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The science of mayonnaise: An in-depth review of ingredients, stability, and emerging trends

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Abstract
Mayonnaise is a widely used emulsified condiment with diverse applications in sandwiches, salads, dips, and even cosmetics. First developed in 1756 and originally named "mahonnaise" after Port Mahon, it is a classic example of an oil-in-water emulsion comprising oil, vinegar, egg yolk, and various seasonings. The egg yolk serves as a natural emulsifier due to its lecithin content. Despite its high nutritional value attributed to its oil and protein content, mayonnaise is often scrutinized for its cholesterol and fat levels. Consequently, there has been a growing interest in formulating healthier alternatives by replacing traditional ingredients such as eggs and fats with plant-based substitutes. According to the Food Safety and Standards Authority of India (FSSAI), mayonnaise falls under the category of emulsified sauces. Industrial-scale production involves equipment like colloid mills to ensure consistent emulsion stability and texture. Proper packaging and storage are essential to prevent microbial spoilage, as mayonnaise's high moisture and nutrient content can support the growth of pathogens including *Escherichia coli*, *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Staphylococcus aureus*, and *Listeria monocytogenes*. Emulsion instability, often caused by incorrect oil-to-water ratios or inadequate emulsifying agents, remains a significant challenge. This review highlights the formulation, processing, stability, and safety concerns of mayonnaise, along with current trends in its innovation and plant-based development.

Keywords: Mayonnaise, emulsion, role of ingredients in mayonnaise, recent trends in mayonnaise, spoilage of mayonnaise.

Introduction

Mayonnaise is a versatile compounds in sandwiches, salads and dips. According to Code of Federal Regulatios (2024), it is an emulsified semisolid food prepared from vegetable oil, acidifying ingredients, and egg yolk. Its global market has been growing steadily due to the rising demand for convenient foods and its wide range of uses.

Mayonnaise was invented in 1756 by Duke de Richelieu, a French military leader. He captured the

Port Mahon, located on the island Menorca, Spain. During the victory celebration, his chef meet some culinary challenges and he made a creamy sauce with egg yolk, vinegar and oil. It is named as mahonnaise, in honour to its birth place Port Mahon and later it evolve as mayonnaise. In 1907 Ricahrd Hellmann, a German immigrant invented the Hellmann's mayonnaise brand in New York City and it is the most popular brand of mayonnaise in the world (Sarkar *et al.*, 2022) [16].

Mayonnaise is a solid oil-in-water mixture made with oil, vinegar, egg yolk, and spices. It contains high oil content and protein, making it a nutritious choice. It is commonly used as an emulsifying agent due to its capacity for emulsification. Increased public awareness of diet and health has led to a demand for healthier food options. Mayonnaise is often associated with health concerns due to its cholesterol and fat content. Researchers have tried to replace fat and eggs with alternatives, but stability is a challenge. The ingredients in mayonnaise play specific roles in texture, flavor, and oxidative stability. Like other fatty foods, mayonnaise is prone to oxidation. Using fat replacers can enhance the health benefits of mayonnaise, creating a more nutritious sauce (Mirzanajafi-Zanjani *et al.*, 2019) [11]. According to Cognitive Market Research, the global mayonnaise market will grow at a compound annual growth rate (CAGR) of 4.5% from 2023 to 2031. In India, the mayonnaise market is rising, driven by increasing interest in international cuisines, higher incomes, and a preference for easy-to-use products. This growth is expected to continue, with a compound annual growth rate of 28.2% from 2024 to 2028.

Science of mayonnaise

FSSAI mentioned mayonnaise as under the category of emulsified sauce. Compared to other sauces, this unique texture made mayonnaise different. Emulsion is the science behind the texture of mayonnaise. It is a mixture of two or more liquids that are usually immiscible, where one liquid is dispersed in the other. Mayonnaise is an example of oil-in-water emulsion, where water is the major component which is in continuous phase and oil is the minor component in dispersed phase. Emulsion is enabled by some emulsifiers present in mayonnaise. The emulsifier in traditional egg-based mayonnaise is lecithin, a phospholipid present in egg yolk. It is an amphiphilic compound. Its one end is hydrophilic or has an affinity towards water and another end is hydrophobic or has an affinity towards fat or lipid (lipophilic). By continuously mixing this oil and water will bind towards these regions.

