FOOD GRADE FILLER PARTICLES

Abstract

Food-grade filler particles refer to materials that are safe for consumption and are used to increase the volume or improve the texture of food products without significantly altering their taste or nutritional value. These particles are typically added to various food items such as sauces, dressings, frozen desserts, meat products, and bakery goods. Fillers can be derived from natural sources such as fruits, vegetables, grains, legumes, and seaweed. They can also be synthetic substances that are specifically manufactured for food applications. The particle size of these fillers can vary, with some being fine powders and others larger granules. The incorporation of fillers in food formulations serves multiple purposes. They can enhance the mouthfeel and give a smoother texture to the final product. Additionally, by increasing the bulk of a food item, they can provide a better value for money, as the cost per unit weight is reduced. Fillers can also aid in stabilizing emulsions, preventing separation or settling of ingredients over time. Food fillers must adhere to strict regulations and guidelines to ensure their safety for human consumption. These regulations govern factors such as the composition of the filler particles, levels of contaminants, and potential allergenicity. In addition to these safety considerations, fillers should also be selected based on their compatibility with the specific food product, as they should not negatively impact taste or affect the overall quality of the food. As consumer demand for healthier and more natural ingredients in food products increases, the development of food grade fillers that are organic, non-GMO, and free from artificial additives is becoming more prevalent. Manufacturers are also exploring innovative techniques to enhance the

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functionality and nutritional value of these fillers, such as incorporating fortifying ingredients like vitamins and minerals. In summary, food grade fillers are particles that are added to food products to improve texture, increase volume, and enhance stability. They must adhere to safety rules and might be made from natural or synthetic sources. The production of food grade fillers is a continuing subject of research and development in the food industry due to increased customer desire in healthier and more sustainable food options. The use of sweeteners as fillers in various food products is discussed in this abstract, along with the many kinds of sweeteners that are frequently used in this capacity. Many food manufacturers enhance the sweetness of their products by incorporating sweeteners as fillers. Sweeteners fulfil a dual role - they add taste while also increasing the bulk and volume of the product, thereby reducing costs. Several types of sweeteners are used as fillers depending on the desired qualities and requirements of the food product.

Keywords: Food Fillers, Sweeteners, Types, Functional Ingredient.

I. INTRODUCTION

Consumption of dietary fats and sugar-containing foods products pose health problems in humans. The consumption of dietary fats can result in elevated levels of total cholesterol (TC) and low-density lipoprotein (LDL) cholesterol, contributing to the development of cardiovascular diseases. The sugar contained food products add calories to our diet which could lead to diabetes, obesity, and cardiovascular diseases (Sahin et al., 2019). According to World Health Organization (2017), there are over 1.9 billion adults over 18 years and 41 million children under 5 years of age, suffering from obesity. Thus, an alternative to high-calorie foods is essential for maintaining a healthy body. This could be achieved by the use of food fillers. The outlook for the food filler market appears optimistic, presenting growth prospects within various sectors such as processed meats, seafood, dairy, bakery products, food supplements, and beverages. Projections indicate that the global food filler market is poised to achieve an estimated value of $819.3 million by 2027, exhibiting a compound annual growth rate (CAGR) of 3.6% from 2021 to 2027. (Lucintel, 2021). The factors propelling this market include a rising appetite for processed foods and the expansion of food supplement product offerings. Food-grade fillers are additives that are used to add bulk to food products with low-cost ingredients, which in turn reduces the cost of the product (Heinz & Hautzinger, 2007). These fillers are being used as fat substitutes/ fat replacers, meat extenders, sugar replacers, and bulking agents, finding application in many of the food sectors such as seafood, food supplements, processed meat, bakery, beverages and dairy, etc. They add little or no calories to the foods thus helping in the effective management of one's body weight. Furthermore, fillers play a role in extending the shelf life of food items while maintaining the affordability of the product.

The Food Fillers industry offers substantial opportunities for companies seeking sustainable growth. By prioritizing market segmentation and aligning with customer preferences, the report highlights the industry's most promising avenues for expansion. Within the Food Fillers sector, the report identifies five major factors with considerable influence: adaptability in the supply chain, digitalization, the impact of advanced technologies, consumer preferences and awareness, and sustainability. These factors present a range of challenges and opportunities on a global scale in the Food Fillers Industry. There is indeed a market for these fillers due to the growing consumer demands for processed meat and bakery products as well as food supplements being the major drivers of this market. The surge in demand for low-fat dairy and bakery items has led to starch emerging as one of the prominent fillers, experiencing more robust growth compared to other fillers. Notable manufacturers in the filler foods industry encompass, Elementis, Imerys, Omya, Rayonier Advanced Material and Mineral Technologies, (Lucintel, 2021). As familiar with, sugar is a contributor to sweetness, mouthfeel, texture shelf-life, and bulking. Because of the above-mentioned attributes, sugar is considered a very difficult food component to be replaced (Erickson & Carr, 2020).

