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Replacement of fat, salt, and sugar: Need of an hour for food industries

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Abstract
The escalating concern of consumers towards the consumption of healthy food and leading a healthy lifestyle has encouraged the food industry to develop and market food products manufactured by considering the health aspect of the consumers. Health consciousness these days has become a trend. Excess weight is considered to be a key factor associated with the diseases like CVD, Hypertension, and Diabetes etc. Fats, salt, and sugar no doubt are the principal ingredients in the majority of food preparations worldwide. They play a major role in flavor development and preservation. People desire to replace these ingredients without compromising the flavor and taste. Developing replacement strategies and creating replacers of these ingredients is a major challenge before the food industries. This review article has a focus on the replacement strategies of fat, salt, and sugars in foods and the use of analogs for replacement of these ingredients.

Keywords: analogs, fat, salt, sugar, health consciousness

1. Introduction
Statistical surveys are performed regularly by the World Health Organization in order to check the health and well-being of people and estimate the number of deaths and patients affected due to various diseases every year. The results of the statistical surveys over years has shown a continuous increase in the number of people affected and the deaths caused due to diseases like hypertension, diabetes, CVD etc. A majority of people all over the world have fallen prey to these diseases. The main factors responsible for this condition today is the modernized lifestyle (more a sedentary one), lack of exercise, adoption of fast food culture and mainly an improper diet loaded with fat, salt and sugar. The development of Hypertension is usually linked to the consumption of salt similarly diabetes is associated with sugar consumption and CVD to the consumption of fats.
The Food Safety and Standards Authority of India (FSSAI) has recently launched a campaign, 'Eat right movement', at a national level which focusses on reducing the content and intake of fat, salt and sugar on everyday basis and at an industrial level, thus making the food more nutritious and combat the ill effects of excessive consumption of fat, salt and sugar. This campaign is a collective effort to encourage people in making safe, healthy and nutritious food choices. As a part of this campaign, citizens are empowered to make the right food choices and food business operators are requested to reformulate their products, provide accurate nutritional information to consumers and make an investment in healthy food.
The analogs of these ingredients extend a helping hand towards the minimized use of these ingredients and ultimately contributes to minimizing the occurrences and exercise control over these diseases. Moreover, these analogs have proven to be beneficial for consumers with a desire to cut off the calories from their diet without compromising the flavor and quality of the food product. Food analogs may be referred to as 'engineered food'. A food manufactured with a view of replacing the traditional ingredients. They are manufactured food product or ingredient intended to mimic or replicate the characteristics of a particular food. They must possess the characteristics equal to or higher than that of the original food which it is intended to replace.
They are designed with a basic objective of replacing the food ingredients, to save money, change the nutritive value of food, improve the performance of foods and compounds, provide an option for replacing the foods that are restricted for health reasons, religious views and provides an attractive option for the health-conscious consumers. Some of the examples of food analogs are Texturized vegetable protein from soybean used as a meat analog, Meat analog like (Tofu, Quorn), Artificial sweeteners (Saccharin, Aspartame, Sucralose), Fat replacers (Olestra, Caprenin), Salt substitutes (Potassium chloride), Gums etc.
Some of the advantages of this technology are that it provides benefits of low-fat reduced calorie options, keep prices of other food products reasonable, and provides more options for people with heart diseases, food allergies, and diabetes. Certain disadvantages of food analogs are firstly they are not natural, the manufacturing cost may be expensive which ultimately leads to the increased cost of the final product and may withdraw the consumer's interest to purchase them. However, it cannot replace all the traditional foods in the diet and their use may tempt some people to avoid eating a variety of foods. Food analogs have gained increased consumer

acceptance these days because of the proven benefits. In this present article, we are going to discuss the replacement strategies and the analogs of fat, salt, and sugar.

2. Fast food culture

Salt, sugar, and fat are the vital ingredients not only for the household preparations but also for the processed foods. With the modernized lifestyle and lack of time, consumers are shifting their interest towards the ready to eat and ready to serve foods which use fat, salts and sugar in a greater amount. Also, the fast food culture is accepted widely. Fast foods have become a primary part of the diet. Fast foods are fully loaded with these ingredients thus contributing to the associated diseases. Methods for reduction of fat, salt and sugars must be practiced in preparation of fast foods, this may be a major contribution towards reducing the risk of associated diseases. Also, a significant concern should be given by the food industries to the possible reduction of these ingredients in processed foods, in response to consumers demand for healthy food and ultimately promoting the good health of people.

3. Fat replacement

The unique functional properties of fat are a key reason for its influence on the parameters like flavor, texture, and preservation of foods. The consumer's acceptability towards any food product depends majorly on taste check. Although consumers desire the acceptance of foods with minimal to no fat content they do not give a significant response when asked about compromising the flavor and quality of the food product. Thus, consumers wish to get a product with low calories and no reduced organoleptic properties have motivated the food industry to develop reduced fat options with same desirable attributes to full-fat foods which have created a major challenge before food manufacturers. Some of the traditional techniques are used for replacement of fats like alteration of cooking techniques like opting for methods like baking, roasting, boiling etc instead of frying, substituting water or air for fat, using skim milk instead of whole milk etc [10].

3.1 Role of fat in the human body and food

Fat is the most concentrated source of energy. It provides 9 kcal on 1 gram of consumption. World Health Organization (WHO) and the United Nations Food and Agriculture Organization (FAO), recommends that daily fat consumption should not be lower than 15-20% of energy demand per day and not more than 30-35% [22]. Lipids are necessary for proper functioning of the body as they are the chief source of energy. Fat consumption in the proper amount is highly essential for the victorious absorption and metabolism of the fat-soluble vitamins (A, D, E, and K). Fat also serves as building blocks of the body [52, 72]. It plays an important role in brain and retinal development. Fat serves the function of insulation and protection of the body organs and is also a source of fatty acids required by the body. The importance of fat in the proper functioning of the human body cannot be neglected while searching for an ideal fat replacer and has to be taken into account. An intended fat replacer should not adversely affect the described functions of fat.

