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Development Of Tapioca Starch Incorporated Mayonnaise And Its Quality Analysis

[1]Hrishikesh Sutar, [2]Dr. S. V. Ghodke, [3]Dr. P. D. Shere, [4]Dr. R. S. Agrawal
[1]Student at MIT-SOFT, [2]HOD &Associate Professor, [3]HOD & Professor, [4]Assistant Professor
[1]Department of Patronage and specialty foods, MIT school of Food Technology,
[1]MIT ADT University, Pune. India.

Abstract: Mayonnaise is a thick, white, creamy condiment prepared by emulsifying eggs, oil, lime juice, and vinegar. Globally variety of products such as burgers, sandwiches, salads, dips, sauce, pasta, and pizza served with mayonnaise as a core ingredient. This is one of the key reasons driving the market expansion, along with the expanding food and beverage (F&B) market. The growing demand of mayonnaise in market is mainly attributed to the growing working population, fast urbanization, increasing purchasing power, and higher standards of living of people. Globally, Cardiovascular diseases occurrence is growing in human being and main cause is fatty food consumption. Fat substitutes in specific quantities are possible to produce a product with a texture close to that of traditional mayonnaise. Therefore, it is a big challenge to use fat analogue with different functions to remove partial fat and remain traditionally pleasant. Tapioca Starch is a capable fat replacer which is low in calorie and can be used in many foods without fat. Hence the research is undertaken to incorporate tapioca starch as a fat replacer in mayonnaise and standardize the formulation to produce stable and acceptable low-fat mayonnaise. The oil was replaced by tapioca starch paste in mayonnaise samples and were assessed for sensorial, textural and microbial assessment. The 40% tapioca starch paste level was found to be overall acceptable. The texture and viscosity as a rheological property of formulated low-fat mayonnaise has shown similar behavior to the control variant, and the standardized mayonnaise has the advantage of higher emulsion stability and preserved the sensory characteristics over storage tenure.

Index Terms **- Low-fat mayonnaise, soybean oil, peroxide value, tapioca starch, mayonnaise shelf-life.**

I. Introduction

This Mayonnaise is an oil-in-water emulsion and is a widely consumed product. Traditionally, mayonnaise is prepared by blending a mixture of egg yolks, vinegar, oil and spices especially mustard to form a tightly packed foam of oil droplets. It is also incorporated with other optional ingredients such as colours and flaours. Its colour varies from near-white to pale yellow, and its texture from a light cream to a thick gel. Traditional mayonnaise is an oil-in-water emulsion containing 70-80% fat [13]. Mayonnaise is an oil-in-water emulsion, even though it contains more oil than water. This emulsion is formed by first mixing the eggs, vinegar and mustard and then slowly mixing the oil. This results in an emulsion consisting of dense "bubbles" of oil droplets. Conversely, when the oil and water phases are mixed at once (as many novice cooks can attest), the result is a water-in-oil emulsion of similar viscosity to the original oil. [7]

Mayonnaise must contain at least 78.5% total fat and 6% pure egg yolk (Codex Alimentarius Commission, 1989). An excessive dietary fat consumption is a primary cause for increased risk of obesity, coronary heart disease, and several cancers. However, as an essential food component, fat plays important role in determining rheological properties and sensory characteristics of foods, such as flavor, mouth-feel, color, and texture. With the decrease of fat concentration, the aqueous phase and water content may increase correspondingly, inducing the decrease of viscosity and firmness of 40 semi-solid emulsions. Therefore, it is necessary to use fat analogue of different functions to supply the quality attributes lost when fat was removed [5][26].

India recorded 63% of all non-communicable diseases related deaths in 2016, with 27% of those deaths being attributed to CVDs. Moreover, 45% of deaths in people aged 40 to 69 are caused by CVDs. In 2016 WHO survey in India, cardiovascular diseases (CVDs) are now the main cause of death. CVD is responsible for 25% of all deaths. For more than 80% of CVD deaths, ischemia heart disease and stroke are the main causes. India's age-standardized CVD death rate of 272 per 100,000 people, according to the Global Burden of Disease study, is higher than the world average of 235 per 100,000 people [20]. In 2016, India has a higher age-standardized CVD death rate than any other country at 272 per 100 000 people. Hence, identification of appropriate fat substitute and application of them in food product is a need of hour.