In accordance with a 2015 guideline from the World Health Organization (WHO), it is recommended that sugar intake be limited to less than 10% of the daily calorie intake. To address the heightened consumption of sugary foods, many governments have implemented sugar taxes. In the United States, a sugar tax ranging from 1% to 8% has not yielded significant alterations in sugar consumption. Meanwhile, the British government has advised the bakery industry to reduce sugar content in their products by 20% by the year 2020.

(Tedstone et al., 2017). Potential sugar substitutes include non-nutritive sweeteners, which offer lower calorie content compared to sugar.

The Food and Drug Administration (FDA) has granted approval for specific artificial sweeteners, including acesulfame-K, aspartame, neotame, saccharin, sucralose, and stevia. Sugar plays a significant role in food products due to its properties, which encompass reducing water activity, lowering freezing points, and participating in browning reactions.

Thus, replacing sugar is a challenge faced by the food industry The browning reaction and caramelization play vital roles in enhancing the color and flavor profiles of particular food products. (Erickson & Carr, 2020). Meat products contain various nutrients like protein, zinc, iron, vitamin etc. in which proteins has many essential amino acids required for growth (Williams, 2007; Elango et al., 2009). But these processed meat products contain high amount of fats which are unhealthy for the body. Some meat products contain about 20-30% fat content. So, the consumers are more into the products that does not contain any ingredients that affect their body health.

In meat industry, processed meat products such as hamburgers and sausages are the best foods to contain fillers. These fillers and extenders could help in reducing the final cost of the product by 10-30 percent. There are both meat and non-meat fillers used. Example of meat filler is the mechanically deboned meat (MDM) that are cheaper material obtained from animal carcasses. Examples of non-meat fillers include cereal binders, bread crumbs, maltodextrin, rusk etc. Reducing fat content or substituting fat poses a challenge to the food industry due to the potential impact on the quality and sensory characteristics of meat products, often resulting in lower quality outcomes. This could have an influence on the marketability and consumer acceptability of the product (Alves et al. 2016). This article discusses about the various kinds of filler particles along with their limits in different foods, advantages of using these fillers, applications, health effects, challenges and future scopes.

II. TYPES OF FILLERS

1. **Sweeteners as Fillers:** Sweeteners are compounds that are used to provide sweetness to food and beverages without adding calories or carbohydrates like conventional sugar does. People who want to limit their calorie intake, manage their blood sugar levels, or control their weight frequently use them as sugar substitutes.

   Sweeteners Come in A Variety of Forms, Including

   - Sugar alcohols, which are also referred to as polyols, are naturally occurring carbohydrates present in various fruits and vegetables, with examples including xylitol, sorbitol, and erythritol. Sugar alcohols are only partially absorbed by the body and have less calories than sugar. If ingested in excessive quantities, they can have a laxative effect.

   - Artificial sweeteners are chemical substances that deliver sweetness without adding calories. Examples of artificial sweeteners include aspartame (sold under brand names like Equal and NutraSweet), sucralose (commonly known as Splenda), saccharin (found in products like Sweet'N Low), and acesulfame potassium (used in brands like

Sunett and Sweet One). Because artificial sweeteners are more intensely sweet than sugar, lesser amounts are required. Aspartame (found in products like NutraSweet) and saccharin (found in products like Sweet'N Low) are popular artificial sweeteners that have been related to reports of negative reactions in some people. In rare instances, these might include allergic reactions, stomach discomfort, and headaches. Additionally, several research raise the possibility of impacts on hunger and metabolism.

- Natural sweeteners come from natural sources such as plants. Two examples are stevia, derived from the leaves of the stevia plant, and monk fruit extract, which is obtained from the monk fruit. Natural sweeteners are typically thought to be lower in calories than sugar, however their amount of processing and purity might vary.

It's worth noting that the safety and health impacts of sweeteners as fillers are still being researched and debated. While regulatory authorities usually see them as safe, several studies have raised concerns about potential side effects. Individuals with certain health issues should contact with their healthcare professional before consuming sweeteners, as with any meal or product.

2. **Polyols:** Polyols, often referred to as sugar alcohols, represent a unique category as they are neither sugars nor alcohols. They typically exist in the form of white crystalline powders or syrups and are widely employed as sugar substitutes, particularly in sugar reduction efforts. These compounds result from the hydrogenation of carbohydrates, wherein the carboxyl group, such as aldehyde or ketone, undergoes reduction to form primary or secondary hydroxyl groups.

   Polyols offer lower energy content due to their reduced sweetness compared to sucrose, and they do not contribute to dental caries. Recommended daily intake for adults is typically 40-50g, while for children, it's advised to limit intake to 30g per day to avoid potential gastrointestinal issues, including osmotic diarrhea, associated with excessive consumption. (Ghosh & Sudha, 2012). Hence, food products containing more than 10% added polyols should carry a label stating, "Excessive consumption may lead to laxative effects." (Sahin et al., 2019). This category encompasses a range of polyols, including xylitol, sorbitol maltitol, lactitol, mannitol erythritol and isomalt, all of which will be examined in-depth.