Fat is an essential component of a wide variety of food preparations. Besides its vital role in the human body, it also proves to be of importance in foods with regards to their texture and organoleptic properties. It contributes to flavor development and taste improvement of a food product and also to aroma/odor. A sense of satiety is imparted by fat and it also does much in giving a good mouthfeel to foods [45, 50, and 65]. Fats play a vital role in enhancing the necessary properties like creaminess and lubricity of foods. It also contributes to the development of texture and good appearance [60, 69]. Fats carry lipophilic flavor compounds, they act as a precursor for flavor development and avoid fluctuations in the flavor of the food product and preparations.

Some of the important functions of fat in food are given in the figure below (Figure1).

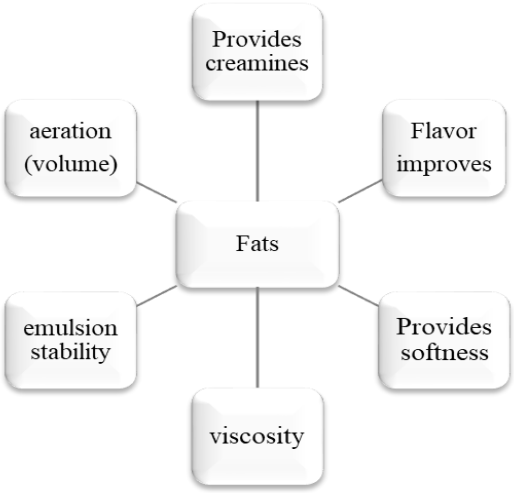

Fig 1: Role of fat in food

3.2 Need for fat replacement

The presence and excess intake of fats, especially the saturated ones are usually linked with the occurrence of some diseases like obesity, atherosclerosis, high blood cholesterol, coronary heart diseases and also some types of cancers [42, 57]. Fat as already known is the most concentrated source of energy. Thus overconsumption of fats especially that of the saturated fats has contributed to the development of the described diseases [52, 72]. The daily fat intake of an individual should be governed by the limits as prescribed by the WHO. FAO/WHO experts recommend that monounsaturated fatty acids should provide 13% of the daily energy intake. The consumption of saturated fatty acids, should not exceed 7% of the total lipids [3, 35]. The knowledge of the contribution of over intake of fats to the associated diseases has led the consumers to shift their interest towards the consumption of less fat and the acceptance of healthy lifestyle by modifying their dietary habits.

3.3 Fat replacers

Some reformulated chemical substances possessing fat-like properties prove to be helpful in replacement of fat [71, 69]. Fat replacers are ingredients designed to replace all or part of the fat in a product, with minimum impact on the organoleptic properties of a food product. Surveys indicate that 56% of adult Americans are trying to minimize fat intake and are

interested in trying foods manufactured using fat replacers [8]. A survey performed by the Calorie Control Council (CCC, Atlanta, Ga.) came up with the results that 88% of adults reported accepting intake of low-fat, reduced-fat or fat-free foods and beverages[9]. The food manufacturers continue to search for an "ideal fat replacer" that has a potential to replicate the properties of fat with no adverse health impact. There is no such ideal fat replacer accounted. Every fat analog or fat replacer has its own advantages and disadvantages. Single fat replacer may not prove to be suitable for all the applications. Every fat replacer has its unique suitability to a particular application and must be chosen wisely.

3.4 Effect of fat replacers on rheological properties of food

For the design of a successful fat replacer, it is necessary to have an emphasis, not only on calorie reduction through the use of low-calorie ingredients but also on valorizing the quality or maintaining the same. A fat replacer is intended to mimic the organoleptic properties, functional properties as well as maintaining the quality attributes of fat in a food product. Carbohydrate and protein-based fat replacers usually have a significant effect on the rheological properties of a product as compared to lipid-based replacers. Carbohydrate-based fat replacers are usually hydrocolloids having a high water retention capacity. Their functional properties like gelling, thickening and emulsifying properties help them to mimic the organoleptic properties, the mouthfeel and flow properties of fat in the aqueous system. Fat replacers (carbohydrate or protein based) are usually dispersed/ dissolved in water to form a solution or gel. The increased viscosity aids in stabilizing the structure of the food matrix [64].They can compensate for volume and textural loss of foods. A light and slimy mouthfeel is provided to food by the use of fiber-based fat replacers. They exhibit a shear-thinning flow behavior [46]. Thus the choice of a fat replacer is highly dependent on how it affects the rheological properties of a food product.

3.5 Types of fat replacers

A fat replacer is designed with an intention to replace all or part of the fat in a food product [43]. They are basically derived from lipid, protein or carbohydrate by means of chemical alterations. They may be used alone or in unique combination [1, 15]. They may be categorized as 1) Fat substitutes 2) Low-calorie fats 3) Fat mimetics. Figure 2 shows the classification of fat replacers.