The tapioca starch granules are mainly consisting of two major polysaccharides components as amylose and amylopectin. These molecules consist of chains of a-(1-4)-linked D-glucose residues, which are interlinked with a-(1-6)-glycosidic linkages, thus creating branches in the polymers. Amylose is the longer chains linear polymer composed of glucopyranose units, while amylopectin is the short chains branched polymer with significantly higher molecular weight. The amylopectin chains form double-helices, responsible for the crystallinity in starch. Typical cassava starch consists of 0.03–0.29% ash, 0.06–0.75% protein, 0.01–1.2% lipid, 0.0029–0.0095% phosphorous, and 0.11–1.9% fibres contents respectively. The fatty acids in the starch 90 granules are mostly palmitic, oleic, linoleic, and linolenic acids [27]. Tapioca starch is differentiated from other starches by its low level of residual materials (fat, protein, ash), lower amylose content than for other amylose-containing starches, and high molecular weights of amylose and amylopectin.

The creation of new food products seems to be becoming more and more difficult because it must satisfy consumers, especially when it comes to delicious healthy foods. Functional foods, particularly those with lower fat content, are crucial in this regard since they provide additional health benefits in addition to their nutritional value. High-fat food-related public health issues have created a social crisis. A trend towards the development of reduced-fat (RF) products has emerged within the food business as a result of the negative health effects of excessive consumption of specific types of lipids and consumer demand for more natural, more nutritive, and healthier food items [40]. Hence in present investigation sincere efforts are undertaken to incorporate tapioca starch as a fat replacer in mayonnaise and standardize the formulation to produce stable and acceptable low-fat mayonnaise

II. MATERIALS AND METHODOLOGY

2.1 Ingredients

Refined soybean oil, eggs, vinegar, salt, sugar and citric acid were procured from the local shops of Loni-kalbhor, Pune. Tapioca starch were procured from Shri Dhanvantari Exports, Tamilnadu. Analytical grade chemicals were made available from Food process and Product technology/Food safety, quality and nutrition laboratory, MIT School of Food technology, Loni-Kalbhor.

2.2 Methodology:

2.2.1 Preparation of tapioca starch paste

Tapioca starch was weighed and mixed with distilled water to make 20% (w/w) solution. The slurry was stirred manually for 2 minutes for uniform mixing followed by heating in water bath at 85°C temperature [10] for 5 minutes to gelatinize the starch (20% w/w). The starch paste is further utilized in formulation of mayonnaise.

Table 1: Recipe for starch paste incorporated mayonnaise

Materials (g)	Control	S_1	S_2	S_3
Starch paste	-	35	40	45
Xanthan gum	-	0.75	0.75	0.75
Soybean Oil	66	30	25	20
Egg	15	15	15	15
Vinegar	7.5	7.5	7.5	7.5
Water	1.624	2.034	2.034	2.034
Salt	1.6	1.6	1.6	1.6
Sugar	8	8	8	8
Citric acid	0.016	0.016	0.016	0.016
Guar gum	0.16	-	-	-
Sodium Benzoate	0.1	0.1	0.1	0.1

2.2.2 Pre-treatment to control salmonella in egg-based mayonnaise.

Egg, citric acid, vinegar and preservatives with water weighed as per formulation (Table no 1) and heated to 150°F (65.6°C) for 1 minute in water-bath for pasteurization. This treatment does not cause denaturation and coagulation of egg yolk proteins because of the acid and water dilution [21]. The mixture was stirred continuously with frequent measurement of temperature and used in the preparation of mayonnaise.

2.2.3 Processing technology for tapioca starch incorporated mayonnaise

The previously formulated egg mixture and tapioca starch is used for mayonnaise preparation. Egg mixture is blended with sugar (8g), salt (1.7g) and xanthan gum & guar gum (0.75g) by beating with electric hand blender for 1 min. Proper mixing of the ingredient should be carried out to raise volume which indicates good emulsion forming ability of the mixture. Then fat replacer is incorporated at varying levels (0, 35%, 40% and 45%) to mixture and blended well. Then oil is added with continuous stirring followed by mixing for 5-6 min to get the stable texture. The formulated mayonnaise samples were packed in HDPE pouches and stored in the refrigeration temperature for sensory assessment.