3. **Sorbitol :** Sorbitol, known by various aliases like sorbogem, sorbo and glucitol, is a sugar alcohol primarily present in pomaceous and stone fruits in nature. However, it is predominantly produced on a large scale through the hydrogenation of hydrolyzed starch. Sorbitol is one of the water-soluble polyols that are hygroscopic in nature which makes them a good humectant for various foodstuffs. It is 0.5 times sweeter when compared with sucrose and finds application in sugar free cakes, cookies, muffins etc. When examined under the microscope, it was observed that the cake batter showed an elevated formation of air cells, which were substituted with sorbitol and steviol glycosides. (Ghosh & Sudha, 2011; Struck et al., 2014).

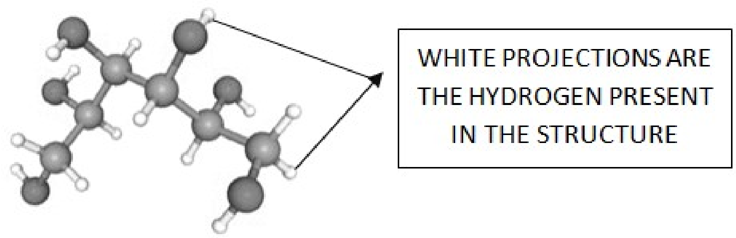

Figure 1: Structure of Sorbitol, Molecular Formula : C6H14O

4. **Xylitol:** Xylitol is a polyol with five carbon atoms has sweetness comparable to sucrose. While it occurs naturally in small quantities in fruits and vegetables, it is primarily produced on a large scale from xylan. Xylitol exhibits a lower water activity than sucrose, thereby extending the shelf-life and microbial stability of food products. Additionally, at a specific temperature of 30^{o}C, xylitol shares the same water solubility as sucrose. (Struck et al., 2014). The Food and Drug Administration (FDA) has granted approval for the use of xylitol since the 1960s, affirming its safety for children. This polyol has found application in bakery items like biscuits, cakes, and bread, serving as a sugar substitute. When consumed in a single dose not exceeding 30g, it does not typically lead to health issues such as elevated blood sugar levels. However, excessive consumption may result in diarrhea due to the inability of intestinal bacteria to metabolize such large quantities.

   Xylitol is also utilized as an ingredient in toothpaste and other oral hygiene products because it is non-fermentable by cariogenic microbes in the oral cavity. Studies conducted on rats fed with xylitol diets in comparison to cariogenic diets revealed a complete elimination of dental caries in the rats consuming xylitol-based diets. Same results were attained in the case of human beings (Grunberg et al. 1973; Scheinin and Mackinen 1975; Struck et al., 2014; Ghosh & Sudha, 2011).

   In the manufacture of cookies replaced with xylitol, a similar sweetness to sucrose, cooling effect and aftertaste was observed. In the case of cookies, no lingering aftertaste was detected, and there were no noticeable alterations in flavor or texture during storage, contributing to an extended shelf-life. Conversely, when xylitol was incorporated into cake formulations, specific volume increased, while crumb hardness decreased, and the browning reaction was reduced. They have also been used in bread manufacture with an increase in springiness and loaf volumes (Struck et al., 2014; Sahin et al., 2019). In biscuits, there was found to be no adverse effect on the browning of biscuits but decreased the spreading and hardness properties. When sugar was entirely substituted with xylitol in burger buns, it resulted in reduced browning and had an impact on CO2 production, resulting in lower specific volume and a firmer crumb texture. However, when only 50% of the sugar was replaced with xylitol, no discernible effect was observed on the product. (Sahin et al., 2018).

5. **Maltitol:** Maltitol is a sugar alcohol consisting of glucose and sorbitol is made by catalytic hydrogenation of maltose. It is a bulk sweetener with fewer calories. The intensity of sweetness varies between 0.8 and 0.9 as that of sucrose. They are less hygroscopic in nature than the other polyols and are heat stable. The various trade names under which they are known are Maltisorb,

Maltisweet and Lesys. Maltitol does not cause tooth decay and does not have much effect on the blood glucose. Studies have shown that there was low glycemic and insulinemic indexes in healthy persons who consumed chocolates with added maltitol Maltitol is being used in food products like breads, cakes, cheesecakes, muffins, nutritional bars etc.

When maltitol was entirely substituted in cupcakes, it resulted in a light brown coloration with a satisfactory crumb texture and rise, although it lacked and crumb moisture sweetness. Conversely, cupcakes created using a 1:1 ratio of sucrose to maltitol exhibited a golden-brown hue with a pleasing texture and sweetness. As for cookies and biscuits crafted with maltitol, they exhibited a firm texture while still maintaining an satisfactory sensory quality. (Sahin et al., 2019 Ghosh & Sudha, 2011).

