# A Comparative Analysis of Natural and Artificial Flavorings through Analytical Methods and Flavor Additive Regulations

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**Abstract**

Food is a valuable commodity due to its necessity to satisfy human hunger and enable human growth. One does not frequently know what to eat and depend exclusively, on what they see and read about on a product's label, and may end up consuming unsafe flavorings and coloring. Flavors are characterized by a material's sensory analysis; natural flavors generally means essential oils. Artificial flavors, on the other hand, are made of various compounds that react and form a specific concentrate flavor. For the purpose of this study, natural strawberry flavors from a selected company was compared with artificial flavors created in a laboratory, using sensory, Refractive Index (RI) and Specific Gravity (SG), and consumers' perception analyses. It was observed that both SG and RI are higher in artificial flavor compared to natural one, indicating artificial flavor to be more viscous. Furthermore, the result indicated that consumers preferred natural flavor over artificial flavor.

**Keywords**
Additives, flavors, artificial, natural, regulatory

## 1. Introduction

In the second half of the twentieth century, regulatory attention was fixated on the flavor industries, after an influx of sweeteners, additives, flavorings and other ingredients added to processed food. The regulatory authorities had to ban the utilization of harmful chemicals and ingredients in foods, however, before utilizing a new additive, food industries were required to demonstrate lack of harm (Nielsen, 2015). In the 1950s, hundreds of additives, sweeteners, flavorings and colors were for commercial use, and no health warning were investigated at that point (van Zwanenburg and Millstone, 2015).

The management of Food Safety and Quality was regulated by three main government departments, namely the Department of Health (DoH), Department of Agriculture, and the Department of Trade and Industry (DTI). The DoH oversees food hygiene and issues certificates of acceptability to manufactures. They also develop food safety and quality standards ensuring that food industries comply with labelling, nutritional and fortification requirements. As

the population increases annually, food technologists are compelled to determine ways to improve their knowledge and apply this to the food we consume. Processed foods such as smoked foods, dehydrated foods, canned foods, frozen foods, or foods that are preserved with additives, in order for it to have a longer shelf life, or improve food organoleptic (Bloom, 2017). Flavor profile is one of the most important ingredients of our daily consumption. Flavor profile is very significant in terms of food of quality and depends on consumers to decide whether or not this flavor is desirable, as stated by Ranadive (2006).

Consumers globally, take pride in health care, 49% of global consumers consider themselves overweight, in a survey study conducted by Nielsen (2015) on global health and wellness. Approximately 50% attempt to lose weight by making healthy food choices. This is primarily due to food industries providing information to consumers about ingredients in their food products. In order to reduce or remove dietary cholesterol, diabetes, carbohydrates, the worldwide manufacturers pursue to reformulate their products' sugar and sodium content.

Flavoring additives are multi-faceted blends obtained in spices and processed through the receptors of smell and taste in all-natural flavors. They belong to groups of chemical compounds and were found in restricted quantities. Hageen-Smit (2011) identified that substances with completely different chemical compounds such as saccharin, sucrose and dulcin, are types of sugars which not well known. According to Sluss (2009), the key support for flavor compounds is to boost the food's nutritional value and to simply add flavor. It is known, that artificial flavors, also called organic, are safer and that the chemical taste is derived from a natural source. Natural flavors are complex mixtures of fruit and plant-derived chemicals. A synthetic flavor has only the main flavor and the natural flavor has other ingredients including the main flavor. Regulatory authorities globally, analyse the flavoring industry's risk and health effects.

Flavor is characterized as aroma and taste (Barrett et al., 2010). Aroma compounds are very volatile molecules and are experienced primarily through the nose. Taste receptors are in the mouth, and when the food is chewed, flavors are tasted. The aesthetics and color of a product is the initial quality characteristics that attract consumers to food. There are five main tastes characteristics, which are sweet, salty, sour, bitter and umami that are described as a taste associated with nucleotide salts and monosodium glutamate (MSG). Natural flavors are oleoresins, essential oils or natural extracts, which have been subjected to hydrolysis or heating, in order to develop flavors that will not add any nutritional value, but add taste or smell of a product. Ranadive (2006) explained that the two forms of aromas deal with sensation where the compound's molecular form is of great importance. The shape of the molecule can be matched with our receptors for sensory nerve endings. This induces impulses in the nose and is tranferred directly to the brain, providing us with an understanding of the nature of the material. This is great when utilized as a tool in chemical analysis (Williams et al., 2005).

### 1.1 Problem Statement

Flavor additives are utilized in the processed food and beverage industries. These additives strengthen the properties of taste, and disguise undesirable tastes and aromas. Food fraud and food safety is a warning signal for manufacturing industries, and regulations have been implemented in order to promote law-abiding industries. Consumers seem to prefer products that have no artificial ingredients and are willing to pay high prices for it. Consumers do not know that the artificial foods are produced through different processes, as consumers are not well informed. Food product protectors have attempted to inform consumers that such processed food has shown no harm associated with the ingestion of small amounts of chemicals. There has been some clarity that artificial and natural flavors contain similar characteristics with the aid of RI and SG, as conducted by Sitaramaraju et al. (2008).

It has been assumed that artificial flavors are harmful and contribute to most cancerous and health conditions globally, and no one has informed consumers of such harmfulness, and that the government is not investing more resources on educating consumers regarding this, or control the laws that governs additives. The purpose of the study is to inform customers about the regulations and laws that enforce the production sector's compliance. Studies have also shown that psychologically, humans prefer scientifically proven information or information extracted from a lab experiment and this study will provide evidence to support that.

### 1.3 Aim and Objectives of the Study

The study aimed to distinguish between natural and artificial flavors, and how the regulation authorities contribute to the food supply chain. The study also aims to obtain more insight from consumer on their preferences.
The objectives of this study are:

(i) To examine the characteristics of natural and artificial flavors in the food industry.
(ii) To explore how flavors are regulated for human consumption.
(iii) To evaluate analytical methods to measure similarities between natural and artificial flavors.
(iv) To determine how consumers relate to flavors.