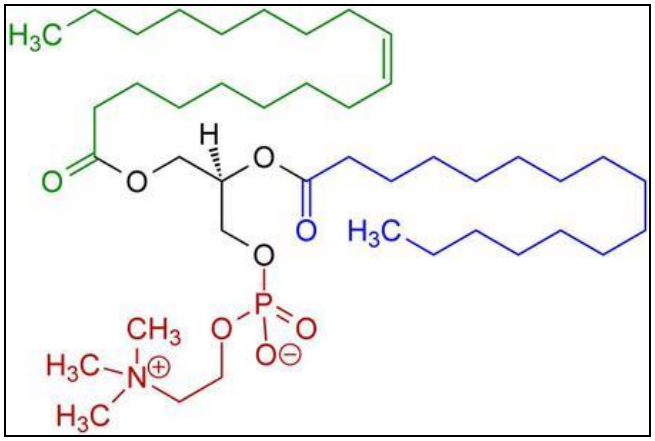

Fig 1: Chemical structure of lecithin

The constituents of mayonnaise are oil, water, egg yolk, salt, sugar, sweetener, and optional additives. The quality characteristics of an emulsion are determined by the level and quality of each of these elements. The microstructure or ingredient interaction of emulsion-based food items determines their perceived quality. The high fat content of mayonnaise helps it stay free from microbes. Unsaturated fatty acids undergo oxidation in a spontaneous manner.

1. Egg yolk

Egg yolks in mayonnaise are primarily used as an emulsifying agent. One of nature's ideal emulsifiers, egg yolk, is the foundation of the mayonnaise emulsion. The type and quantity of egg yolk is one of the variables affecting the emulsion's stability and stiffness. About 65 per cent of the total solids are made up of the lipids found in egg yolks. Based on total solids, the lipid content of an egg yolk is 40.3 per cent glycerides, 21.3 per cent phospholipids, and 3.6 per cent cholesterol. Lipid components of egg yolk have a profound effect on flavor, color, and stability of mayonnaise and other dressings (Hill *et al.*, 2020) [7].

2. Acid

Acidity, which is determined by calculating the amount of acetic acid in vinegar, lemon, or lime juice, must not be less than 2.5 per cent of the product's weight. The package label needs to say "citric acid added" when an optional acidifying additive like citric acid is used. The FDA approved malic acid as an acidifying agent on January 1, 1978. Acetic acid acts as a preservative by protecting food against microbiological degradation, which includes certain types of yeast. Acetic acid can also be used as a flavoring ingredient if used properly. However, an excessive amount of acid will make the flavor less appealing. The additional water and the water in vinegar combine to produce the continuous phase of the emulsion. Acetic acid usually makes up approximately 3.5 per cent of the volatile chemicals in vinegar. The stability of the mayonnaise may be affected by high concentrations of trace metals in vinegar. Thus, vinegar quality is important. Material preserved in acidic environments can be kept at normal room temperature, but deterioration in quality will occur (Hill *et al.*, 2020) [7].

3. Oil

Mayonnaise can have a minimum of 65 per cent oil in it. In fact, however, 75-82 per cent of mayonnaise made in the US is made with oil typically non hydrogenated soybean oil. Mayonnaise can be made using other salad oils, such as partially hydrogenated winterized or non-winterized soybean oil, safflower oil, corn oil, and winterized cottonseed oil. Because they tend to break the emulsion at refrigerator temperatures, oils containing high quantities of saturated acids like palm oil or oils that solidify at those temperatures like peanut and olive oils are rarely utilized. When a stiffer body is required, mayonnaise is made with oil levels 1-2 per cent greater than usual. Over 85 per cent oil content makes the emulsion more likely to be unstable (Hill *et al.*, 2020) [7]. The rheological properties and sensory qualities of the finished mayonnaise are favorably influenced by oil, one of the main ingredients. Furthermore, it enhances the taste, consistency, creaminess, acceptability, look, and longevity of mayonnaise (Mirzanajafi-Zanjani *et al.*, 2019) [11].