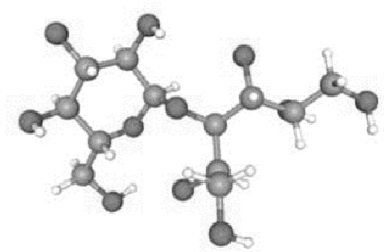

Figure 2: Structure of Maltitol , Molecular Formula : C12H24O11

6. **Lactitol:** Lactitol is a sweet tasting synthetic disaccharide comprising of sorbitol and galactose with nutritional, physiological and pharmaceutical properties. They are highly soluble in water and is of low hygroscopic nature. The molecular weight of lactitol is similar to that of sucrose, therefore their impact on water activity is also the same as sucrose (Ghosh & Sudha, 2011). When compared to sucrose, the sweetness level is between 0.3 and 0.4, and there is no aftertaste. It is typically used in conjunction with high intensity sweeteners due to its low sweetness. According to EC, consumption of 20g/ person/day of lactitol does not cause any laxative effects. Lactitol, that remain unabsorbed by the body have a chance of causing diarrhea, bloating and abdominal pain. Cookies prepared with lactitol produced product with softer and less brittle texture and a large diameter (Ghosh & Sudha, 2011).

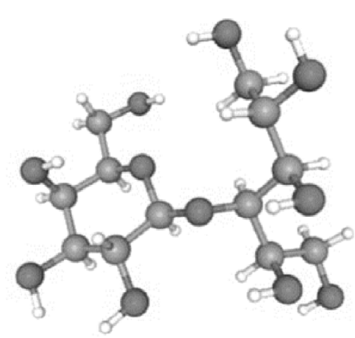

Figure 3: Structure of Lactitol , Molecular Formula : C12H24O11

7. **Erythritol:** Erythritol is a 4-carbon polyol which are naturally found in fruits such as grapes, pears, melons and in mushrooms but on a large scale produced from wheat or corn starch by fermentation. They are the only ones which are produced by fermentation method. They are regarded as safe for use in foods since they are thermally stable and only mildly soluble in water (EFSA ANS Panel, 2013b). The sweetness is between 0.6 and 0.8 in intensity. Erythritol's estimated calorific value was discovered to be 0.4 kcal/g. Erythritol has a high digestive tolerance, is non-caloric, non-cariogenic, and non-glycemic, which makes it suitable for use in functional meals.

Erythritol is categorized as non-cariogenic and non-toxic. It was discovered that the levels of glucose and insulin did not rise when given orally to healthy male participants. Only polyol is effectively absorbed by the gut and delivered to the kidneys for urine excretion. All polyols, with the exception of erythritol, have a laxative effect when ingested in excess.

For both males and females, the highest dose that won't have a laxative effect is 0.66 g/kg BW and 0.80 g/kg BW, respectively. In the repeat-dose research, consumption of erythritol at doses of 1 g/kg BW per day was well tolerated by people. (Ghosh & Sudha, 2011). Because of its smaller molecular mass, erythritol produced the lowest onset and peak temperatures during the gelatinization of starch in DSC studies of muffin batter utilizing sucrose or polyols. Erythritol was not regarded as a more acceptable sugar replacement than other polyols in the making of muffins due to height decreases and an increase in hardness. In contrast, replacing up to 75% of the sugar in chiffon cakes with erythritol had no effect on the cake's physical or sensory characteristics. Cakes and muffins with a partial sugar substitute had delicate crumbs. In biscuits, it reduced fragility and inferior textural quality while increasing dough strength and elasticity. Martinez-Cervera et al. (2014) claim that it is completely impractical to replace all of the sugar in cakes and biscuits with erythritol. (Sahin et al., 2019; Struck et al., 2014).

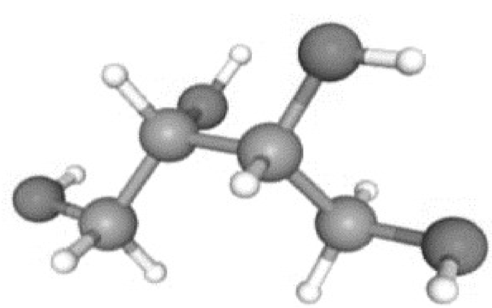

Figure 4: Structure of Erythritol, Molecular Formula : $C_4H_{10}O_4$

8. **Mannitol:** An isomer of sorbitol is mannitol, a white crystalline substance. It was the initial "sugar-free" component used in food. It can be found in the ash tree's sweet exudates (Ghosh & Sudha, 2011). Because it has a sweetness level that is half that of sucrose, it is profitable to use in baking items. It is utilized as an excipient in pharmaceutical tablets because it is non-hygroscopic (Struck et al., 2014). Mannitol has a lower solubility in water, just 220 g/kg water at 258˚C, compared to other sweeteners, which range from 1650 to 2350 g/kg water (Ghosh & Sudha, 2011). Mannitol was used in place of sucrose to produce products that had a firmer texture and less spring in cakes and cupcakes. In comparison to samples using other polyols, samples using mannitol as a sugar replacement had the lowest sensory scores. The low solubility of mannitol is being compensated for by adding more water to cookie doughs, but this results in very stiff dough that is challenging to sheet. Due to its poor spreading properties and disagreeable biscuit flavor, this polyol is not regarded as a good sucrose replacement (Zoulias et al., 2000; Struck et al., 2014).