2.2.4 Peroxide value:

Peroxide value was determined by method described in FSSAI manual for oil and Marroquín et al. 2018 [15]. Oil/fat sample of approx 5g was taken in flask, followed by addition of 30 mL acetic acid chloroform solvent mixture and dissolving the sample in it for a minute. Addition of 0.5 mL saturated potassium iodide solution. Mixing and store in dark for 1 minute. And it is titrated against 0.1N/0.01N sodium thiosulphate solution in presence of starch indicator, endpoint for titration dark violet followed yellow and to colourless.

$$PV = \frac{1000(V - Vb).C}{M}$$

2.2.5 Acid Value: It is described as the quantity of potassium hydroxide needed to neutralise one gram of fat's free fatty acids. Given that free fatty acids are often produced during the breakdown of triglycerides, it is a relative indicator of rancidity. Known amount of oil sample is taken in 250 ml conical flask, 50ml hot ethyl alcohol is added along with phenolphthalein indicator. It is heated over waterbath at 75°C -80°C for 15 min. and titrated against standard KOH solution.

$$Acid\ value = \frac{56.1 \times V \times N}{W}$$

2.2.6 Free Fatty acids:

Free fatty acid is determined by titrating the oil/fat in an alcoholic media against standard KOH/NaOH solution in presence of phenolphthalein indicator. The number is an indicator of how many fatty acids have been released from the glycerides by hydrolysis as a result of moisture, temperature, and/or the lipolytic enzyme lipase. (FSSAI oil revised manual)

$$Free\ fatty\ acid\ as\ oleic\ acid(\%) = \frac{28.2 \times V \times N}{W}$$

2.2.7 Emulsion stability:

About 10 g of sample is heated for 30 min in a centrifuge tube by a waterbath at temperature of 70°C. followed by centrifugation for 15 min under 5000 rpm. Emulsion stability calculated as below equation. [9, 22, 3, 19].

$$Emulsion\ stability = \frac{Emulsified\ layer\ sample\ weight}{Total\ sample\ weight} \times 100$$

2.2.8 Texture Profile Analysis

The texture profile analysis of mayonnaise samples was estimated by using Texture Pro CT V1.7 Build 28 texture Analyzer. The samples were placed on the sample holding table and the cylindrical probe was used in mayonnaise sample. A double cycle was programmed with the test speed set at 1 mm/sec. Based on the deformation curve, different parameters like hardness, fracturability, adhesiveness, cohesiveness and chewiness were calculated by the in-built software.

3.8 Viscosity measurement

Viscosity was directly measured by Brookfield Viscometer. The resistance offered by liquid sample, to the spindle of viscometer, is measured digitally with helps of gauges on instrument panel.

3.9 Proximate and microbial analysis:

The proximate analysis done with the parameters Moisture, fat, protein, ash content and Carbohydrates content. Microbial estimations include total plate count, yeast & mold count, coliform count, and detection of salmonella.

III. RESULTS AND DISCUSSION

3.1 Sensory profile of tapioca starch incorporated low-fat mayonnaises.

The effect of tapioca starch as fat replacer on the organoleptic characteristics (Colour & appearance, Taste, Flavor, Consistency, Mouthfeel and Overall acceptability) of mayonnaise were assessed and represented as in fig 1.