4. Salt

Salt plays a crucial role in the production of mayonnaise, improving stability and quality in three different ways. Primarily, it neutralizes the charges on proteins, allowing lipovitellin to attract water in order to improve the outer layer of the oil droplets, leading to the expansion of the egg yolk granules. Also, salt helps evenly spread the egg yolk, forming particles and expanding their surface area. Ultimately, dropping the charges allows nearby oil droplets to have a more intense interaction. The presence of Na+ in salt enhances the stability, viscosity, and firmness of NaCl salted egg yolk. Polyvalent ions enhance the viscosity of emulsions, unlike monovalent ions such as K+, I-, and Cl- which typically disturb water interactions (Dadkhah *et al.*, 2020).

5. Sugar

The interactions in an emulsion may be weakened as a result of sugar shielding the reactive groups. Thus, the charged sugars, such as carboxymethyl from being in touch with cellulose, the egg white proteins and creating effective cross-links sandwiched between oil globules. Powerful protein-sugar interactions change how the system's structural emulsion through a reduction in droplet size, and thereby it enhances the stability of the emulsion (Dadkhah *et al.*, 2020).

6. Spices

Spices like garlic, mustard, mint and pepper are commonly used to enhance the taste and flavor of mayonnaise. Typically, mustard is used as a flour in mayonnaise. Mustard comes in two varieties: brown and white. Although it tastes spicy, white mustard has almost little smell. The brown variant, however, smells strongly of something. To attain the appropriate degree of flavor and pungency, the two types are therefore combined in different ratios. The aromatic mustard oil, allyl isothiocyanate, is released when a glucoside found in mustard is hydrolyzed. This ingredient gives mayonnaise its bite. Mustard's nature, origin, and adding technique all affect the emulsion in addition to its taste contribution. When combined with egg yolk, mustard functions as a powerful emulsifier (Dadkhah *et al.*, 2020).

Recent trends in mayonnaise

A trend toward growth has been observed in recent times, with the substitution of eggs with plant-derived ingredients, especially in the development of substitutes for mayonnaise.

Likewise, there is a tendency to substitute vegetable oils because of the need for healthier food options. Several methods have been explored to diminish or reduce higher calorie ingredients with lower calorie options in mayo. Moreover, there is an increasing fascination with utilizing ingredients with lower levels of chemical remnants from the processing phase in oils and reduced microbial consequences. Fatty acid glycidyl esters, for example, are one of the primary impurities found in the process of refining almost all cooking oils.

1. Organic mayonnaise

Made from ingredients that are farmed without the use of artificial pesticides, fertilizers, or genetically modified organisms (GMOs), organic mayonnaise is a healthier option than traditional mayonnaise. Typical components of organic mayonnaise consist of:

Organic Egg Yolks: Derived from hens kept on pasture or in a free-range environment, guaranteeing animal welfare and devoid of antibiotic or hormone usage.

Organic Oil: Free of chemicals and additives, organic olive, sunflower, or avocado oils are frequently used in recipes.

Lemon juice or organic vinegar: Used to add taste and acidity. Occasionally used to enhance flavor and aid in emulsifying the ingredients is organic mustard.

Salt and organic spices: To increase flavor and add seasoning. Generally, artificial flavorings and preservatives are absent from organic mayonnaise.