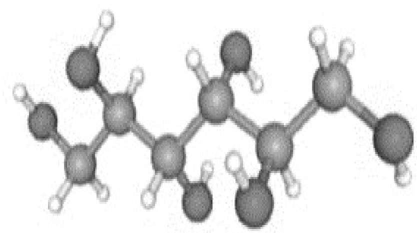

Figure 5: Structure of Mannitol , Molecular Formula : C6H14O6

9. **Isomalt :** Isomalt is a disaccharide made of glucose and mannitol that is odorless, low in calories, and non-hygroscopic (Ghosh & Sudha, 2011; Strater, 1986, 1988). Palatinose has been its name since its discovery in 1957. According to Ghosh and Sudha (2011), the sweetness is between 0.45 and 0.6 in intensity and leaves no aftertaste. It exhibits a cooling effect when chewing and is resistant to Maillard processes. It is beneficial for integration into low moisture baking products like cookies due to its low hygroscopicity.

   In terms of color, structure, look, and flavor, cupcakes made with isomalt in place of 33% sucrose had sensory scores that were rather close to control (Edelstein et al., 2007; Struck et al., 2014). According to Gomez (2008), Martinez-Cervera et al. (2014), and Struck et al. (2014), isomalt is an acceptable sugar substitute in muffins due to its similar thermosetting qualities of the batter and good textural and sensory features.

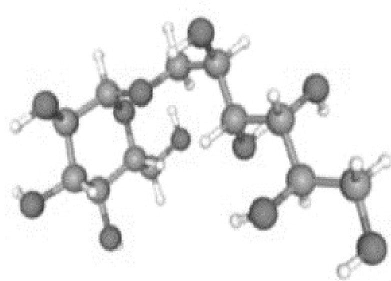

Figure 6: Structure of Isomalt , Molecular Formula : C12H24O11

10. **Hydrogenated Starch Hydrolysate (HSH):** This group of polyols contains hydrogenated oligo and polysaccharides. It has a sweetness intensity that ranges between 0.4 to 0.9 compared to sucrose. Due to its delayed absorption, it has a lower glycemic potential than glucose for people with or without diabetes (Wheeler et al., 1990; Ghosh & Sudha, 2011). This sweetener can partially replace sucrose or corn syrup in baked goods including cakes, cookies, and granola bars because of its humectant properties. (Ghosh & Sudha, 2011)

III. HIGH INTENSITY SWEETENERS

Artificial sweeteners with a higher degree of sweetness than sucrose are known as high intensity sweeteners or non-nutritive sweeteners. They do not change the product's digestible energy, are non-cariogenic, or raise blood sugar levels. Different countries use these sweeteners in different ways. i.e., It might be legal in one nation but unlawful in another (Struck et al., 2014). In order to give foods bulk, viscosity, and texture, intense sweeteners must be combined with bulking agents such polyols or dietary fibers. Intense sweeteners alone do not contribute to these features. High intensity sweeteners, often known as artificial sweeteners, include cyclamate, aspartame, sucralose, alitame, acesulfame-K, neotame, and saccharin. Six of these artificial sweeteners, including saccharin, aspartame, acesulfame-K, sucralose, neotame, and advantame, have received FDA approval. (FDA, 2017).

1. **Saccharin:** One of the first artificial sweeteners was unintentionally found by Remsen and Fahlberg at John Hopkins University in 1879 and is called saccharin. Initially, saccharin was employed as a preservative and an antibacterial rather than a sweetener. This sweetener is produced for use in commerce from toluene and is offered as a sodium salt and occasionally as a calcium salt. It has a 200–700 range in terms of sweetness intensity. Saccharin's ability to maintain its sweetening potency even when heated makes it a valuable ingredient in low-calorie, sugar-free products. It is the only high intensity sweetener that has been given approval that can endure high acid conditions, baking, and heating operations. Since more than a century ago, this sweetener has been sold under the trade names Sweet'N Low, Sugar Twin, and Necta Sweet. It is used in numerous home products, including mouthwash, lip gloss, toothpaste, vitamins, and medications, as well as numerous food products, including soft beverages, baked goods, jams, canned fruit, salad dressing, chewing gums, etc. One sugar alternative that diabetic individuals can eat is saccharin because it is not digested in the digestive system and does not raise insulin levels (Shankar et al., 2013).