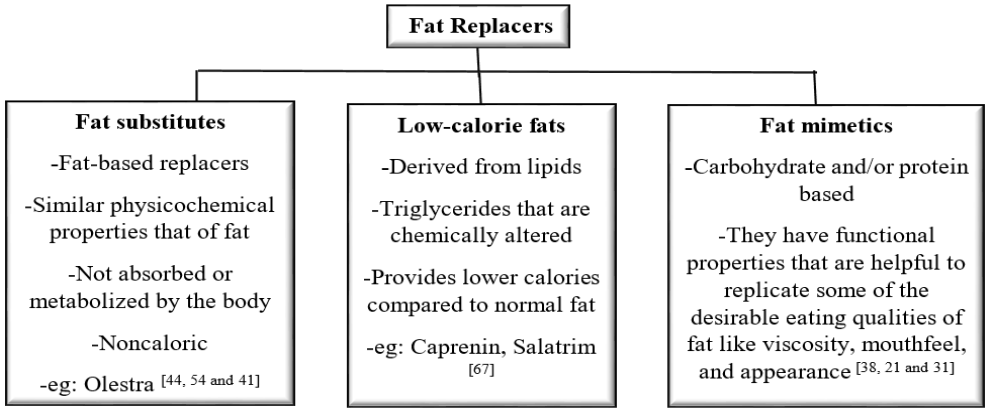

Fig 2: Classification of fat replacers

Some of the commercial lipid-based fat replacers and low-calorie fats with their caloric density, specific applications, and functional properties are given in the table below (Table 1).

Table 1: Lipid-based fat replacers and low-calorie fats [12]

Type of fat replacer/Brand name	Developers	Energy Density	Specific application	Functional Properties
Olestra/ Olean	Procter & Gamble Co. (Cincinnati, Ohio), C. Akoh (Univ. Georgia, Athens) B. Swanson (Washington State Univ., Pullman)	Noncaloric	Savory snacks	Texturize, provide flavor and crispiness, conduct heat
Caprenin	Procter & Gamble Co. (Cincinnati, Ohio)	5 kcal/g	Confectionary coatings	Properties of cocoa butter
Salatrim/Benefat	Nabisco Foods Group (Parsippany, N.J.)/Cultor Food Science, Inc.	5 kcal/g	Chocolate-flavored coatings, deposited chips, fillings, and inclusions	Range melting points, hardness, appearance Emulsify, provide cohesiveness,
Dialkyl di hexadecyl malonate (DDM)	Frito-Lay, Inc. (Dallas, Texas)	Noncaloric	Replacing oil in foods and for frying	Provide crispiness
Sorbestrin	Cultor food science, Inc., N.Y.	1.5 kcal/g	Intended to replace fat in salad dressings, baked goods, and frying.	Texturize, heat stability
Esterified propoxylated glycerols (EPG)	ARCO Chemical Co. and CPC International/ Best Foods	Low caloric	Replacing oils and fats in frozen desserts, salad dressings, spreads etc	Appearance, Provide, cohesiveness,

3.6 Fat mimetics

A) Protein-based fat mimetics

Some of the commonly used commercial protein-based fat mimetics are shown in Table 2.

Table 2: Protein-based fat mimetics [12]

Type of fat replacer	Energy density	Application	Functional properties
Simplesse	4kcal/g	Yogurt, cheese, sour cream	Stabilize, emulsify
Simplesse100	4kcal/g	Salad dressing, dips, mayonnaise	Texturize, provide Mouthfeel
LITA	1-4 kcal/g	Baked goods	Texturize

B) Carbohydrate-based fat mimetics

Various fat mimetics from carbohydrate sources prove to be effective fat replacers and their increased use is reported in food industries. Table 3, Table 4 and Table 5 gives an overview of such carbohydrate-based fat mimetics.

Table 3: Gums as fat replacers [12]

Type of fat replacer	Energy density	Application	Functional properties
Guar	Noncaloric	Baked goods	Retain moisture, retard staling
Xanthan	Noncaloric	Baked goods	Retain moisture, retard staling
Locust bean	Noncaloric	Baked goods	Retain moisture, retard staling
Carrageenan	Noncaloric	Salad dressings	Increase in viscosity, provide mouthfeel.
Gum arabic	Noncaloric	Salad dressings	Increase in viscosity, provide mouthfeel.
Pectins	Noncaloric	Sauces	Thicken, provide mouthfeel, texturize

Table 4: Cellulose as fat replacers [12]

Type of fat replacer	Energy density	Application	Functional properties
Microcrystalline Cellulose	Noncaloric	Salad dressings frozen desserts	Contributes body, consistency, Mouthfeel, stabilizes emulsions and foams.
Powdered cellulose	Noncaloric	Frying	Reducing the fat in fried batter coatings and fried cake donuts
Methylcellulose	Noncaloric	Baked goods, frozen desserts	Impart creaminess, lubricity, air entrapment and moisture retention
Hydroxypropyl methylcellulose	Noncaloric	Sauces, dressings	Impart pouring and spooning qualities

Table 5: Other carbohydrate-based fat replacers [12]

Type of fat replacer	Energy density	Application	Functional properties
Maltodextrin	4kcal/g	Table spreads, margarine, baked goods	Contributes body and mouthfeel, bind/control water, build viscosity
Polydextrose	1kcal/g	Frying	Reducing the fat in fried batter coatings and fried cake donuts

However certain issues came in front regarding the use of fat replacers. A fat replacer should be safe for use, should have similar organoleptic and functional properties as that of fat. Consumers are resistant to use them firstly because of a higher cost and secondly due to their traditional preference for fatty foods which in turn increases their calorie count. Fat replacers provide an aid to consumers desiring to replace fats in the diet and hence lower their calorie count but they should not be completely relied on for the purpose of weight management. A healthy lifestyle should be adopted. With fat replacers, consumers are not required to make major changes in dietary habits.

4. Salt replacement

The ingredient "salt" is sodium chloride with 39.34% sodium and 60.66% chloride on a molecular –weight basis. Sodium is found naturally in many foods but in processed foods usually, it is used in a greater amount. To reduce sodium in food products, the factor to which the utmost preference should be given by food technologists is the flavor and taste development due to salt. A good salt replacer is the one which replaces or reduces a considerable amount of salt without affecting its flavor.

