive, 2011).

Mexican Vanilla can be considered as good quality vanilla, because it has generally 2% of vanillin content by weight and 61 volatile compounds with 11 only found in Mexican Vanilla. Vanillin and other volatile compounds give Mexican Vanilla strong and distinct aroma and flavors (Hernandez-Hernandez, 2011).

5.2.5 Conclusion

Mexico is the third largest production country of vanilla and most of the vanilla produced are imported to countries all over the world. Consumer perception survey we conducted shows that consumers also prefer Mexico as the country of origin for vanilla that they would like to purchase. Mexican vanilla appears to have high vanillin content which contributes to high quality products with stronger flavors and distinct aromas. Finally, the best method to extract the caffeine from Mexican vanilla is through the extraction process using ethyl acetate in acidic condition. Therefore, based on the relatively large production and high quality of Mexican Vanilla and consumers’ preferences, we recommend Bell Flavors to consider Mexico as their potential supplier of vanilla.

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Appendix A

Consumer Perceptions Survey on Caffeine and Vanilla

1. How often do you consume caffeine-containing products? (ex. coffee, tea, energy drinks, sodas, chocolate etc.)
    a. Less than once a month or never
    b. Once a month
    c. Once a week
    d. Almost everyday
2. What caffeine-containing products do you consume most often? (check all that apply)
    a. Coffee (such as black coffee, latte, etc.)
    b. Tea (such as boba milk tea, matcha latte, Chinese tea, etc.)
    c. Chocolate (such as chocolate wafer, dark chocolate, etc.)
    d. Energy drinks
    e. Soft Drinks
    f. Other, please specify
3. What is the determining factor in buying caffeine containing products? (drag and drop to rank them from 1 to 7, with 1 as the most important and 7 as the least important)
    a. Price
    b. Origin of Ingredient Sourcing
    c. Brand Familiarity / Loyalty
    d. Sustainability
    e. Packaging

f. Accessibility

g. Caffeine Concentration

4. Would you care about the origin of caffeine in your products?

a. I don't care about the origin of caffeine in products

b. I care but it depends on the country caffeine is sourced from

c. I only buy food products with caffeine mainly sourced in the US

5. Which country of origin would you most likely consume caffeine products from? (May select multiple answers)

	Brazil	China	India	U.S.	Other	I don't consume
Coffee						
Tea						
Chocolate						
Energy Drink						
Soft Drink						
Other, please specify						

6. How often do you consume vanilla or food products containing vanilla (ex. vanilla ice cream, cake and cookies with vanilla etc.)

a. Less than once a month or never

b. Once a month

c. Once a week

d. Almost everyday

7. Which product contains vanilla you consume most often? (Check all that apply)
    a. Vanilla bean
    b. Vanilla extract
    c. Food products containing vanilla (ex. vanilla ice cream)
    d. Other, please specify
8. What kind of vanilla do you prefer to consume?
    a. Pure vanilla (made of vanilla beans)
    b. Imitation vanilla (synthetic vanillin)
    c. I consume both
9. What is the determining factor in buying vanilla containing products? (drag and drop to rank them from 1 to 7, with 1 as the most important and 7 as the least important)
    a. Price
    b. Origin of Ingredient Sourcing
    c. Brand Familiarity / Loyalty
    d. Sustainability
    e. Packaging
    f. Accessibility
    g. Vanilla Concentration
10. Would you care about the origin of vanilla in your products?
    a. I don't care about the origin of vanilla in products
    b. I care but it depends on the country vanilla is sourced from
    c. I only buy food products with vanilla mainly sourced in the US

	China	Mexico	Other	I don't consume
Vanilla Bean				
Vanilla Extract				
Vanilla Containing Food Products				
Other, please specify				

11. Please select your gender.

    a. Male

    b. Female

    c. Prefer not to answer

12. Please select your age group.

    a. 18-24

    b. 25-30

    c. 31-45

    d. 46-65

    e. 66 and above

    f. Prefer not to answer

13. What ethnicity group would you identify yourself with?

    a. African American

    b. Asian

    c. Hispanic / Latin American

d. Native American / Alaskan Native

e. Native Hawaiian / Pacific Islander

f. White

g. Prefer not to answer

Appendix B

Calculation for Two-Way Friedman Test and Two-Way Chi Square Test Analysis

Table 4. Calculation Table for Buying Caffeine Determining Factor's Two-Way Friedman Test α= 0.05

Determining Factor	Rank Average	Number of Participant	Rank Sum	df Value	x^2 Calculated	x^2 Critical	H_o	t Value	LSRD
Brand Familiarity / Loyalty	2.29	154	353	6	3970	12.59	Rejected	2.447	92.77
Price	2.67	154	411						
Accessibility	3.38	154	521						
Caffeine Concentration	4.82	154	742						
Origin of Ingredient Sourcing	4.88	154	752						
Sustainability	4.90	154	755						
Packaging	5.06	154	779						

H_o = There is no significant difference in the pattern of determining factor of people buying caffeine-containing products.

Table 5. Calculation Table for Buying Vanilla Determining Factor's Two-Way Friedman Test α= 0.05

Determining Factor	**Rank Average**	**Number of Participant**	**Rank Sum**	**df Value**	**x^2 Calculated**	**x^2 Critical**	**H_o**	**t Value**	**LSRD**
Price	2.09	146	305	6	3723	12.59	Rejected	2.447	90.33
Brand Familiarity / Loyalty	3.27	146	477						
Accessibility	3.84	146	561						
Vanilla Concentration	3.85	146	562						
Origin of Ingredient Sourcing	4.69	146	685						
Packaging	5.09	146	743						
Sustainability	5.16	146	753						

H_o = There is no significant difference in the pattern of determining factor of people buying vanilla-containing products.