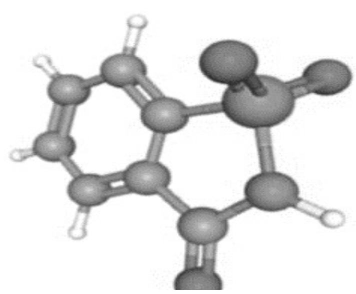

Figure 7: Structure of Saccharin, Molecular Formula : C12H24O11

2. **Aspartame:** Aspartame is the methyl ester of phenylalanine and aspartic acid. James Schalatter, a scientist, made the discovery in 1965, but the FDA didn't approve it until 1981. Equal, NutraSweet, and Natra Taste are some of the several brand names under which it was marketed. It offers roughly 4 Kcal per g. Due to its sweetness, which is around 200 times greater than sucrose's, this sweetener is frequently employed in lower amounts to sweeten meals. According to the FDA, the permissible daily dosage of aspartame for both adults and children is 50 mg/kg body weight.

   Products including chewing gum, yoghurt, puddings, diet soda, dry drink mixes, instant tea, and coffee are all sweetened with aspartame. Aspartame was discovered to have a more pleasant taste than sweeteners like stevia or sucrose in a study on the effects of artificial sweeteners on food intake and satiety. Aspartame is supposed to not affect the brain and pancreas in the same way as sugar does. In a study using magnetic resonance imaging, it was discovered that sucrose consumption decreased the activity of the hypothalamus, whereas aspartame consumption did not. This is because a hypothalamus reaction requires both the stimuli of sweet taste and energy content. Aspartame does not cause the same insulin response in the pancreas as sugar does (Shankar et al., 2013).

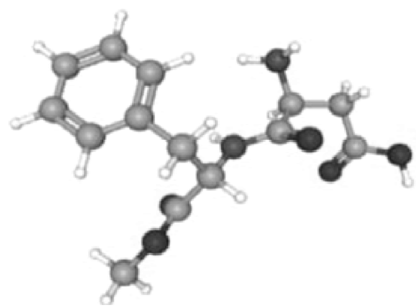

Figure 8: Structure of Aspartame, Molecular Formula : C14H18N2O5

3. **Cyclamate:** Michael Sveda made the sweetener cyclamate in 1937 at Abbott Laboratories in Chicago. It had been given GRAS classification by the FDA in 1958 after being approved as a food ingredient in 1949. It lost its GRAS certification in 1969, was banned in the USA in 1970 because to the tumor it induced in rats, and later in the UK and other nations. This led to a decline in the quality of soft drink flavor and provided a catalyst for the creation of other sweeteners. This sweetener is acceptable for some uses in some nations, including Spain, Germany, and Switzerland. The sweetness of cyclamate is one-tenth that of saccharin in terms of weight. They generated a pleasant sweetness in the 1950s when combined at a 10:1 ratio. Cyclamate was used to cover saccharin's aftertaste, whereas saccharin might boost cyclamate's modest sweetness. As the first commercially available multiple sweeteners, this combination was utilized in a variety of foods, including soft drinks, salad dressings, low-calorie frozen treat, jams, and jellies, among others. Aspartame and saccharin are two more combinations that are frequently employed since they have been shown to enhance sweetness and provide foods like soft drinks, dry beverage mixes, chewing gums, and table-top sweeteners a pleasant flavor (Gelardi, 1987; Smith, 2013).

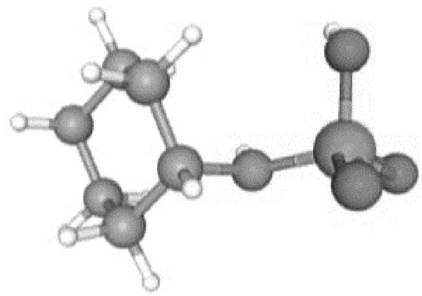

Figure 9: Structure of Cyclamate, Molecular Formula : C6H12NNaO3S

4. **Sucralose:** The FDA has approved the use of sucralose, a non-caloric sweetener first discovered in 1976, as a sugar substitute in 15 different foods and beverages. It tastes similar to sugar and has no unfavorable aftertaste. The brand name Splenda is being used to advertise this sweetener. It is created by specifically changing the hydroxyl groups on the sucrose core to chlorine. Its sweetness is 600 times more than table sugar's. Small amounts of this sweetener are absorbed in the GI tract before being completely removed through stool (International Food Information Council Foundation, 2009). Sucralose is extremely stable since it maintains its sweetness even when exposed to intense heat and acidity. Due to its lack of bioreactivity and bioaccumulation in both humans and animals, sucralose is regarded as a safe artificial sweetener for long-term use. The fact that this sweetener has no impact on how carbohydrates are metabolized makes it safe for patients.

   In healthy individuals given an intraduodenal/intragastric infusion, it neither slows down the rate of glucose absorption from the small intestine nor does it heighten glycaemic response or incretin hormone levels such as glucagon-like peptide 1 and glucose dependent insulinotropic polypeptide. Sucralose also does not speed up stomach emptying or trigger the release of insulin, hence maintaining glucose homeostasis. According to studies, sucralose has no impact on adults with typical healthy weight when it comes to their appetite. (Shankar et. al., 2013).