## 2. Literature Review

Vitamins, antioxidants, emulsifiers, stabilizers, minerals, sweeteners and colors are widely used additives (Williams et al., 2003). By preventing free preservatives, which can form in fats and vitamins, antioxidants protect targeted food components. Antioxidants react with free preservatives for the development of second-stage oxidations. Octyl gallate and ascorbic acid are widely used in manufacturing. As explained by van Zwanenburg and Millstone (2015), preservatives protect food against spoiling or rapid growth of micro-organisms. This includes smoking, dehydrating and pickling foods, since this method has been used in the old ages to prevent spoilage.

Ranadive (2006) conducted more or less appropriate replication of a natural flavor in consumer research in the artificial flavor organizations by expertly mixing established synthetic products. Specialists analyzed their products through tasting and smelling, and this inevitably assisted to solve flavor problems, as it approaches its optimal level when analyzing unknown compound chemical structures. A study conducted by Sluss (2009) revealed a certain competence of the sensory organs of humans and the3ir inadequate knowledge of the odors of theoretical compounds.

Sitaramaraju *et al*. (2008) indicated that processes such as low-temperature distillation, and low-temperature condensation due to enzyme reactions or heating, in order to obtain a flavor element, were utilized. Sluss (2009) formulated a method of extraction of solvents that also generates similar results to obtain flavors. Different flavor profiles are isolated by chemical methods and fractional distillation after the isolation of flavor components from a large amount of water. The derivatives were compared with the equivalent composition's known natural flavor components. In a case where a substance has never been isolated, methods of degradation are conducted to detect smaller parts of a molecule. The results obtained in these methods were combined to provide the original structure of the compound. In an experiment conducted by Hageen-Smit (2011), non-volatile compounds, such as sugars and acids, were found to improve various flavors.

### 2.1 Natural Flavors in Food

Natural and artificial flavors provide a very fascinating function in the food we consume. They add flavor, and most significantly, they ensure that food is more appealing for consumers to eat. Flavors have the ability to replace specific qualities of taste that have been absent during food processing, pasteurization and food storage. In the manufacturing industry, the addition of false flavor to juices is to ensure uniformity after being packaged. Flavors are used in food products as signature dishes to ensure that the food tastes the same when it is consumed globally.

According to Sitaramaraju et al. (2008) the main distinction between natural and artificial taste, is that natural flavors derive from natural sources. This does not imply that a granola bar with blueberry is comprised of smashed blueberries, however, the granola bar consists of a chemical originally found in blueberries and is added to the food product in the laboratories. Purely human, on the other hand, makes artificial flavors. The distinction stems from the origin of molecules of taste, whether it is from a natural source, or refined in the laboratory or processed synthetically.

All natural and artificial flavorings in food products can compromise between 60 to 100 ingredients, which does not indicate that all other ingredients are in the clear. A mixture often has a preservative or solvent that formulates up to 80-90% of the flavoring of the meat. The distinction between natural and artificial flavors eventually originates from microscopic differentiation. According to Shewfelt (2000), the quantity of preservatives and diluents in natural flavors

is very restricted, to such a degree that it can be associated to any health effects, and that creates immense confusion and misleads consumers. A study conducted at the Nutrition and Dietetics Academy is confident that natural or artificial flavors may induce food cravings.

It is crucial for consumers to have knowledge of ingredients in food products, in order to understand that any type of excess food will affect weight loss. Figure 1 clarifies the ingredients of natural and artificial compounds. Any material, natural or artificial, when consumed in excess, can be harmful to the body. Consumers need to understand that chemical flavors are controlled and food scientists use the allowed dosages in flavor creations.

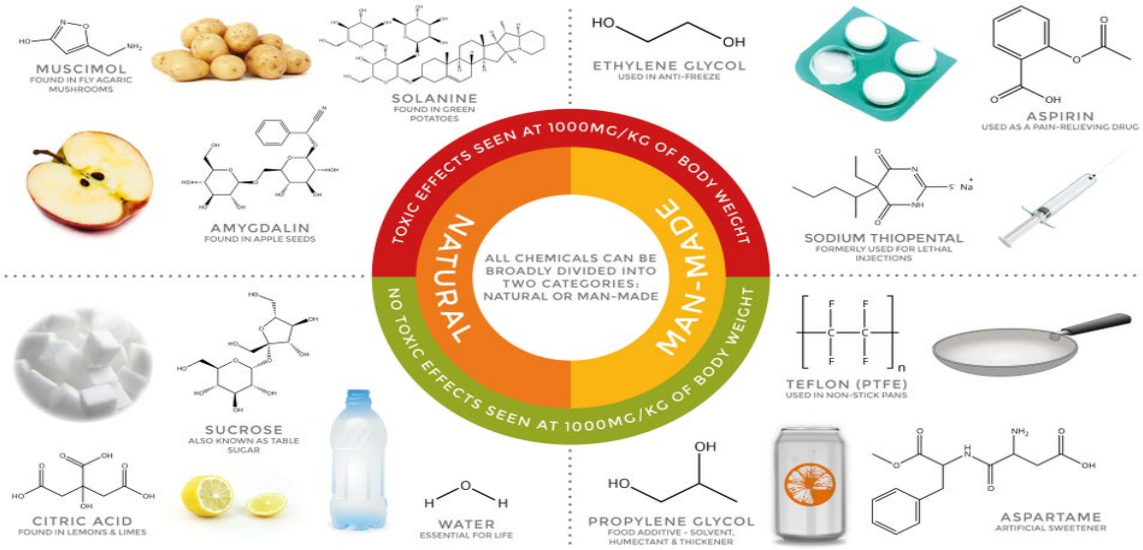



Figure 1. Natural versus artificial compounds (Siam Botanicals, 2014)

### 2.2 Quality Control in Flavor Analysis

Product quality is defined as the structure of all features that distinguish separate units of a food product and have a value in regulating the degree of acceptability of that unit to the consumer (Ranadive, 2006). Flavor industries seek to provide a reliable product of high quality for the consumer. Quality control plays a vital role in ensuring that this task has been fulfilled. Quality control in the flavor industries is distributed between two functions, the sensory analysis of the organoleptic evaluation and the analysis of the chemical and physical properties of a flavor. This is included in all the raw materials that are utilized in the flavor of the end product.