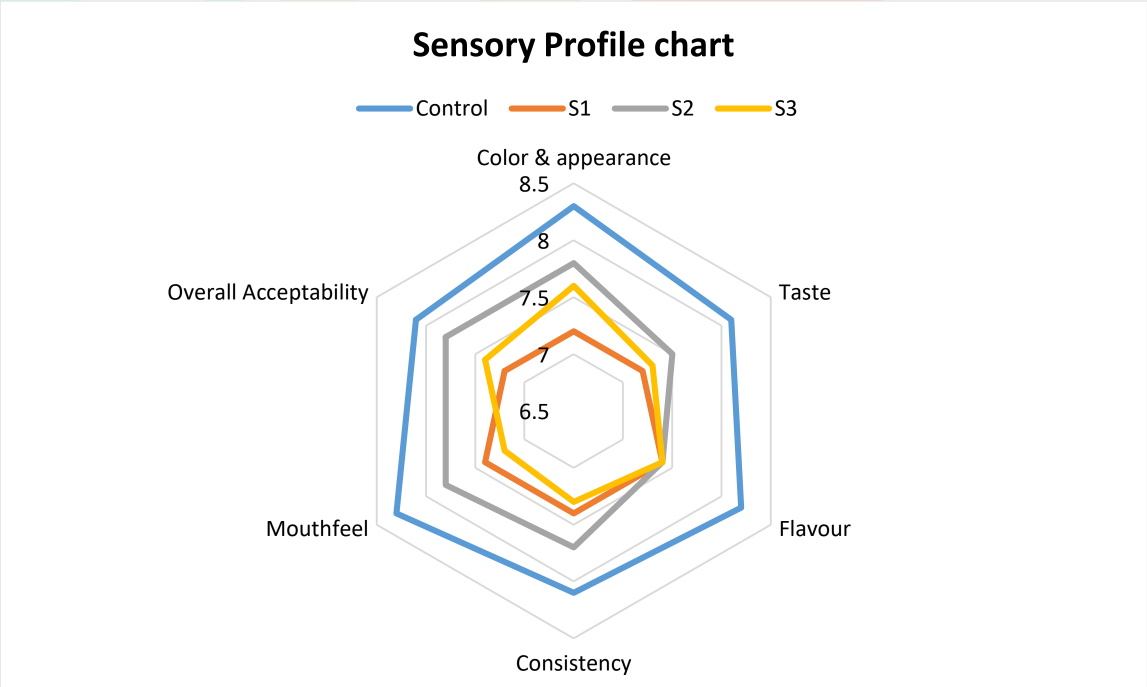

Fig 1: Sensory profile of tapioca starch incorporated mayonnaise

Tapioca starch incorporated low-fat mayonnaise was developed by replacing oil with starch paste at 35%, 40% and 45% with reduced oil from 30%, 25% and 20% in recipe and control sample is prepared with 66% of oil. Colour & appearance is an important sensory parameter that affects consumer acceptability. Colour score of developed tapioca starch incorporated mayonnaise found in the range of 7.2 to 7.8. Colour & appearance is mainly affected by emulsion quality and uniformity of particles in product. Highest score (7.8) for colour and appearance was recorded by sample S2. Taste, being an important attribute for consumer acceptance, recorded score from 7.2 to 7.5 in tapioca starch incorporated mayonnaise. However, mayonnaise without tapioca starch recorded the highest score for taste (8.1).

3.2. Proximate analysis of tapioca starch incorporated mayonnaises

The proximate composition (Moisture, fat, protein, ash and carbohydrate) of control mayonnaise and formulated low-fat mayonnaise was analyzed and results are reported in table 2.

Table 2: Proximate composition of tapioca starch incorporated mayonnaises.

Sample	Moisture Content (%)	Fat Content (%)	Protein (%)	Ash Content (%)	Carbohydrate (%)
Control	19.19±0.45	63.49±1.07	4.68±0.015	1.74±0.83	10.90±0.04
S_1	43.48±0.15	29.37±0.15	4.59±0.08	1.78±0.01	20.78±0.26
S_2	47.24±0.29	24.49±0.25	4.65±0.03	1.81±0.02	21.82±0.05
S_3	51.61±0.37	19.24±0.06	4.64±0.03	1.92±0.02	22.59±0.37

***values are average of three observations and represented as mean ± SD.**

The moisture content in control mayonnaise is 19.19% which lower, the rest of portion has made from oil, sugar, salt and acids. However, in case of low-fat mayonnaise the moisture increases from S1 to S3 because oil has significantly replaced with starch paste, the moisture content in S1 is 43.48%, S2 with 47.24% and S3 with 51.61%. The resultant increase in the moisture has been holds by starch molecules, starch absorbs most of free water which is added in paste formations, which avoids water syneresis.