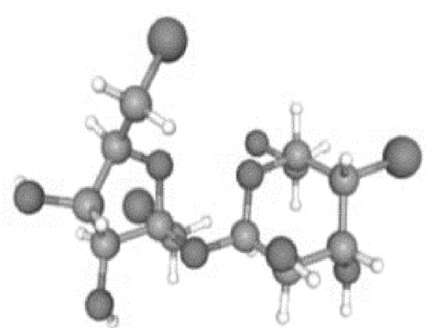

Figure 10: Structure of Sucralose, Molecular Formula : C12H19Cl3O8

5. **Acesulfame-K:** Acesulfame K, also known as Sunett, is a potassium salt made from acetoacetic acid that was first developed in 1967 by Hoechst AG while working for a pharmaceutical business.

About 200 times sweeter than sucrose is this sweetener. Initially, the US permitted the use of this sweetener in products including sugar-free baked goods, chewing gum, and gelatin desserts. However, this sweetener was given FDA approval to be used in soft drinks in July 1998. Acesulfame-K also goes by the brand names Sweet One and Swiss Sweet in addition to Sunett. Acesulfame-K is a sweetener that can be used in baking and cooking processes since it is heat stable. ; Shankar et al., 2012; Center for Science in the Public Interest). When combined with aspartame and cyclamate, acesulfame-K has a synergistic effect that increases sweetness intensity by up to 30% or by more than 30%.

It was found to have the best sensory qualities when used in combination with aspartame at a weight ratio of 1:1 for acesulfame-K and aspartame, and with cyclamate at a weight ratio of 1:5. It was also discovered to work well with fructose, isomalt, and sorbitol. Aspartame is a pricey sweetener, but a combination of acesulfame and thaumatin is less expensive and imparts a comparable flavor in some food products. (Smith, 2013; Von Rymon Lipinski, 1986). According to the International Food Information Council Foundation (2009) and Shankar et al. (2013), acesulfame-K is eliminated by the body unchanged. One of the byproducts produced by the breakdown of acesulfame, which is extremely hazardous in high concentrations, is acetoacetamide. However, this sweetener is used in beverages in smaller levels, which means there is no health risk (Kroger et al., 2006; Shankar et al., 2013).

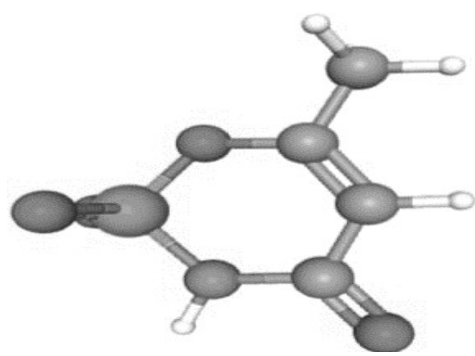

Figure 11: Structure of Acesulfame - K , Molecular Formula : C4H4KNO4S

IV. NATURAL SWEETENERS

These are the sweeteners that are produced naturally in the environment and have a low energy content. They can be extracted from various plant components, including roots, seeds, flowers, and leaves, and then they are further cleaned. Foods can use tegatose, stevia, and fructans (oligofructose and inulin) as sugar substitutes. Brazzein, monatin, and other sweeteners have not been used (Struck et al., 2014).

1. **Tegatose:** Tegatose, a ketohexose, has a lower calorie content of about 1.5 Kcal/g than sucrose due to its partial absorption in the GI tract and a sweetness of 0.92 when compared to sucrose. Although it is found in tiny levels in fruits and dairy products, lactose can be used to make it commercially. Tegatose is a non-hygroscopic, prebiotic, and synergistic sweetener that, when combined with other sweeteners, increases sweetness or lessens bitterness. Due to its smaller molecular mass, it displays less water activity than sucrose at the same concentration. It now has GRAS certification, allowing

for usage as a sugar substitute and sweetener in a variety of foods and beverages (Struck et al., 2014). Tegatose did not alter the flavor or sweetness of cakes, cookies, or muffins when used at 3% or 6% (Armstrong et al., 2009; Struck et al., 2014). The hardness, cohesion, and resilience of the dough in cookies were not affected when 20–100% of the sucrose was replaced by tegatose (Taylor et al., 2008; Struck et al., 2014). Due to the weak water binding ability of. tegatose, which makes more water accessible for gluten synthesis and promotes browning, tegatose raised the height and decreased the diameter of cookies (Struck et al., 2014).

2. **Steviol Glycosides:** Steviol glycosides, such as stevioside and rebaudioside A, have been used extensively in Japan for more than 20 years (Chan et al., 2000; Shankar et al., 2013; Struck et al., 2014). They are isolated from the Stevia rebaudiana Bertoni plant species. They can be used as a sucrose replacement because they are around 300 times sweeter than sugar and are thermally stable. Both of them taste clean and sweet when consumed in lower quantities (sucrose equivalency level 6), but when concentrated, they both taste harsh (sucrose equivalency level >6). When compared to rebaudioside A, steviosides have a more bitter taste and a black licorice aftertaste (Prakash et al., 2008; Struck et al., 2014). With an appropriate daily dose of 4 mg/kg body weight, the European Union had approved this sweetener as an ingredient for specific foods in 2011 (Anonymous, 2011; Struck et al., 2014).