### 2.3 Sensory Analysis

Sensory analysis in the flavor field is separated into two sections, affective and analytical measurements. Analytical tests are utilized in the descriptive analysis of a substance, conducted by a professional sensory expert, and the affective analysis is utilized to assess that specimens are preferable to others. According Ranadive (2006), sensory analysis include the distinction in flavor, color and aroma of a flavor material, when an analyst is evaluating the flavor, flavor strength and attributes are most important.

According to Shewfelt (2000), over time, taste and color changes and this is known as a flavor agent. Non-enzymatic browning affects fruit flavors. A newly produced color of strawberry flavor is bright red and tastes very fresh while an older flavor of strawberry becomes a brownish-red color with a prune smell. A flavor's refusal conditions are primarily the variations in taste. The rejection criteria of a flavor is mainly the inconsistencies in taste and color when compared to a standard, which is the old batch of the same flavor.

The olfactory nerve is used during sensory evaluation, (Figure 2), as it is the shortest human nerve (Sarafoleanu *et al.*, 2009). It is situated in the olfactory mucosa, also called mucus membrane, which sits along the roof of the nasal cavity or nostril. This nerve is composed of several small nerve fibers, which are called fascicles, which are joined together by connective tissues. The primary function of olfactory nerve is to enable one to smell. When one inhales air particles,

the air particles travels through the nasal cavity and interacts with olfactory nerve receptors. The receptors will send the information to the central nervous system and the information will be received as a scent.

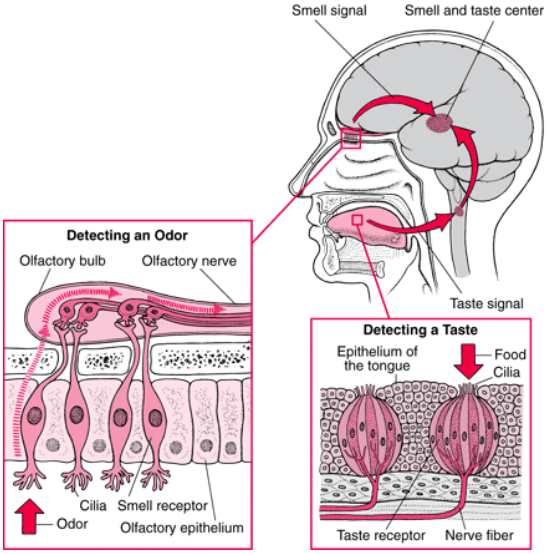



Figure 2. Taste and smell perceptions (Fried, 2019)

## 2.4 Analytical Methods

Specific Gravity (SG) is termed the ratio of the density of a material to the density of a reference material, typically water at the same temperature. It measures how dense a substance is in a water medium. SG for heavier materials are generally above 1.00 and they settle at the bottom of the medium it is submerged in. SG for lighter materials are less than 1.00 and they float in the medium it is submerged in. Refractive Index (RI) is determined when an electromagnetic radiation passes from one medium to another, and the light changes its direction or bends. It is the ratio of the angle of refraction, which can define RI. This method indicates the differences in a nature of a compound, concentration of a compound, wavelength of the light and its temperature.

RI and SG are the two common analytical methods that practiced in all flavors and raw materials. Shewfelt (2000) established that the SG and RI results of a natural and artificial strawberry flavor were greater than 1.00. The author used the Abbe method refractometer to analyze the RI, which is the degree at which light is refracted, when it rapidly strikes a given substance. The instrument covers the RI range between 1.30 to 1.70, which is accurate and precise with four decimal places. Flavor combinations are always in mixtures and not separate components. RI results of flavors is a function of the RI of the individual components and their ratios. Similarly, SG results of flavors is also the components of their ratios since its component has its own SG. Through application of the RI and SG equipment, errors can be detected in compounding easily.

## 2.5 Consumer Intake

A market research performed by Ranadive (2006) on whole foods, stated that manufacturers tend to include information that is not relevant for consumers. Food manufacturers specified a page entitled "Unacceptable Food Ingredients," which included a list of ingredients that the company indicated that they are not using in their products. For instance, they claimed that they do not use vanillin ingredients in their products, which in contrast because vanilla flavor involves vanillin in its component as an important chemical group. There is no vanilla flavor profile, which does not contain vanillin extract; hence, the company is clearly deceitful as the product already consists of vanillin.

Food industries are to blame for the confusion (Zabetakis and Holden, 2007) as they do not inform their customers and instead they seek to gain profit through myths. Once we hear that food is associated with chemicals, as a customer, our perception toward the product changed instantly. When food products are labeled as natural organic and chemical free, then customers are more inclined to purchase these products. According to van Zwanenburg and Millstone

(2015), customer expectations are very high as they expect products to have a lower sugar content and expect the same taste. Industries need to determine ways to meet these requirements of customers.

Figure 3 indicates the new format for nutrition labels that were announced on May 20, 2016 by the Food and Drug Administration (FDA), which must display any new scientific information, including the association between chronic diseases like heart disease and diabetes. The FDA has released final rules and regulations, and extended them to 1 January 2020, requiring all companies to comply with the new regulation (Guentert and Shah, 2018).