2. Light / low fat mayonnaise

Mayonnaise that has reduced fat and calorie levels are defined as light or low fat mayonnaise. The American Heart Association recommends limiting fat usage to less than 30 per cent of total calories. Fat replacers play a crucial role in producing low-fat foodstuffs without compromising taste. Three categories exist for fat replacers: protein, carbohydrate, and fat-based replacers. While carbohydrate and protein based replacers are generally referred to as fat mimetics, fat-based replacers are known as fat substitutes because they can mimic the mouthfeel and texture of fats while also providing a significant amount of dietary polysaccharides and proteins. Fat substitutes can also increase the texture of mayonnaise, with hydrocolloids playing a significant role in enhancing density and stability. There are many options available for replacing the fat in mayonnaise with ingredients such as konjac gel, salted duck egg white gel, 4aGTase-modified rice starch, oat dextrin, modified starch, inulin, pectin, and several thickeners.

3. Flavoured mayonnaise

To improve its taste and adaptability, mayonnaise can be made more flavorful by adding other flavors to it. This is known as flavored mayonnaise. Herbs, spices, fruits, vegetables, and even other condiments can all contribute to these flavors. Typical instances of flavored mayonnaise are as follows:

Truffle mayonnaise is a delicious condiment that enhances gourmet food with its earthy, rich flavor. Subterranean ascomycete fungus produces these truffles as its fruiting body.

Chipotle mayonnaise are smoky, spicy taste compliments sandwiches and grilled meats perfectly. Mexican ripe jalapeño chili, smoke-dried and used as a condiment, is called chipotle.

Sriracha mayonnaise is a creamy sauce made with Sriracha chili. Thailand is the source of Sriracha, which is known for its hot, acidic flavor.

Garlic mayonnaise is a popular choice for adding a delicious, pungent taste to sandwiches, burgers, and dips.

4. Functional mayonnaise

Functional mayonnaise is a form of mayonnaise that has been fortified with additional ingredients to give specific health benefits beyond its typical use as a condiment. These extra ingredients may consist of Omega-3 fatty acids, probiotics, prebiotics, antioxidants etc.

Omega-3 fatty acids: This variety of mayonnaise is enhanced with these fatty acids, which are well-known for their heart-healthy properties.

Probiotics: This mayonnaise can aid in promoting digestive health because it contains live, active probiotic cultures.

Prebiotics: A kind of mayonnaise enhanced with prebiotic fibres. Prebiotics are indigestible carbohydrates that feed good microorganisms in the digestive system.

Antioxidants: Mayonnaise that has been enhanced with antioxidants. Antioxidants are compounds that assist in shielding your cells from the oxidative damage that free radicals produce, which can lead to chronic illnesses including cancer, heart disease, and early aging. BHA, BHT, and TBHQ are synthetic antioxidants that are used to prevent fats from going rancid. Many marine algae and plants are the source of natural antioxidants, and many of them have a great deal of potential for improving food's resistance to oxidation. These antioxidant compounds also offer a host of other benefits that promote health.

5. Vegan mayonnaise

Vegan mayonnaise is a thick, creamy, eggless sauce made by combining oil, a plant-based ingredient, and an acid like lemon juice or vinegar. Major plant based ingredients used for vegan mayonnaise are; plant milk, pulses, mucilage, and starch.

Commonly used plant milk is soymilk, almond milk, and peanut milk. Because soymilk, almond milk, and peanut milk are derived from plants, using them to make vegan mayonnaise has a number of health benefits. Compared to traditional dairy-based mayonnaise, soymilk is rich in protein and essential amino acids, almond milk offers heart-healthy fats, vitamin E, and antioxidants, and peanut milk is a good source of plant-based protein and heart-healthy fats. All of these nutrients help to lower cholesterol and improve heart health.

There are various health advantages to using chickpeas as a plant-based replacement in vegan mayonnaise. Rich in fibre, protein, and important vitamins, chickpeas support heart health, facilitate digestion, and offer a plant-based dietary supply of nutrients without the cholesterol of traditional mayonnaise made from eggs.