Only stevioside and rebaudioside A are commercially accessible in the proper purity despite the fact that more than 10 different forms of steviol glycosides have been found (Carakostas et al., 2012; Struck et al., 2014). These sweeteners can be combined without losing any stability with artificial sweeteners such saccharin or aspartame (Kroyer, 2010; Struck et al., 2014). In contrast to cyclamate, synergistic effects were seen when aspartame or acesulfame-K were used (Frank et al., 1989; Struck et al., 2014).

In an experiment, steviol glycosides and inulin were used to substitute 30% of the sucrose in muffins, and it was discovered that this reduced the glycaemic response. While an aqueous extract from stevia leaves was able to replace sugar in a low-calorie yoghurt cake, ground stevia leaves improved the hardness, cohesion, and toughness of the cake. Steviol glycosides cannot totally replace sucrose since they only display high intensity sweetness, not bulk characteristics.

The diameter, thickness, and hardness of the cookies were reduced (15–20%) in the cookies that had stevia leaf powder added. When coupled with hydrocolloids, bulking agents, or fibers, the steviol glycosides produced sugar-free products with acceptable quality features (Struck et al., 2014).

3. **Fructans:** Fructans are polymeric carbohydrates containing fructosyl-fructose connections and a linear, branching, or cyclic structure. Due to the development of advantageous microbes like bifidobacteria and lactobacilli, they are recognized as prebiotic dietary fibers. They have been discovered to lower triacylglycerols and blood cholesterol, enhance mineral absorption, and guard against colon cancer. Inulin and oligofructose are two examples of this class of carbohydrates. A fructan called inulin is utilized in conjunction with sweeteners of high intensity to offer bulk properties. Inulin, which can be used to replace fat and alter texture, can occasionally form a gel in an aqueous solution (Zoulias et al., 2002; Struck et al., 2014). Jerusalem artichoke and chicory are the two main suppliers of inulin. After extraction, the degree of polymerization (DP) ranges from 2 to 60. Inulin's DP is affected by a variety of variables, including the type of plant used, the climate, and the time of harvest. Inulin and other fructans are indigestible non the small intestine but may be partially digestible into short-chain fatty acids, lactic acid, and gas by microorganisms in the large intestine, which increases stool weight.

   Short chain fructans known as oligofructose are produced when inulin is partially hydrolyzed by enzymes. Oligofructose-based cakes have a decreased hardness, increased volume, and surface browning. Instead of recrystallizing, short chain inulins have a higher solubility and water retention capacity than sucrose, which results in a softer crumb structure. Due to its higher hygroscopicity than sucrose, oligofructose lowered cookie height and increased diameter while lowering gluten development in cookies (Struck et al., 2014).

V. CONCLUSION

Food grade filler particles are essential components in the production of various food products. These inert substances, such as starches, fibers, hydrocolloids, minerals, and other miscellaneous particles, fulfill important functions in enhancing the texture, stability, and overall quality of foods. By carefully selecting and incorporating these particles, manufacturers can create products that meet consumers' expectations in terms of taste, appearance, and functionality. Moreover, food grade fillers play a crucial role in various food products by providing desirable attributes such as texture, mouthfeel, and improved shelf life, the use of food grade filler particles ensures that the nutritional value, safety, and sensory aspects of the food are not compromised. In the end, these filler ingredients help produce delicious and enticing food items that satisfy a variety of consumer preferences and dietary requirements. However, due to health and safety concerns associated with the use of certain fillers containing harmful particles or chemicals, the food industry is actively seeking alternative replacement options. The search for suitable replacements involves considering several factors such as the nature of the filler, its functionality, cost-effectiveness, and compatibility with different food matrices. Several potential replacement options have been explored, ranging from natural ingredients to innovative technologies. Natural ingredients, such as fiber-based fillers derived from fruits, vegetables, or grains, have gained attention as they not only provide similar functional properties but also offer additional health benefits. These fillers often contain dietary fiber, vitamins, and minerals, which can contribute to improved digestion and overall well-being. In addition to natural options, advancements in technology have paved the way for innovative solutions such as microencapsulation and nanotechnology.

These techniques involve the encapsulation or modification of fillers at the micron or nanoscale level to enhance their functional properties without compromising food safety. For example, encapsulated particles can be used to control taste release, prevent oxidation, or provide targeted nutrient delivery. Although the use of alternative fillers shows promise, further research and development are necessary to ensure their long-term safety and scalability. Furthermore, consumer acceptance and perception of these alternative fillers will play a crucial role in their successful implementation. Public education and transparent communication about the benefits and safety of these replacements are key to creating consumer trust and acceptance.

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