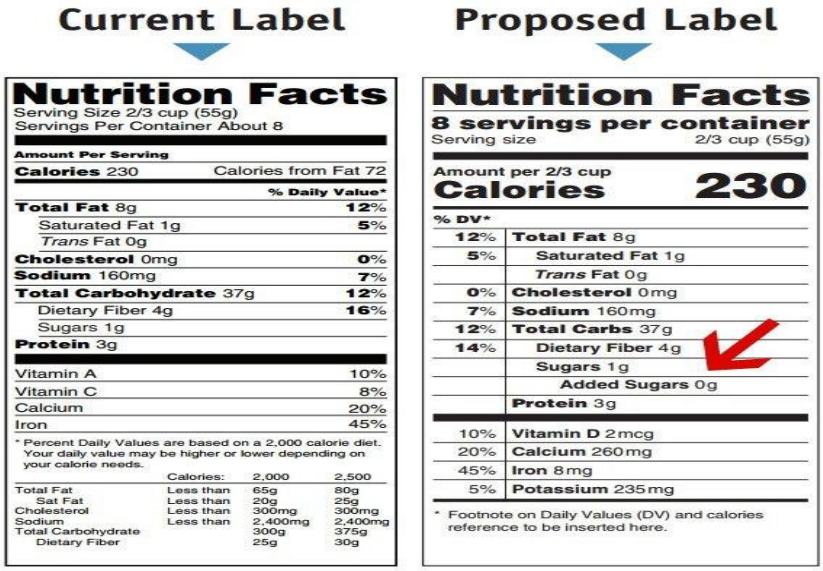



Figure 3. Nutritional package label (Guentert and Shah, 2018)

## 2.6 Flavor Creation

Food and beverage industries do not produce their own flavor profiles, but have external contracts with flavor companies to generate flavors for them. Food and beverage industries require flavoring for their new products, or to sell a variety of flavors of one product (Guentert and Shah, 2018). They also require flavors for existing products due to variations in formulation or processing such as reduced fat. Technologists or 'flavorist' whom are professionals and qualified in the specialty of flavoring creates flavors. The work of flavorist blends a wide range of scientific knowledge of the chemical palette and artistic creativity to develop fresh and distinct flavors (Hageen-Smit, 2011).

Before the implementation of the type of flavor required by the consumer, specifications must be clearly stated (Zabetakis and Holden, 2007). Many consumers are unable to adequately describe the type of flavors they favor, so it is the responsibility of flavorists to utilize their knowledge and expertise of chemical ingredients to produce a mixture and combine it in a balanced method. This conducted manually or automatically in repetitions. The consumer will send the final product for review. This could be conducted several times when the tasting expert is not satisfied with the flavor balance until the flavor house gets it correct according to requirement (Zabetakis and Holden, 2007).

## 2.7 Consumers' Perceptions

Consumers possess a need to understand what they are eating, and to make rational decisions on what they purchase. Using a term as "natural" appears to be the answer to the organic or natural food demand. An increased education and clarity is required from flavor industries, as it will assist consumers in understanding the ingredients of the packaged food that they purchase. This will assist in reducing the misconceptions that exist and enable consumers to make informed decisions when it concerns to their dietary requirements, indulgence, sustainability and their overall health.

A recent survey conducted in the USA (Food Insight, 2018), consumers were requested to choose a food product, produced with similar ingredients - option A has an artificial ingredient and option B has a natural flavor. It was observed, that 69% of the respondents chose option B, and the group that is most likely to purchase option B is the

women aged from 50 to 80, which generate a higher household income. This reveals on how profound the misconception of artificial food is.

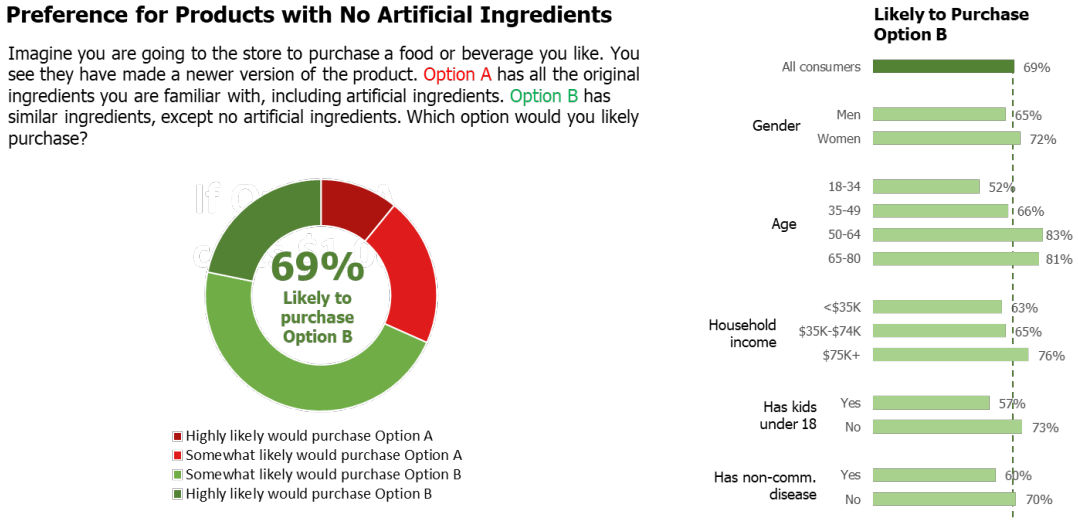



Figure 4. Preference varies by age, income, gender and other demographics (Food Insight, 2018)

## 2.8 Food Regulations

Figure 5 illustrates a hierarchy of food regulatory authority in South Africa. These regulatory authorities are assisted by the minimum requirements of the compulsory specifications, which are based on:

- Pre-requisites for food safety
  - Good Manufacturing Practices (GMP)
  - Good Hygiene Practices (GHP).
- Standards and guidelines set by Codex Alimentarius
- National requirements