Vegan mayonnaise made with chia and isfarzeh seed mucilage, sometimes referred to as psyllium, has several health advantages. Its two mucilages provide plant-based texture and emulsification, lowering the need for artificial stabilizers, and provide heart-healthy omega-3 fatty acids from chia seeds. Soluble fibre can help with digestion and support gut health.

Plant-based alternatives to mayonnaise, such as arrowroot, rice, and potato starches, provide various health advantages. While rice starch is hypoallergenic and imparts a smooth

texture without triggering common allergies like gluten, arrowroot starch is easily digested and may help relieve digestive problems. Potato starch, being high in resistant starch, has the potential to improve gut health through its ability to nourish good bacteria, aid in digestion, and enhance insulin sensitivity. Since all three starches are superior natural thickeners, they're perfect as a low-allergen, healthier substitute for conventional mayonnaise. Moreover, vegan mayonnaise has low calories, low total and saturated fat, high unsaturated fat and cholesterol free compared to egg based mayonnaise (Cerro *et al.*, 2021) [2].

Substitutes for ingredients

The structural formations of commercial mayonnaise differ greatly. However, there appears to be a consistent pattern in its elements, including vegetable oil, an acidifying agent, and eggs (particularly yolks). Traditional mayo recipes call for blending 180–240 mL of oil with each egg yolk, along with careful attention to the proportion and speed of adding the oil to the yolks to achieve the desired thickness and stability. The fat per centage in mayonnaise ranges from 65 per cent to 80 per cent with common oils used being soybean, rapeseed, sunflower, and corn. These oils, along with the eggs, are the key components responsible for their physical-chemical appearance and their sensory qualities. Furthermore, there is a rising curiosity regarding the adoption of ingredients with reduced residues of compounds from oil refining and reduced microbiological implications.

Glycidyl fatty acid esters are the primary impurity present during the refining of edible oils, forming in nearly all refined edible oils. Hence, there is a growing need for creative recipes that use healthier ingredients to substitute for oil or eggs, even if only partially. Some polysaccharide-based ingredients, like freeze-dried yam mucilage, bananas, and gums such as xanthan and guar gum, minimally change the qualities of traditional mayonnaise while replicating its sensory and physical-chemical attributes. These ingredients have thickening, stabilizing, and gelatinizing qualities, along with vegetable proteins that are widely used in the food industry for their health benefits.

Oil will be substitued with rapeseed oil and chia seed oil. Rapeseed (canola) oil and chia seed oil offer better health benefits than various common vegetable oils. Rapeseed oil has low levels of saturated fat, is high in monounsaturated fats beneficial to the heart, and provides a good balance of omega-3 and omega-6 fatty acids, making it beneficial for heart health. Additionally, its high smoke point and neutral flavor contribute to its versatility in cooking. Chia seed oil is rich in omega-3 fatty acids, specifically alpha-linolenic acid (ALA), promoting heart and brain health, and is abundant in antioxidants that offer anti-inflammatory benefits. Conversely, oils like sunflower and corn oil tend to be higher in omega-6s, which may cause inflammation if consumed excessively compared to omega-3s (Romero-Guzman *et al.*, 2020 [15]; Metri-Ojeda *et al.*, 2020) [13].

Utilizing frozen and fermented egg yolk in mayonnaise provides various advantages in comparison to using fresh egg yolk. Mayonnaise that uses fermented egg yolk has improved shelf life, taste, consistency, and appearance. It exhibits a more consistent look after being stored for 30 days. Freezing egg yolks can prolong their shelf life, halt microbial growth, and hinder chemical reactions. Nonetheless, freezing may result in gelation, leading to a negative effect on the yolk's emulsifying capability and other functional characteristics. In order to avoid gelation, you can include 10% salt or sugar, or hydrolyzed egg yolk protein (Huang *et al.*, 2015; Jia *et al.*, 2023) [9].