Table 6. Calculation Table for Caffeine Customer Origin Preference's Two-Way Chi Square Test α= 0.05

Available Options	**Observed Frequency (O)**	**Expected Frequency (E)**	**O-E**	**$(O-E)^2$**	**df Value**	**x^2 Calculated**	**x^2 Critical**	**H_o**
Do Not Care	101	51.33	49.67	2467	2	95.47	5.99	Rejected
Depends on the Origin	51	51.33	-0.33	0				
Only US Sourced	2	51.33	-49.33	2434				

H_o = There is no significant difference in the pattern of origin preference of customers buying caffeine-containing products.

Table 7. Calculation Table for Vanilla Customer Origin Preference's Two-Way Chi Square Test α= 0.05

Available Options	**Observed Frequency (O)**	**Expected Frequency (E)**	**O-E**	**(O-E)^2**	**df Value**	**x^2 Calculated**	**x^2 Critical**	**H_o**
Do Not Care	94	48.67	45.33	2055	2	87.01	5.99	Rejected
Depends on the Origin	50	48.67	1.33	2				
Only US Sourced	2	48.67	-46.67	2178				

H_o = There is no significant difference in the pattern of origin preference of customers buying vanilla-containing products.

Table 8. Calculation Table for Gender Demographic of the Survey Taker's Two-Way Chi Square Test α= 0.05

Available Options	**Observed Frequency (O)**	**Expected Frequency (E)**	**O-E**	**(O-E)^2**	**df Value**	**x^2 Calculated**	**x^2 Critical**	**H_o**
Male	21	53.67	-32.67	1067	2	197.1	5.99	Rejected
Female	137	53.67	83.33	6944				
Prefer not to Answer	3	53.67	-50.67	2567				

H_o = There is no significant difference in the pattern of the gender of the survey takers.

Table 9. Calculation Table for Race Demographic of the Survey Taker's Two-Way Chi Square Test α= 0.05

Available Options	**Observed Frequency (O)**	**Expected Frequency (E)**	**O-E**	**$(O-E)^2$**	**df Value**	**x^2 Calculated**	**x^2 Critical**	**H_o**
African American	4	32.20	-28.20	795	4	325.7	9.49	Rejected
Asian	21	32.20	-11.20	125				
Hispanic / Latin American	6	32.20	-26.20	686				
White	123	32.20	90.80	8245				
Prefer not to Answer	7	32.20	-25.20	635				

H_o = There is no significant difference in the pattern of the race of the survey takers.

Appendix C

pH, Reflective Index, and Specific Gravity Calculation for Caffeine Solution, Tahitian Vanilla, and Mexican Vanilla

Table 10. Calculation for Specific Gravity Data of Caffeine

Trial	Caffeine Sample				Water	Specific Gravity	Average ± Standard Deviation
	Mass (g)	Volume (mL)	Density (g/mL)	Temperature (˚C)	Density (g/mL)		
1	0.495	50	0.00990	19.9	0.998	0.00992	0.0100 ± 0.00011
2	0.506	50	0.0101	19.8	0.998	0.0101	
3	0.501	50	0.0100	19.7	0.998	0.0100	

Table 11. Calculation for Specific Gravity Data of Tahitian Vanilla

Trial	Tahitian Vanilla Sample				Water	Specific Gravity	Average ± Standard Deviation
	Mass (g)	Volume (mL)	Density (g/mL)	Temperature (˚C)	Density (g/mL)		
1	0.831	1	0.831	20.7	0.998	0.833	0.8347 ±

2	0.834	1	0.834	20.8	0.998	0.836	0.0015
3	0.833	1	0.833	20.6	0.998	0.835	

Table 12. Calculation for Specific Gravity Data of Mexican Vanilla

Trial	Mexican Vanilla Sample				Water	Specific Gravity	Average ± Standard Deviation
	Mass (g)	Volume (mL)	Density (g/mL)	Temperature (˚C)	Density (g/mL)		
1	0.080	0.1	0.80	20.3	0.998	0.80	0.800 ± 0.010
2	0.081	0.1	0.81	20.2	0.998	0.81	
3	0.079	0.1	0.79	20.3	0.998	0.79	

Table 13. Caffeine Sample Data

Trial	pH	Brix (%)	Specific Gravity
1	7.85	2	0.00992

2	7.99	2	0.0101
3	7.90	2	0.0100
Average	**7.913**	**2.00**	**0.01001**
SD	**0.071**	**0.00**	**0.00011**
C.V	**0.0090**	**0.00**	**0.0011**

Table 14. Vanilla Samples Data

Vanilla Type	Trial	pH	Brix (%)	Specific Gravity
Tahiti Vanilla	1	4.67	24	0.833
	2	4.61	22.5	0.836
	3	4.62	22.5	0.835
Average		**4.633**	**23.00**	**0.8347**
SD		**0.032**	**0.87**	**0.0015**
C.V		**0.0071**	**0.038**	**0.0018**

Mexican Vanilla	1	4.0	18	0.80
	2	4.0	18	0.81
	3	4.0	18	0.79
Average		**4.00**	**18.00**	**0.800**
SD		**0.00**	**0.00**	**0.010**
C.V		**0.00**	**0.00**	**0.013**