4.1 Role of salt in the human body

Sodium is an essential mineral for the human body, in combination with potassium serves various functions in the human body. It helps in the establishment of fluid balance, transport of nutrients and other molecules into and out of the cells. Sodium helps to maintain acid-base balance in the body. Its significant role in muscle contraction is observed. It also performs the function of conducting the nerve impulse. Also, sodium is an essential mineral for good health. While designing any salt replacer, care should be exercised that the Replacer does not impair or affect these significant functions of salt in the human body

4.2 Role of salt in foods

Replacing salt is an extra challenging task before the food industry. The main reason is, sodium contributes so much to the flavor of a food product, especially processed foods. Majorly, flavor development of any food product is due to salt, Also a significant contribution is made by sodium in the reduction of water activity of foods and ultimately increasing the shelf life of a product. Studies have depicted that, sodium releases certain flavor compounds, selectively filters some off flavor forming compounds and masks off unpleasant taste like bitterness and metallic notes. Sodium is known to increase the volatility of certain chemical compounds. In addition, it makes

many flavors taste brighter. Salt also plays a vital role in determining texture, because it has a binding effect on proteins. Sodium enhances the mouthfeel of a food product. Hence sodium is an essential component of foods serving so many important functions and it becomes challenging to find a salt replacer with which these important functions of sodium are not affected.

4.3 Why reduce salt??

Reducing salt levels in processed food has been one of the goals of the food industry [74]. No doubt sodium chloride is an essential nutrient for good health, excess intake is associated with the development of cardiovascular diseases, hypertension, neurological diseases, osteoporosis, gastric cancer, kidney disease, asthma, and obesity [19, 33 and 76]. Therefore, the World Health Organizations (WHO) recommends reducing sodium in order to promote health. WHO has recommended 6g daily as a limit [74].Thus, a growing interest production of low sodium foods was observed.

4.4 Challenges for food industries for sodium reduction

Sodium chloride is mostly used mainly due to the reasons like its low cost, properties of flavor and texture development and other functional properties [34, 40].The main constraint which influences sodium acceptance is "palatability" [6]. Sodium reduction will likely decrease preference for foods. Several factors which are to be taken into account while designing or choosing a salt replacer are discussed further. Figure 3 represents the major challenges faced by food industries in sodium reduction.

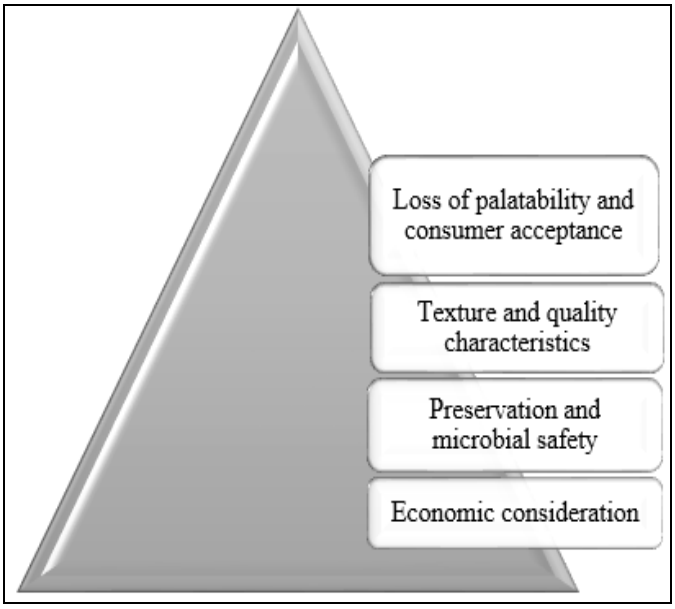

Fig 3: Challenges faced by food industries in sodium reduction

1. Loss of Palatability and Consumer Acceptance

Taste is one of the most important factors influencing food choice. Salty taste in limits is usually liked by people [11]. Therefore, with a decrease in sodium in large amounts there occurs a decline in consumer acceptance. Consumers do not show interest in accepting ill-flavored products. Small incremental decreases prove to be effective, as consumers may not be able to detect gradual reductions in sodium upto a point. Sodium needs to be replaced but with due regards to the fact that consumer acceptance does not show a decrease [18].

2. Texture and other quality characteristics

The salt reduction affects texture and other characteristics like, moisture levels, fat content, pH and processing conditions [18]. For example, sodium chloride is able to bind proteins and fats and hold water. Therefore, meat batters with low sodium need to have a sodium replacer, which not only replaces salty taste but also needs to compensate for the other functions, which are lost when sodium is decreased [77]. Sodium chloride also limits the growth of yeast and enables the gluten structure in bread to develop. Thus it is used as an aid in fermentation and baking processes.

3. Preservation and microbial safety

Sodium reduces water activity in foods and therefore inhibits the growth of micro-organisms [19]. Sodium reduction is a risk for growth of unwanted bacteria and ultimately shorten shelf life.

4. Economic considerations

Producing foods with low sodium content, as already stated, is a challenging task for food manufacturers not only due to the considerations like flavor and taste development but also an economic consideration. Sodium chloride is relatively cheap and any substitute used will increase the final cost of the product. Furthermore, in order to find suitable salt replacers, bitter blockers and or flavor enhancers, effort and money need to go into research, development and consumer testing. The food industry will need to take all functions of sodium in foods into account when opting for the sodium reduction in foods.

Saltiness is the most desired property in many foods, and sodium chloride influences flavor. Adequate dietary sodium intake is vital to health but excessive amounts of sodium are associated with hypertension and other diseases [39]. Changing the dietary sodium content of a population that is comfortable with a high sodium diet will not be easy, and will require to empower a number of strategies [40]. Barriers occurring in sodium replacement are the function of sodium in foods and decreased consumer liking. However, compulsory sodium reduction in certain food categories would be beneficial which will enable sodium reduction without compromising on food safety.