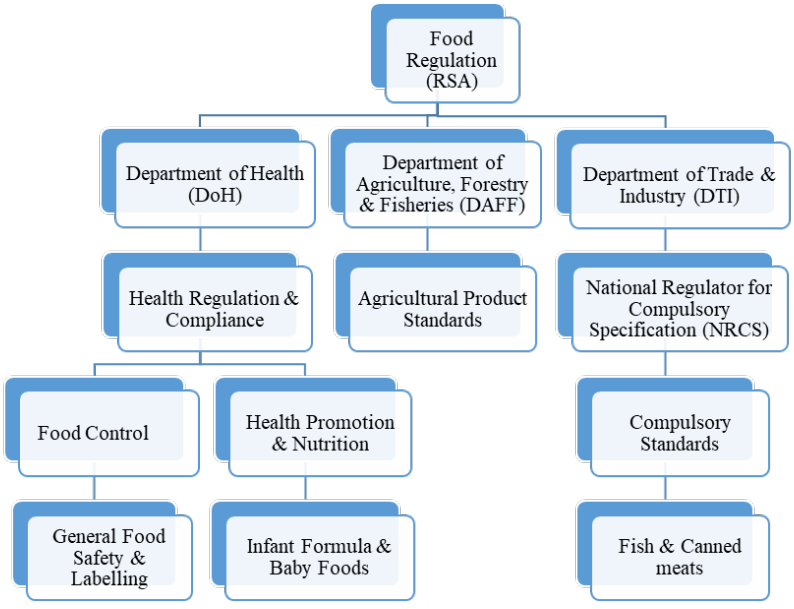



Figure 5. Food regulation that food industries have to comply within this hierarchy to certification and customer requirements

Flavors are in everything food product we consume, from beverages, food, and medicines, household to pet food. Food industries are required to indicate the profile of ingredients, but at the same time the consumers are not well informed and thus resort to buying natural food products. However, based on research studies, there is not much distinction between natural and artificial ingredients. This gap requires consumers to be well educated and informed in order for them to can make informed and healthy choices. They also need to understand that there are regulations that enforces food industries to prepare food that will cause adverse effects to consumers.

## 3. Research Methods

A mixed research method approach was conducted in achieving the research objectives to educate consumers about the disticntion in artificial and natural flavors. A lab experiment was executed to compare natural strawberry flavor bought from a wholesale store and an artificial strawberry flavor that was generated in a laboratory. The results were investigated using an RI and SG equipment at 20$^{o}$C. Data was evaluated and tabulated, statistical calculations were computed to determine the correlation coefficient. Questionnaire were distributed to 60 consumers, and the data was analyzed and correlated to the experiment.

### 3.1 Method of Data Collection

#### 3.1.1 Experimental Setup

The natural and artificial strawberry flavors were prepared as following:

*Natural Strawberry Preparation for Extraction*

a) Strawberry samples were cleaned to remove any contaminants.
b) The strawberries were strained with a mesh sieve, and sorted into separate beakers.
c) 1g of each strained strawberry was weighed and sorted into a separate beaker.
d) 10 ml of methanol was added to each beaker and stirred for 30 min on a magnetic stirrer.
e) The mixture was filtered to remove any strawberry particles in the solution and injected in SG and RI.

*Laboratory Strawberry Preparation*

a) 2g of ethyl butyrate was combined with 5g of ethyl maltol in a beaker until a homogenous mixture was obtained.
b) This mixture was injected in the SG and RI.

*Equipment used include:*
Specific Gravity and Refractive Index Anton Paar (Abbe model) were used. Each flavor sample was analyzed in triplicate of 5 ml by injecting it in the instrument.

#### 3.1.2 Survey

The participants around a consumer research facility at the East Rand, Johannesburg were randomly selected to participate in the study and given a consent form to voluntarily participate. They were aware that the answers given were completely confidential and that their identity would remain anonymous. There was a briefing on how the artificial and natural samples had to be tasted and how the questionnaires should be completed, before sensory analysis was conducted on each group. The survey took a maximum of 8 minutes per participant, which included tasting the flavors and rating their preference. The participants were requested to cleanse their pallet with water to eliminate any bias on taste. Consumers had to provide truthful and honest answers.

*Sensory*
Dilution factor: 0.2 ml of the natural and artificial strawberry flavors was pipetted in 100 ml beaker, which were filled to 100 ml with the tasting solution of 70g of sugar in 1l of tap water. This prepared solution was dispensed into small sensory cups for consumers to taste.

*Sampling*
The targeted population was open to all consumers, races, gender and age groups. The simple random sampling method of selecting participants was effective because the consumer research facility is located near a mall, school, taxi rank, bakery and corporate business center. The area has a well-balanced population. The natural strawberry bought from the wholesale store, were randomly selected. The packet had 30 strawberries and only 20 were chosen. The strawberries were then crushed in a sterile plastic and refrigerated for a day before extraction commenced.

### 3.1.3 Reliability of the study

The laboratory equipment was calibrated, and the air and water inspections were performed to determine whether the results were consistent with previous results. SCFQ Test-Retest Reliability was used to test reliability of the study, as its primary purpose was to assess cognitive fusion of new questionnaires.

## 4. Results and Findings

The two samples of artificial and natural flavors were sensorically and analytically evaluated, two 150ml glass beakers were utilized to contain the two samples in order to observe the colors of both samples. This procedure was to examine sample colors through a clear beaker, can also be useful in determining the viciousness of a liquid sample. Color observations are important when it relates to the quality control, as it can be used to determine product specification parameters.

### 4.1 Sensory Analysis

Sensory analysis of flavors were conducted to define their physical characteristics. When pouring into beakers, the following findings were established per sample beaker. As both flavors were concentrated, samples responded differently when combine with water thus determining whether or not the flavors homogenously mixed with the tasting solution.