Malic acid, known for its tart flavor, can enhance flavors, reducing the amount of flavoring required. It has the ability to combine flavors in order to enhance the overall taste. Mayonnaise and salad dressings' shelf life can be prolonged by it. It functions alongside antioxidants to stop fats and oils from becoming rancid. Acetic acid functions as an acidifying agent that can manage yeast and bacterial infections. It can assist in eliminating salmonella bacteria found in mayonnaise. Citric acid, a mild organic acid, can impart a sour taste and function as a preservative (Moustafa, 1995 [12]; CFR, 2024).

Arabic gum, guar gum, and xanthan gum are often added to mayonnaise to improve its consistency, durability, and longevity. Arabic gum functions as an emulsifying agent, ensuring the creamy texture of mayonnaise by stopping the oil and water from separating. Guar gum acts as a thickener, enhancing thickness and producing a smooth consistency. Xanthan gum acts as a strong thickener and stabilizer, promoting great stability over time by avoiding ingredient separation, even in different storage environments. By working in unison, these gums increase the durability of mayonnaise by enhancing its ability to withstand changes in temperature and prevent the growth of microbes, maintaining its freshness and stability for an extended period of time (Ali and Said, 2020; CFR, 2024).

Incorporating arrowroot starch, potato starch, and rice starch into mayonnaise offers unique advantages, especially in terms of texture and stability. Arrowroot starch provides a smooth, silky texture and is easily digested and hypoallergenic, making it perfect for individuals with sensitivities. It also assists in keeping the mayonnaise looking shiny. Potato starch provides great thickening abilities and improves creaminess without changing the taste, resulting in a mayonnaise with a luxurious, velvety texture. Its high ability to bind water leads to improved retention of moisture and stability of emulsions. Rice starch is light in weight and produces a smooth, velvety feel, while also serving as a natural thickener and stabilizer, enhancing the longevity of the mayonnaise without imparting an overwhelming flavor. These starches work together to produce a balanced, creamy, and stable product (Park *et al.*, 2020 [14]; Ghazaei *et al.*, 2015 [6]; Lee *et al.*, 2013) [10].

Potassium sorbate is frequently utilized in mayonnaise to prolong its shelf life by preventing the growth of mold, yeast, and some bacteria. This ensures the product remains fresh and safe for consumption for an extended duration, particularly in commercial environments. In contrast to certain preservatives, potassium sorbate doesn't change the flavor, texture, or color of mayonnaise and has a neutral taste. It is deemed safe to eat in controlled quantities and is commonly employed in the food sector because of its efficiency and durability in acidic conditions such as in mayonnaise (Wind and Restaino, 1995) [19].

Calcium disodium EDTA preserves the flavor, texture, and color of foods like mayonnaise. It inhibits rancidity by preventing the odor and taste of decomposed fats. EDTA extends shelf life by preventing oxidation and chemical reactions that cause discoloration. It also chelates metal ions, increasing iron bioavailability and controlling negative effects in the intestine (Hill *et al.*, 2020) [7].

Preparation of mayonnaise

Mayonnaise is a creamy, rich and adaptable, mayonnaise is a creamy emulsion mostly composed of egg yolks, oil, and an acidic component like lemon juice or vinegar. It is a typical practice in several culinary arts to whisk the ingredients carefully in order to mix them and create a consistent texture.

Making homemade mayonnaise is an easy cooking activity that results in a creamy, fresh condiment that is tailored to individual preferences. The only ingredients required to produce mayonnaise are egg yolks, oil, and a small amount of acid, like vinegar or lemon juice.