4.5 Challenges in sensory evaluation of reduced salt products

Sensory evaluation of salt reduced products is a major challenge for food industries. Different salt reduction strategies may work differently for different products. Eg: In meat and bread products, salt may prove to be of importance in maintaining the texture, quality, and color. But the intensity of salty taste is low [68].Taking into account the practical aspects of sensory evaluation, the use of trained panels or consumers should be carefully planned. Consumers' evaluation and preferences are evaluated to take an idea of market potential. Combination of trained panels and consumers in the sensory evaluation proves to be an effective step.

Different groups of consumers eg: gender, age, and smoking

may be considered for sensory evaluation. Different consumers have adopted different lifestyles, attitude, motives and variables which affect their taste preferences. Manufacturing a product considering all these aspects is a major challenge for food industries [55]. The results found that in most of the cases, the reformulated products were successful in maintaining consumers' acceptance.

4.6 Salt reduction in food services

Efforts are constantly exercised to reduce the salt content in the industrial food products but less is known about the reduction of salt in workplaces, canteens, restaurants, and fast food outlets. The sodium content of many food items and meals is reported to be high [7]. Trends do not seem to be improving because the salt consumption in 1997/1998 and 2009/2010 at leading fast food outlets has increased by 23% [62]. Customers usually underestimate the sodium content of meals. Experiments were conducted at the food services, results of which have proven that slight to moderate reduction in sodium levels is willingly accepted by consumers but an increased reduction has an adverse effect on consumers' acceptance [53]. Food industries could come up with this method of using sodium moderately which as a result will be beneficial in reducing the sodium content of food product without adversely affecting the consumers' acceptance of the product.

4.7 Salt replacement strategies

Salt reduction and replacement is a challenging task, as salt is significantly important in the flavor of any food product. Replacement or reduction of salt in many cases is reported to have adverse effects on consumer acceptance and quality of food product. Some of the possible alternatives for salt reduction are depicted in Figure 4.

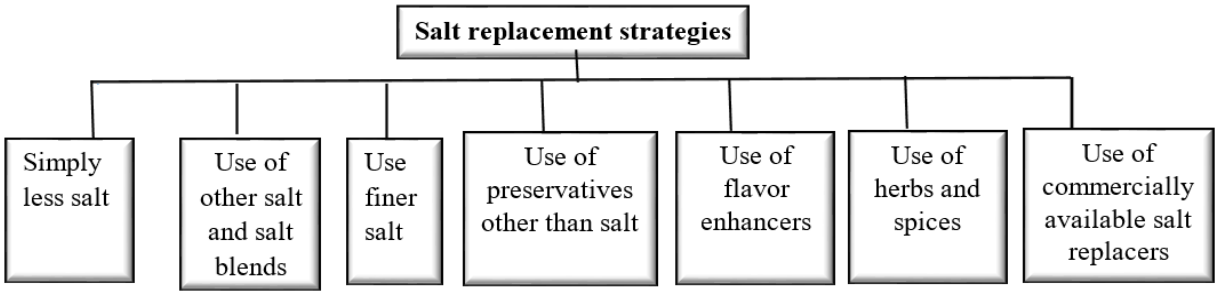

Fig 4: Salt replacement strategies

1. Simply less salt

The simple solution to reduce sodium lies in adding less sodium chloride. Sometimes salt concentration exceeds the amount required to meet its functions (preservation, texture or appearance). If this strategy is practiced gradually over several years, the consumer may not notice the difference. Care must be exercised to ensure that the consumer does not reach the stage of taste threshold. With this strategy, salt reduction is achieved to an appreciable extent. However, consumers' preference and their resistance may cause problems in the employment of this strategy of gradual salt reduction.

2. Other salts and salt blends

A range of products intended to accomplish salt reduction is present in the market. This broad range of products falls into two categories: blends that consist partly of sodium chloride and those that contain no NaCl at all.

a. **Potassium chloride (KCl; E508):** Sodium chloride is not the only type of salt on the market. There are various compounds which, when used in combination, perform nearly the same functions in food products as sodium chloride. One of the well-known salt is potassium chloride. The choice of combination depends on the functions it needs to perform. Potassium occurs naturally in the body and is associated in the regulation of heart function and also in the regulation of blood pressure etc. Intake should be within proper limits as fluctuations may adversely affect the health.
b. **Potassium sulfate (K2SO4; E515):** It is a white crystalline powder with a bitter, salty taste. It is freely soluble in water. Potassium sulfate is synthesized by reacting sulfuric acid with potassium hydroxide or other potassium salts.
c. **Magnesium sulfate (MgSO3and MgSO4; E518):** It is a natural salt consisting of sulfuric acid and magnesium salts. It is referred to as Epsom salt. It is also used as a firming agent in processed vegetables and fruits.
d. **Calcium carbonate (CaCO3; E170):** It occurs abundantly in nature in the form of the mineral, calcite. It is used as a filling agent in some chewing gums and used for the white "mold" on dry sausages.
e. **Ammonium chloride (NH4Cl; E510):** It is the ammonium salt of hydrogen chloride. It is a white crystalline powder used as an acidity regulator in baking products, etc.