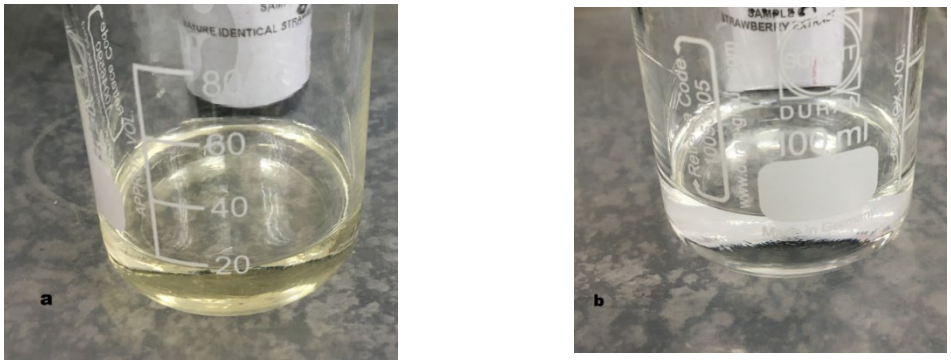



Figure 6. Physical observation of strawberry flavoring samples – (a) Artificial and (b) Natural

The artificial flavoring was a pale yellow transparent liquid. While pouring, the material was detected to be slightly viscous (Figure 6a). The aroma was too strong and required chemicals through the olfactory receptors. This is due to the raw material used to match the natural flavor, some liquid raw material used were yellow, which contributed to the color of the end product. When preparing for the taste testing, it was determined that the sample was immiscible with water. An oil and water emulsion were prepared using 8 ml of 96% ethanol, 1 ml of Tween twenty and 1 ml of the sample in a measuring cylinder. Dilution followed for tasting preparation.

Natural flavor was a colorless transparent liquid (Figure 6b). When poured into the sample beaker, it was detected to be less viscous than the artificial sample and the sample flowed easily like water. The sample had a natural aroma

sensed through the olfactory receptors as explained by Sarafoleanu *et al.* (2009). The aroma was sweet and fruity, the flavor was stable.

It was observed that artificial flavors are produced as concentrates; they are then diluted with final products according to the levels specified by flavor experts. The artificial flavors preserved over a period to mature, in order for the chemicals to become stable enough to match the natural flavor entailing a fruity aroma when smelled.

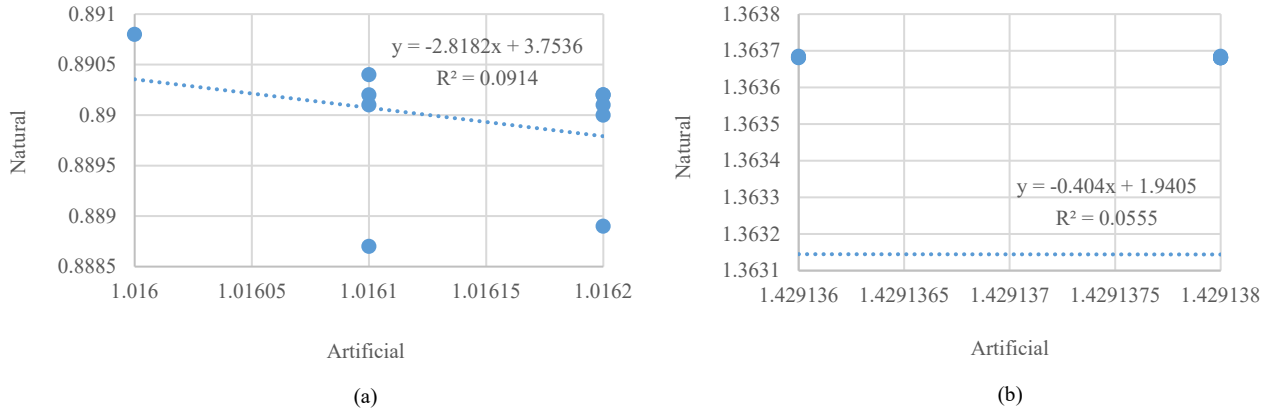
### 4.2 Refractive Index and Specific Gravity Analysis

5 ml of each samples was injected in the RI and SG equipment, this was repeated 10 times for each sample. Table 1 displays the results obtained from RI and SG analysis for both natural and artificial strawberry flavors. The SG of natural strawberry flavor varied from 0.8887 to 0.8909 with an average of 0.88996, whereas for artificial strawberry flavor SG varied from 1.016 to 1.0162 with an average of 1.01614. It indictaes that artificial strawberry flavor is heavier than the natural one, which could be due to different raw ingredients used in artificial favor to match with natural strawberry flavor. This may be due to the main carrier ingredient used to blend this flavor. The RI of natural strawberry flavor varied from 1.363681 to 1.363685 nD with an average of 1.3636821, whereas for artificial strawberry flavor RI varied from 1.429136 to 1.429138 with an average of 1.4291374. The RI of artificial strawberry flavors is also higher than natural one, which specifies that the light moved gradually through the sample medium. All liquid raw materials, such as antioxidants, vitamins and other materials, have their individual RI and SG results, and this has an impacted the final flavor product. The natural strawberry flavor, in contrast has low SG results, it is lighter and the velocity of light that passed through the medium was faster, therefore lower RI results were achieved. This indicates the distinction between the flavors when compared using RI and SG.