Industrial manufacturing mayonnaise requires stainless steel equipment to prevent corrosion from vinegar. An intensive mixer, like a Hobart mixer with a paddle, is essential for dispersing oil into small droplets, commonly used in high-end restaurants. Industrial production uses colloid mills and other mixers for continuous flow. The Dixie-Charlotte system, with capacities between 15 and 200 gallons per batch, produces 60-1200 gallons per hour. Two Dixie mixers and a Charlotte colloid mill are linked for continuous operation. One mixer supplies formulation to the mill while the other mixes a new batch. The Dixie mixer has turbine mixers on a shaft in a container. The finished mayonnaise is smooth and textured, achieved by passing it through the Charlotte colloid mill (Duncan, 2004) [5]. Homogenizers are used in mayonnaise preparation to break down and uniformly distribute oil droplets, creating a stable emulsion. This ensures a smooth texture and prevents the separation of the oil from the water-based ingredients.

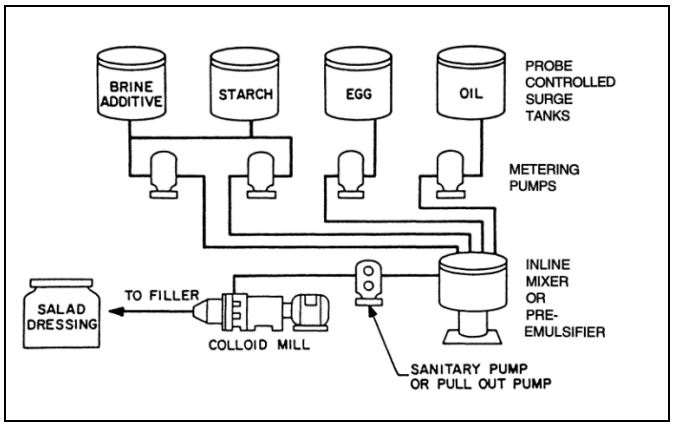

Fig 2: Industrial preparation of mayonnaise

Proper packaging is crucial for maintaining the freshness and quality of mayonnaise after it has been made. Popular ways of packaging mayonnaise include standup pouches for easy carrying, glass jars for preserving taste and reusability, sachets for individual servings, and HDPE bottles for simple pouring and recycling, enabling consumers to enjoy mayonnaise in different situations and reducing waste.

Application of mayonnaise

Mayonnaise is a flexible component in cooking, acting as a smooth foundation for a variety of meals. Mayonnaise, typically consisting of egg yolks, vinegar or lemon juice, and oil, is a versatile condiment that enhances the flavor of sandwiches, burgers, and salads. In addition to being used as a dressing, mayonnaise can also serve as a foundation for sauces such as aioli and tartar sauce, and can be added to dips, spreads, and even baked goods. Its ability to emulsify effectively makes it perfect for creating stable textures in coleslaws, potato salads, and creamy dressings. Moreover, mayonnaise is often utilized as a marinade to boost the moisture of grilled meats and seafood, establishing itself as a common ingredient in kitchens across the globe.

Mayonnaise is becoming popular in the beauty industry for its nourishing properties, being seen as a natural beauty treatment. Egg yolk, oil, and vinegar mix is frequently used in homemade beauty treatments due to its positive effects on skin and hair. Mayonnaise can be used as a deep conditioner for hair care to replenish moisture, add shine, and improve manageability in dry or damaged hair. It is available in market as hair mayonnaise. In general, the versatile properties of mayonnaise make it a beneficial ingredient for both culinary and cosmetic purposes.

Spoilage of mayonnaise

Mayonnaise can easily spoil because it contains a high amount of oil, eggs, and water, creating ideal conditions for bacteria growth if not handled or stored correctly. The presence of harmful bacteria like *Clostridium botulinum*, *Shigella* and *Salmonella* as evidenced in recent cases of food poisoning, can pose significant health hazards, emphasizing the importance of controlling microbial growth in the production and storage of mayonnaise.

There are three major areas of quality problems in mayonnaise and salad dressing which are:

- Emulsion instability
- Flavour deterioration due to oxidation and hydrolysis
- Off-flavors due to microbial growth

Mayonnaise emulsion can become unstable due to issues like incorrect oil-to-water ratio or lack of proper emulsifying agents like egg yolk, resulting in phase separation. Outside influences such as changes in temperature and physical strain can leads to deterioration of mayonnaise (Smittle, 1977) [17].