Fat is important characteristic that has significant role in the texture, rheology and appearance of mayonnaise. Control mayonnaise content highest fat of 63.49%, due to is made by traditional recipe. The designed low-fat mayonnaise has fat content of 29.37%, 24.49% and 19.24% for S1, S2 and S3 respectively. Protein is due to the addition of egg in the recipe, each mayonnaise sample content about protein near to 4.6% in the final products. There is no significant difference in protein because each sample was designed with the same amount of egg.

3.3 Chemical parameters of tapioca starch incorporated mayonnaises.

Table 3: Chemical parameters of tapioca starch incorporated mayonnaises.

Sample	Acidity (%)	Peroxide value (mEq/kg)	pH	Acid Value (mg KOH/g)
Control	0.42±0.005	3.24±0.03	4.20±0.01	0.72±0.04
S_1	0.41±0.04	3.22±0.02	4.29±0.005	0.77±0.02
S_2	0.41±0.003	3.25±0.04	4.24±0.005	0.75±0.03
S_3	0.41±0.002	3.23±0.01	4.23±0.005	0.74±0.04

***values are average of three observations and represented as mean ± SD.**

The acid value indicates the amount of acids produced in product by decompositions of triglycerides in oil. It's an indicator of rancidity of oil in product. The acid value of oil in mayonnaise is nearly same in all sample, it is near to 0.75mg of KOH/g. The acidity of mayonnaise is one of parameter shows tart, sour taste in product, it mainly depends on citric acid and vinegar added in formulation. Also, pH is an indicator for the quality of product, mayonnaise pH ranges between 3.5 to 5, pH results for both control and low-fat mayonnaise is 4.20 to 4.29.

Enzyme and microbial action breakdown complex molecules to acids, results in a change in acidity, the acidity of final product is nearly 0.41%. Peroxide value is a parameter that measures the state of oxidation in fat and oils, higher peroxide value indicates product has been damaged by free radicals which produces aldehydes and ketones, cause to smell rancid. The finished product has peroxide value near to 3.24 mEq peroxide/Kg of oil.

3.4 Viscosity as rheology governing parameter of tapioca starch incorporated mayonnaises.

Viscosity is a measure of the resistance offered by the food sample which is essential to decide flow behaviour. Formulated low-fat and full-fat mayonnaise sample were tested under Brookfield viscometer at 28°C and results are presented in table 4.

Table 4: Viscosity of tapioca starch incorporated mayonnaises.

Sample	viscosity (mPa.s)
Control	3911.2±0.05
S_1	5824.7±0.51
S_2	6022.8±0.56
S_3	6219±0.92

***values are average of three observations and represented as mean ± SD.**

The increasing trend was recorded for the viscosity of mayonnaise along with increase in starch paste quantity. The mayonnaise sample with 66% oil exhibited lowest viscosity (3911.20 mPa.sec) against starch incorporated mayonnaises. This may be attributed to absence of stabilizer in formulation. The viscosities of low-fat mayonnaise samples were 5824.70 mPa.sec, 6022.80 mPa.sec and 6219.00 mPa.sec for S1, S2 and S3 respectively which indicated rise in viscosity value.

3.5 Texture profile analysis of tapioca starch incorporated mayonnaises

The texture profile analysis test is a method developed to determine textural attributes of food products. The tapioca starch incorporated mayonnaise analysed in two-pressure action mode which simulates the bite pattern under jaws and nine important texture parameters obtained are presented in graphical form in fig 2, 3, 4 & 5.