Drawbacks of using these blends

The biggest disadvantage of these salts and salt blends (potassium chloride, for example) is their bitter aftertaste. Sensitivity to this bitter taste varies from person to person [20]. However, this bitter aftertaste can be masked off by using masking agents like L-lysine, an amino acid that neutralizes bitter taste and trehalose, which can be used as a sweetener as well as stabilizer and flavor enhancer. Sodium reduction may not prove much beneficial for texture

Health issues

Research has depicted that potassium needs to be in equilibrium with sodium in the body. It has an antihypertensive effect [26]. The average potassium intake is

3.6 grams per day. Potassium may contribute to good health but is a matter of concern for people with hyperkalemia (a medical condition in which kidney is unable to remove potassium) causing severe pain and kidney failure.

3. Use finer salt

After dissolving, sodium chloride gives a salty taste. Since finer salt crystals diffuse more rapidly in food [59]. Technological advancement has made it possible to obtain very small-sized crystals with a particular crystal shape and a large contact surface. For example, vacuum-granulated dentitric salt (macroporous crystals) and "cubic" salt dissolve twice as fast as conventional salt. Applications for these salts can include snacks, chips or certain meat products. Taste is imparted faster with finer salt [37].

4. Use of preservatives other than salt

Often it is observed that in some foods eg: pickles salt is added in more quantity than required to achieve the purpose of preservation. The use of preservatives can reduce the amount of salt in such foods.

5. Use of flavor enhancers

A taste enhancer is a substance which does not have significant taste as such, it does not modify the taste. It increases the intensity of how the smell and taste of a food are recognized. They play a major role in masking off the taste or flavor which is not desired [24].

a. **Glutamates:** Monosodium or mono potassium glutamate (MSG) is the most common and most widely used taste enhancer in the world. It raises the salty taste of a wide variety of food products. In 2003, a million and a half tonnes of MSG were produced, of which about 80 % was produced for the Asian market. Generally known as glutamate or MSG, it adds an umami profile [24].
b. **Yeast extracts:** Yeast extracts are rich in glutamic acid, peptides, nucleotides, glutathione, vitamins, minerals, and other flavorings. Yeast extract also functions as a flavor enhancer. It consists of glutamate and nucleotides, and commonly find its use in savory sauces, cheese, and soups. Yeast extract replaces NaCl up to 40 to 50 % [24].
c. **Hydrolysed vegetable protein (HVP):** HVP (Hydrolysed vegetable protein) is obtained by means of a chemical or enzymatic process. HVP, which contains glutamate, has a slightly meaty aftertaste. It also has a flavor-enhancing effect. The taste profile of HVP can vary depending on the level of discoloration, a protein source (soy, corn, wheat, and canola), added ingredients, and the production and drying process [56].
d. **Non-glutamates:** The second group of flavor enhancers are those that do not contain glutamate and are thus referred to collectively as non-glutamates. They are also addressed as high nucleotide enhancers because they possess a comparatively high concentration of nucleotides.

Guanylic acid (E626) is a white crystalline substance with effective properties than those of glutamic acid. Increased viscosity is provided. It is used in imported meat products, canned fish, sauces, canned vegetables, etc. Inosinic acid (E630) Crystalline substance with a pleasant, sour taste. Inosinic acid is used in soups, spiced minced meat and meat products.

6. Use of herbs and spices

Herbs and spices are often recommended to use in salt reduction. It was reported that the amount of salt added to soup was decreased when the perceived herb flavor increased. However, high levels of herbs decreased the overall liking of soups an herb and spice blend added gave a fruitful result [73].

7. Use of commercial salt replacers

Table 6 represents an overview of certain commercial salt replacers.

Table 6: Commercial salt replacers

Product	Company	Applications	Sodium reduction (%)
Alsosalt®	-	Table salt and as an industrial salt	30-40%
Pansalt®	Accord International	Table salt and as an industrial salt	40 and 45%.
Sub4salt®	Jungbunzlauer	Suitable for all applications	25 to 50%
SaltWise®	Cargill	Suitable for all applications	25 to 50%
SaltPrint®	Firmenich	Soups, sauces ready meals and potato crisps	N/A
Suprasel®	AkzoNobel	Bakery specifically bread	up to 50%

4.8 Low salt claim

The products with salt-reduction claims must satisfy certain conditions. The claim "low sodium/salt content" is only permitted if the product contains no more than 0.12 gram of sodium per 100 grams. Products with a "very low sodium/salt content" must not contain more than 0.04 gram of sodium per 100 grams. For the record, a product may only bear a "sodium free/no salt" label if it contains no more than 0.005 gram of sodium per 100 grams. Comparative claims, such as "lower than a comparable product", are possible, but the difference in salt content must then be at least 25%.

5. Sugar replacement

Research on taste proves that sweetness a widely preferred attribute. Sugars are forms of monosaccharide. All sugars are carbohydrates and contain four calories per gram. Sugars are widely spread in nature and are the basic unit of carbohydrate composition. Sugar is naturally found in many foods, including milk, grains, fruit, and vegetables. Sugars are an excellent fuel source for the body. Also, it is noted that certain body tissues like the brain and red blood cells utilize sugar for energy [4]. Sugar is also added to many foods, such as bread, flavored yogurt, sweetened beverages, sauces, spreads, cakes, pastries etc.

5.1 Need for sugar replacement

Sugary foods no doubt satisfy the calorie requirement but contain very few other nutrients. The World Health Organization recommends that sugar consumption should not be more than 10% of daily calories. Higher intake of sugars is the key factor linked to occurrences of medical conditions such as obesity, diabetes, and heart disease. Therefore, it is important to set a limit on their consumption [75].

5.2 Sugar substitutes/sweeteners

Sugar substitutes may be referred to as food additives that are sweet yet containing fewer calories than sugar. They may be derived from natural or synthetic sources [2].