Major spoilage causing organisms in mayonnaise are *Escherichia coli*, *Salmonella*, *Yersinia enterocolitica*, *Shigella*, *Staphylococcus aureus*, and *Listeria monocytogenes.*

Listeria monocytogenes is a bacterium that can reside inside cells and is transmitted through contaminated food, being an illness-causing microorganism that leads to listeriosis and severe infections in high-risk individuals such as expecting mothers, senior citizens, infants, those with HIV, and cancer patients. It has been found in water surfaces, soil, plants, environments, and different food categories (Jamali *et al.*, 2013) [8].

The low pH levels in food make mayonnaise inhospitable for bacteria, particularly pathogens, hindering their growth and survival. The main way *Salmonella* can contaminate mayonnaise is through egg yolks and/or whole eggs. These components, if not pasteurized, may sometimes be infected with *Salmonella*. As a result, the majority of studies have focused on their ability to survive or thrive in mayonnaise and salad dressing. Typically, *Salmonellae* can perish within a few days in mayonnaise with sufficient acetic acid. pH 5.4 was found to be the lowest pH at which *Salmonellae* could start growing in a broth with tryptone-yeast extract-glucose, using acetic acid as the acidifying agent. Staphylococcus aureus had an inhibitory pH of 5.0 and a fatal pH of 4.9 when measured with acetic acid. The best evidence for Staphylococcus aureus growth suppression and lethality

comes from studies utilizing salad dressings and mayonnaise since pH and NaCI do interact. Salad dressing and mayonnaise made correctly are antibacterial to staphylococci. In order to ensure the product is free from *Salmonella* and *Staphylococci*, it is necessary for the pH to be 4.1 or lower (0.25 per cent acetic acid) and for the product to be stored at 18-22º C for a minimum of 72 hours unless pasteurized eggs are utilized (Smittle, 1977) [17].

The principal strategies for assuring the safety and quality of mayonnaise are:

- Maintain an acidic pH: Acidic environments, usually derived from lemon juice or vinegar, aid in the preservation of the emulsion and hinder dangerous germs.
- Store it in the refrigerator immediately: Inhibit the growth of microorganism.
- Use immediately: Eating mayonnaise as soon as it's prepared reduces the chance of deterioration and contamination.
- Implement strict hygiene protocol: Good hygiene practices during production assist avoid cross-contamination and foodborne diseases.
- Reduce the use of raw eggs: Reducing or eliminating the usage of raw eggs helps to reduce the risk of bacterial infection, including salmonella.
- Lowering the fat content: Cutting fat can result in a healthier, lighter option, although stabilizers might be needed to keep the emulsion stable.

Conclusion

Mayonnaise is essentially a mixture of oil droplets dispersed in a water phase, held together by an emulsifier like egg yolk. When fat and water are mixed correctly, they create the rich, velvety consistency that characterizes mayonnaise. Its unmatched versatility in the culinary field makes it an essential base for a variety of sauces, dressings, and spreads. Mayonnaise improves the taste and consistency of different dishes, such as sandwiches and salads, and its ability to emulsify enables the making of different culinary emulsions. The secret to mayonnaise is in both the perfect mix of ingredients and the emulsification process, which keeps it stable and stops it from separating.

Recently, there has been a notable move towards healthier and more sustainable types of mayonnaise, due to increasing consumer interest in making better food decisions. Progress in food technology has resulted in the creation of vegan, low-fat, and functional types of mayonnaise that incorporate plant-based and organic components instead of conventional eggs and oils. These updated recipes strive to keep the original texture and taste intact, while providing health advantages like decreased cholesterol and fewer calories. Furthermore, product stability has been enhanced by utilizing natural preservatives and fat substitutes, allowing for an extended shelf life while maintaining quality. With increasing consumer focus on health and sustainability, these advancements guarantee that mayonnaise stays a favored and versatile topping in contemporary eating habits.

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