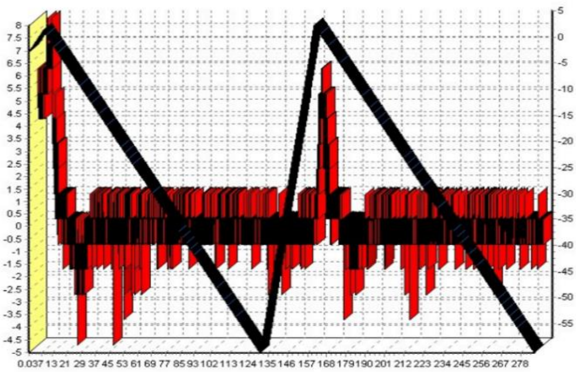

Figure 2: Control (Full fat) mayonnaise

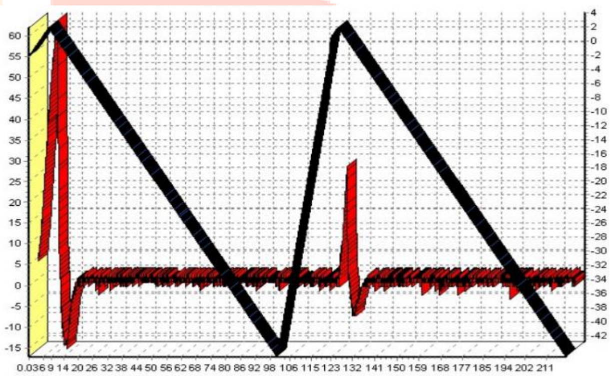

Figure 3: S1 Tapioca starch incorporated mayonnaise

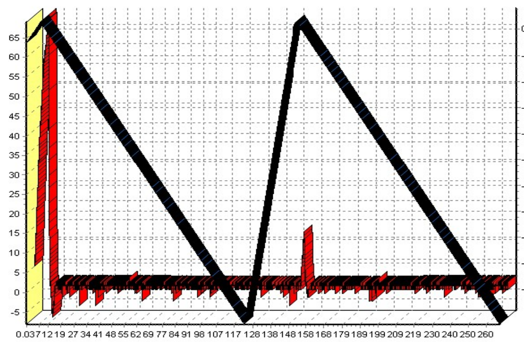

Figure 4: S2 Tapioca starch incorporated mayonnaise

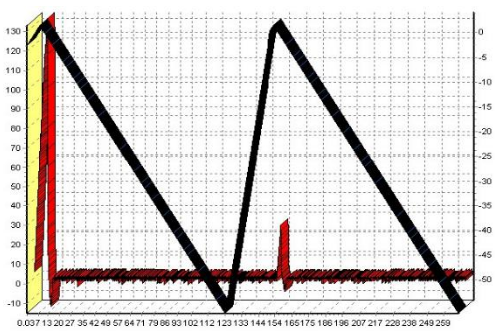

Figure 5: S3 Tapioca starch incorporated mayonnaise

Adhesion is simply stickiness of sample, the energy required for separate the jaws of machine, also during chewing samples slightly holds teeth, tong, palates together. Adhesiveness in full-fat mayonnaise shows 0.1mJ, but in low-fat sample S1 its higher as 0.4mJ, in S2 it is 0.1mJ, and in S3 it is 0.2mJ. Fracturability in control mayonnaise is 6g, also it nearly similar in case of low-fat mayonnaise as S2 having 8g, eventually samples S1 and S3 having same fracturability as 9g. Springiness is the ability of food to retain the initial hardness between the first bite force and second bite. in case of control mayonnaise, it shows no springiness, but low-fat mayonnaise shows springiness as 1.08, 0.4 and 0.87 in S1, S2 and S3 respectively, because it composes tapioca starch paste. Gumminess of control mayonnaise is 4g, also tapioca starch incorporated mayonnaise samples show similar gumminess with control, its values as 6g, 3g and 2g of sample S1, S2 and S3 respectively. The cohesion in control mayonnaise is 0.09 is nearly negligible, also in low-fat samples its 0.08, 0.03 and 0 in S1, S2 and S3 respectively. Chewiness energy of control mayonnaise is zero, also all low-fat mayonnaise shows zero except S1 with 0.1mJ chewiness. Hardness is the firmness of food sample; it is measured as maximum pressure applied on sample to break it. The hardness of control mayonnaise is quite lower than low-fat mayonnaise. control mayonnaise exhibits a hardness of 3.96g, and in low-fat mayonnaise, it is 62g, 69g, and 133g in S1, S2 and S3 respectively. The standardized low-fat mayonnaise with 40% tapioca starch exhibited closer values to the control in terms of adhesiveness, chewiness, springiness, gumminess. Similar results were observed by Ali et al. 2014 [1], Wang et al. 2020 [25]. It indicates that starch is very capable fat replacer for using in mayonnaise to form a mimic emulsion in product.