5.3 Classification of sweeteners

Figure 5 shows the classification of sweeteners

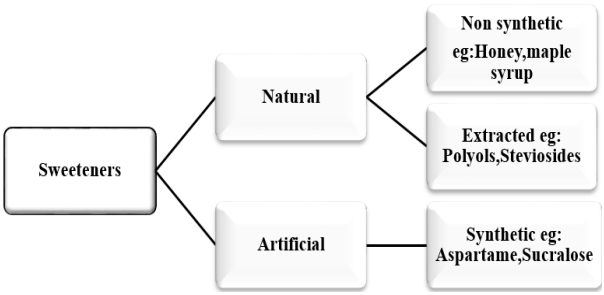

Fig 5: Classification of sweeteners

5.4 Classification based on nutritive value

a. Nutritive sweeteners

Nutritive sweeteners are also called carbohydrate sweeteners (caloric). They are known to impart a sweet taste and has an acceptable texture and shape. They are the most popular sweetener [23].

b. Non-nutritive sweeteners

Nonnutritive sweeteners provide sweetness without adding a calorie. The non-caloric sweeteners are sweeter than sucrose and therefore, should be used in small amounts [30].

5.5 Natural sugar substitutes

A Non-synthetic

1. Molasses

Molasses is a byproduct of table sugar production. It is a heavy dark liquid portion remaining after sugar is extracted from beet or sugar cane. Molasses may vary in grade. Molasses obtained after the first extraction is sweeter and lighter in color because more sugar remains in the solution. Blackstrap molasses is obtained during the third extraction of cane sugar. It is comprised of 55% sucrose. It is less sweet and preferred to use as animal feed.

2. Honey

Honeybees produce honey from nectar and is primarily composed of sucrose. It has antimicrobial properties and is a good source of antioxidants. Processing can also greatly affect the quality of honey. Some manufacturers produce artificial honey, made from beet or cane sugar.

3. Maple Syrup

Maple syrup is made by cooking the sap obtained from maple trees. The sap of a maple tree contains 5% sucrose, and rest of other sugars known as oligosaccharides, it is made of 88-99% sucrose after condensing in syrup form. Maple syrup is rich in various vitamins and minerals, including calcium, potassium, and trace amounts of B vitamins, manganese, magnesium, and zinc.

4. Corn Syrup

Corn syrup is a glucose derivative of cornstarch, used mostly in the brewing and baking industries. High-fructose corn syrup (HFCS) is manufactured by converting some of the glucose to fructose. HFCS is sweeter than sucrose and hence can be used in smaller amounts. HFCS is the chief nutritive sweetener in the soft drink industry and constitutes 55% of the sugar consumed in the US.

B. Extracted

Polyols

Polyols are also known as “sugar alcohols” in general or sugar replacers. They are carbohydrates providing a sweet sensation but are neither sugars nor alcohols. Figure 6 represents the classification of polyols.

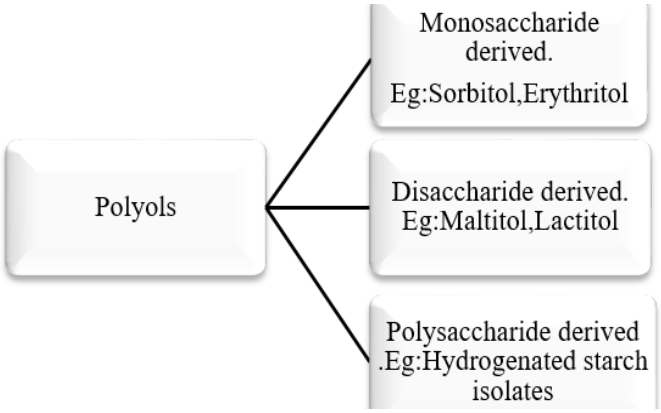

Fig 6: Classification of polyols

The U.S. F.D.A allows the use of the following caloric values for polyol sugar replacers: Table 7 shows a comparison of different polyols

Table 7: Comparison of different polyols [27]

Polyol (cal/g)	(cal/g)
Hydrogenated starch hydrolysates	3.0
Sorbitol	2.6
Xylitol	2.4
Maltitol	2.1
Isomalt	2.0
Lactitol	2.0

5.6 Artificial sweeteners

1. Aspartame

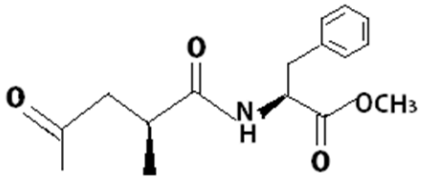

Fig 7: General structure of Aspartame

Aspartame is mainly composed of two naturally occurring amino acids, phenylalanine and aspartate [49]. Aspartame shows a resemblance in flavor to sucrose, and it also functions as a taste enhancer. Aspartame is 200 times sweeter than sucrose. Aspartame is used to sweeten a variety of foods and beverages, used as a tabletop sweetener, in gums, breakfast cereal, and other dry products. Aspartame provides energy of 4 calories per gram. Instability is observed on continued heating and therefore it cannot be used in baking or cooking. It also decomposes in liquids during storage. After ingestion, aspartame breaks down into aspartic acid, phenylalanine, and methanol [27]. Each of them is metabolized as an individual ingredient.

After nearly two decades of safety testing, aspartame was approved by the FDA in 1981 for use in a variety of products, as a table-top sweetener and in carbonated beverages. It is mandatory that products containing aspartame must carry a warning to people with phenylketonuria, a rare genetic disorder that prevents proper metabolism of phenylalanine, an essential amino acid [47]. Figure 7 represents the chemical structure of Aspartame.