Table 1. Specific Gravity and Refractive Index results using Abbe method

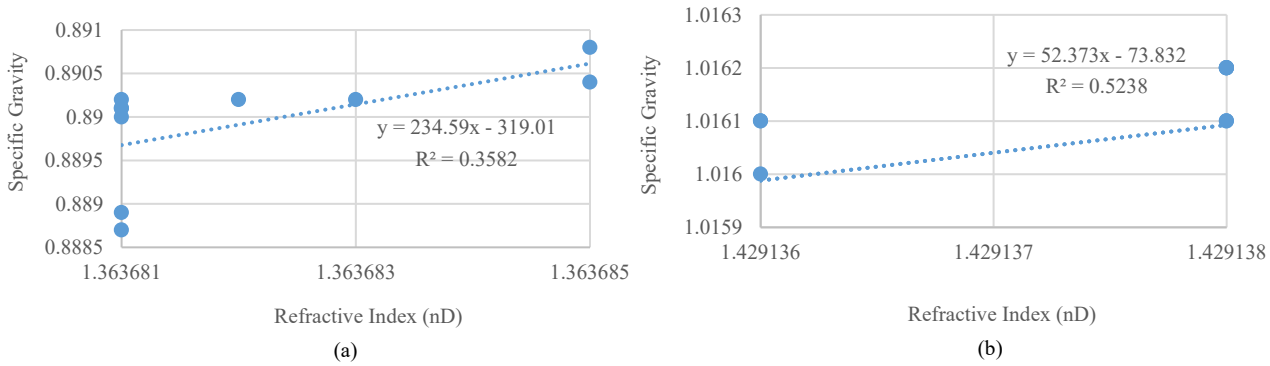
| | **Natural Strawberry** | **Artificial Strawberry** |
|---|---|---|
| **Specific Gravity** | 0.8901 | 1.0162 |
| | 0.8901 | 1.0161 |
| | 0.8887 | 1.0161 |
| | 0.8908 | 1.0160 |
| | 0.8889 | 1.0162 |
| | 0.8902 | 1.0161 |
| | 0.8900 | 1.0162 |
| | 0.8904 | 1.0161 |
| | 0.8902 | 1.0162 |
| | 0.8902 | 1.0162 |
| **Refractive Index (nD)** | 1.363681 | 1.429138 |
| | 1.363685 | 1.429136 |
| | 1.363682 | 1.429136 |
| | 1.363681 | 1.429136 |
| | 1.363681 | 1.429138 |
| | 1.363683 | 1.429138 |
| | 1.363681 | 1.429138 |
| | 1.363685 | 1.429138 |
| | 1.363681 | 1.429138 |
| | 1.363681 | 1.429138 |

Figures 7 and 8 depict the relationship between SG and RI of natural and artificial strawberry flavors. There are negative relationships between SG and RI of natural and artificial flavors, but are insignificant with $R^2$ values of 0.0914 and 0.0551 for SG and RI respectively. However, RI for both natural and artificial flavors seem to increase with SG.




(a) (b)

Figure 7. Scatter plot of natural vs artificial strawberry flavors for (a) SG and (b) RI




(a) (b)

Figure 8. Regression line for SG and RI of (a) natural and (b) artificial strawberry flavors

### 4.3 Respondents' Perception on Natural and Artificial Flavors

The two samples labelled A (natural strawberry flavoring) and B (artificial strawberry flavorings) were prepared in 70% sugar solution. Flavoring A was miscible with the tasting solution, and flavoring B was immiscible. A homogenous mixture of 8 ml of Tween twenty, 1 ml of ethanol and 1 ml of flavoring B was prepared to produce a miscible mixture when added to the sugar solution. 2 ml of each flavorings were prepared with the tasting solution for 60 consumers to taste. Figure 9 describes the preference of consumers when both flavorings were tested. Consumers extremely preferred flavoring A with 30% response and flavoring B with half of the percentage. This was due to the

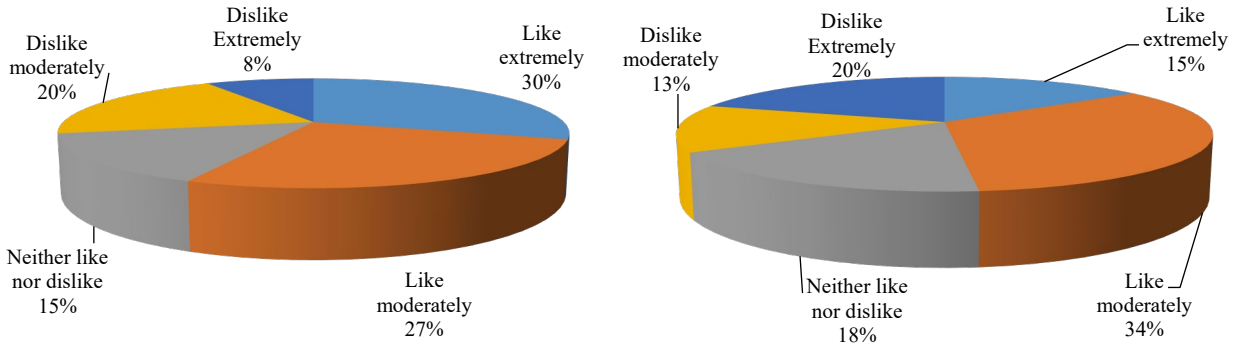


Figure 9. Taste results on (a) natural and (b) artificial strawberry flavor samples

overall sample preparations. Natural strawberry was sweet and the flavor was rounded, the artificial strawberry had chemicals that had not yet settled to mature the flavor attributes. Only 8% of consumers extremely disliked flavoring A than the 20% in flavoring B:

Figure 10 describes how the quality of both flavorings were rated, the natural strawberry was favored most with a high quality of 21.7% when compared to the artificial strawberry with only 8.3%. Again flavoring B had not yet settled. The figures describe how the quality was rated from very high quality to very low, according to consumers' preference.