2. Acesulfame-K

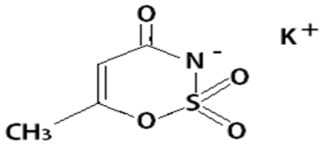

Fig 8: General structure of Acesulfame K

Acesulfame-K was developed as a sweetener by Hoechst [13]. Acesulfame-K is similar to aspartame in sweetening power but holds up better to heat and costs less. It is stable when heated and can be used in baking. [51]. It is approximately 120 times sweeter than sucrose and is highly water soluble [63]. It was approved by the Food and Drug Administration (FDA) in 1988 for limited use in products such as chewing gums and dry beverage mixes. It is usually used in combination with other sweeteners because they mask off its bitter aftertaste. The chemical structure of Acesulfame K is shown in Figure 8.

3. Sucralose

Sucralose is the only alternative sweetener made from sugar. It is 600 times sweetener than sucrose (1.6 calories per teaspoon). Sucralose is derived from sugar through a patented, multi-step process. Sucralose does not contribute to calories. Sucralose finds its use as a tabletop sweetener and in a variety of products including desserts, confections etc. Sucralose does not extend its contribution to tooth decay [5]. The chemical structure of sucralose is shown in figure 9.

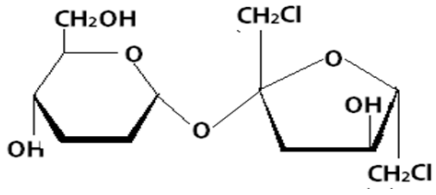

Fig 9: General structure of Sucralose

4. Neotame

Neotame is 7,000 to 13,000 times sweeter than sugar. It was approved for use as a general-purpose sweetener by the FDA in 2002. Neotame contains phenylalanine. However, the product is used in such small amounts that it is negligible in the body and hence does not affect the body adversely. Figure 10 represents the structure of Neotame.

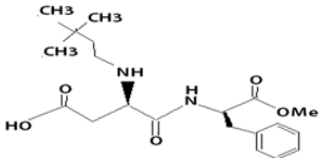

Fig 10: General structure of Neotame

5. Saccharin

Developed in 1878, saccharin is a coal tar derivative that is approximately 200-700 times sweeter than sucrose. Saccharin is used in a variety of foods such as beverages, jams, and baked goods. Saccharin has an unpleasant bitter or metallic off taste. In some individuals, saccharin can cause allergic reactions, resulting in symptoms such as headaches, skin problems, diarrhea, and breathing difficulties [58]. Figure 11 shows the chemical structure of Saccharin.

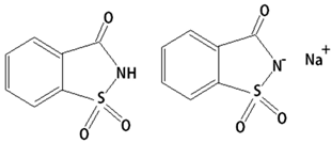

Fig 11: General structure of Saccharin

Stevia

Stevia is sweet, a calorie-free naturally occurring compound occurring in the leaves of a small shrub, Stevia rebaudiana Bertoni, also known as Yerbaa Dulce, which grows wild in Paraguay. It is 300 times sweeter than sucrose. Stevia is heat stable. Stevia is safe for diabetic patients [48].On consumption in high quantities, stevia exhibits metallic taste and is shelf-stable when dry. It is approved for use in various food products, including cereals, beverages, and energy bars, as well as a tabletop sweetener. The chemical structure of Stevia is shown in figure 12. Consumers lack information about NNS. Though the sweeteners are approved by FDA still consumers are resistant to using these sweeteners. Consumers should employ a cautious attitude while using artificial sweeteners. Weight management depends on total calorie reduction rather than avoidance of caloric sweeteners. For optimal health minimum amount of sugar and NNS should be consumed and emphasis should be placed on eating a fresh and balanced diet. Table 8 gives an overview of some of the commonly used artificial sweeteners

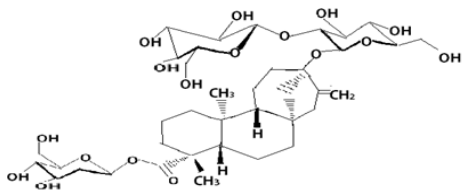

Fig 12: General structure of Steviol glycoside (the basic unit of stevia)

Table 8: Highlights of artificial sweeteners

Artificial sweeteners	Brand name	Highlights
Acesulfame-K	Sunnet	Noncaloric. ADI=15 mg/kg of body weight 200 times sweeter than sugar Suitable for baking, tabletop sweetener Toxic potential: Headache
Aspartame	NutraSweet, Equal	Provides 4 cal /g. ADI= 50 mg /kg of body weight 200 times sweeter than sugar Suitable for carbonated beverages, tabletop sweetener Toxic potential: Persons with phenylketonuria (PKU)
Saccharin	Sweet n low	Noncaloric. ADI= 5mg/kg of body weight 500 -700 times sweeter than sugar Suitable for baking and cooking Toxic potential: nausea, vomiting, diarrhea
Sucralose	Splenda	Noncaloric. ADI=5mg/kg 300-500 times sweeter than sugar Suitable for baking and cooking Toxic potential: Diarrhoea
Neotame	–	Noncaloric. ADI=0-3 mg/kg 8ooo-13000 times sweeter than sugar rarely used in foods Toxic potential: Headache, Hepatotoxic at high dosage
Stevia	Truvia	Noncaloric. ADI=12mg/kg 300 times sweeter than sugar Suitable for baking Toxic potential: Male fertility issues

6. Conclusion

Salt, sugar, and fat are the eternal ingredients of a majority of food preparations and products. Replacing these ingredients has become a necessity today as they assist the development of CVD, obesity, Diabetes etc. Technologies for producing low salt, fat and sugar products that taste similar to their counterparts have multiplied but developing replacers that taste exactly like the ingredients they are intended to replace remained elusive and the consumption of salt sugar and fat remained increasing. No single technology or analog is ideal for reduction these ingredients but efforts should be made to reduce them in diet, make the use of available replacers and adoption of a healthy lifestyle to minimize the occurrences of diseases due to these crucial ingredients.

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