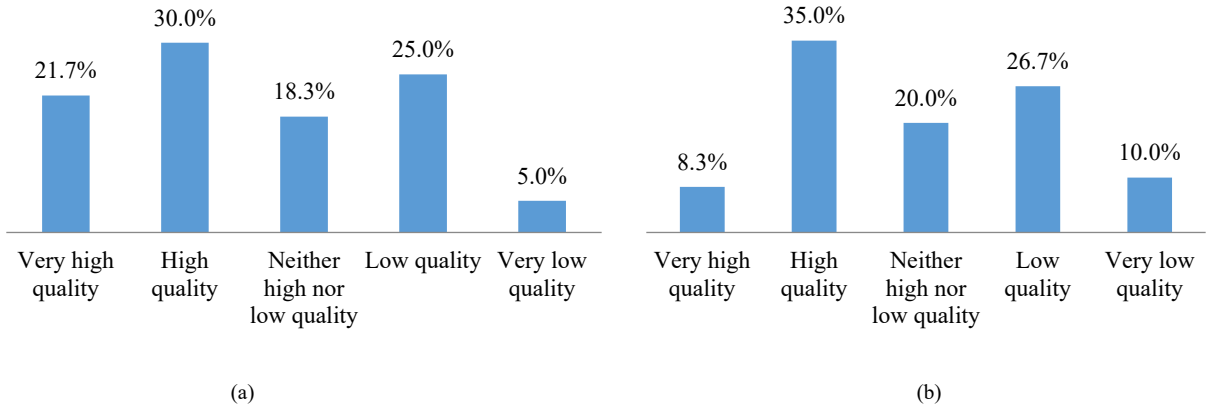



Figure 10. Rating of the quality of (a) natural and (b) artificial strawberry flavor samples

Figures 11 presents that consumers' preference of natural flavorings compared to artificial flavoring. The results verify that consumers do prefer natural flavor with 75% of them preferring to consume food made of natural flavors. This is due to the fact that, they are not aware what could be in the artificial flavoring, and they assume that natural flavors are healthier.

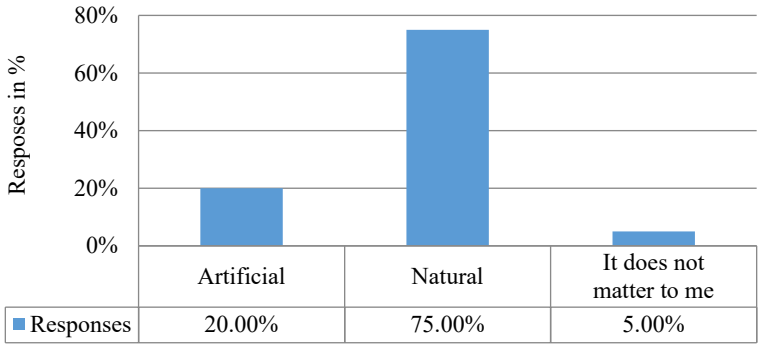



Figure 11. Respondent's preference for natural and artificial flavors

It was observed that consumers were uneducated when it came to the language of flavors, and they do not understand how they are derived and applied in daily food products. Based on the survey, consumers preferred the natural flavor as compared to the artificial flavor. The natural flavor entailed fruity tastes and aromas which consumers preferred as compared to artificial flavor. Artificial flavors have artificial extracts and this makes it difficult for untrained sensory consumers to separate the different flavor tastes and aromas identified in the sample. There are times when artificial flavors created in a lab can be 100 percent pure, whereas natural chemicals found in fruit can be toxic (Bloom, 2017). It all depends on the consumers perception and preference.

## 5. Conclusion and Recommendations

This study focused on strawberry flavor obtained from a wholesale store compared to the artificial flavor generated in a laboratory. Flavor extraction is the most difficult procedure, due to the volatility of the chemical composition of the flavor. Most research studies used the GCMS method for extraction, which allows volatile and semi-volatiles to be injected in the equipment.

Both SG and RI results for the natural strawberry flavor were lower than the artificial flavor. This is due to the fact that an artificial flavor is compounded with all different raw materials, and therefore, it is heavier than the natural flavor. The RI analysis indicated that the light that passed through the artificial flavor took additional time to be refracted. RI seemed to increase with SG for both natural and artificial flavors.

Although literature shows that there are regulations that govern flavor additives, it was observed that consumers are less educated about food regulations. South Africa has governing bodies and regulations in place, that enforces flavor industries to avoid food fraud and enhance food safety. The DoH is responsible for enforcing the laws, but it is identified that the regulations are not policied. Furthermore, there are insufficient environmental Health and Safety Officers in each municipalities whom can ensure that issues such as the listeria breakout do not occur. This is a huge gap and affects consumers, even when the consumer protection service exists but do not communicate with consumers effectively.

Furthermore, it was observed that very few consumers are knowledgeable when it comes to the origin of flavors, how they are derived and integrated into food to deliver quality food products. Consumers have limited knowledge on flavor education, thus it was very difficult to get honest tasting responses from untrained consumers. Nevertheless, the consumers preferred the natural sample when they tasted it. The natural flavor was perceived to be healthier as compared to artificial flavor. They concluded that the sample had a very fruity taste and aroma. They expressed that they would recommend it to be used in the processing of yoghurt. The artificial flavor had an alcohol taste and aroma, mostly due to maturity level of the flavor.

### 5.1 Recommendations

It is recommended that food manufactures label their products such that consumers are able to understand the contents of the food product. Food manufactures should use language that is easily interpreted. Consumer protection agencies should conduct research in Africa as it is very difficult to get relevant research conducted in the continent and most consumer research findings are from an international perspective.

It is also evident that artificial flavors plays a vital role in maturation levels, however this study did not consider comparing flavors using matured artificial flavor. When the sample was prepared for tasting, the flavor had not yet settled to produce rounded fruity taste and aroma, therefore it is recommended that similar studies can be conducted with an artificial flavor that has been preserved for weeks to mature and compared with the natural flavor.

Natural and artificial flavors were compared using the RI and SG method with satisfactory results. However, further statistical analysis can be performed for comparison. It was also observed that consumers have little knowledge about the food they eat, its content and how it is processed, hence more research studies needs to be performed to prove to the DOH, food agencies, consumer services that consumer education is very important.

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