3.6 Shelf-life study of standardized low-fat mayonnaise.

Shelf life of standardized low-fat mayonnaise was estimated by packing it in HDPE pouches and storing at refrigeration temperature (4°C) to identify its safe storage tenure of it. The chemical, microbial and sensorial parameters were evaluated at time interval of 15 days to record observations.

Table 5: Effect of tapioca starch as fat replacer on chemical parameters of mayonnaise during storage tenure

storage time	Acidity (%)		Peroxide value (mEq/kg)		pH		Acid value (mgKOH/g)	
Sample	**Control**	**low-fat**	**Control**	**low-fat**	**Control**	**low-fat**	**Control**	**low-fat**
0 day	0.40±0.03	0.40±.006	3.37±0.22	3.25±0.04	4.27±0.02	4.24±0.04	0.75±0.08	0.76±0.11
15 day	0.41±0.01	0.40±0.00	4.42±0.03	4.36±0.03	4.21±0.02	4.17±0.01	1.07±0.03	1.14±0.07
30 day	0.41±0.01	0.41±0.00	5.59±0.03	5.13±0.05	4.16±0.01	4.08±0.01	1.31±0.04	1.40±0.04
45 day	0.42±0.01	0.42±0.003	6.23±0.05	5.94±0.06	4.08±0.02	4.01±0.01	1.68±0.02	1.72±0.06
60 day	0.42±0.02	0.42±0.01	6.52±0.03	6.39±0.05	4.05±0.01	3.99±0.04	1.82±0.07	1.89±0.03

***values are average of three observations and represented as mean ± SD.**

Acidity of mayonnaise ranges from 0.3% to 0.5% measured as acetic acid. The increase in acidity was observed from 0.40% to 0.42% during storage tenure. In case of control mayonnaise acidity increases more in first 15 days and in case of low-fat mayonnaise it remains constant after 15 days. This may be attributed to hydrolysis of triglycerides to di-acylglycerols, mono-acylglycerols and free fatty acids mainly unsaturated fatty acids in the presence of oxygen [12]. The pH of both mayonnaises decreased during storage tenure. In first 15 days, pH of control mayonnaise decreases from 4.27 to 4.21, and in low-fat mayonnaise it decreases from 4.24 to 4.17. Decrease in pH is inversely depends on changes in acidity. It is observed, pH decreases more in low-fat mayonnaise compared to control mayonnaise, it is may be an enzymatic activity to produce glycerides and fatty acids from gelatinized starch paste and oil in the presence water.

The increasing trend was observed in peroxide value from 3.37 mEq peroxide/Kg oil to 6.52 mEq peroxide/Kg oil, and in low-fat mayonnaise, it increases from 3.25 mEq peroxide/Kg oil and 6.39 mEq peroxide/Kg oil in control and low-fat mayonnaise respectively during storage tenure of 60 days. This may be due to the oxidation of oil to form triglycerides, fatty acids, alcohols and aldehydes. As per FSSAI regulation peroxide value of soybean oil should not exceed 10 mEq peroxide/Kg of oil.

The increasing trend (0.75 mgKOH/g to 1.82 mgKOH/g and 0.76 mgKOH/g to 1.89 mgKOH/g) of acid value was recorded by full fat and low-fat mayonnaise during storage periods. This may be due to acid amount is produced in product by the decompositions of triglycerides in oil. It's an indicator of rancidity of oil in product, and as per FSSAI regulation the limit of acid value for oil products is 4 mg KOH/ g of oil.

Table 6: Effect of tapioca starch as fat replacer on sensory characteristics of mayonnaise during storage tenure.

Day	Sample	Color & appearance	Taste	Flavor	Consistency	Mouthfeel	Overall Acceptability
0 day	Control	8.3±0.67	8.1±1.19	8.2±0.92	8.1±1.19	8.3±0.94	8.1±1.19
	S_2	7.8±0.42	7.5±0.53	7.4±0.52	7.7±0.48	7.8±0.63	7.8±0.63
15 day	Control	8.3±0.19	8.0±1.03	8.2±1.24	8.0±0.71	8.3±1.02	8.0±0.98
	S_2	7.7±0.18	7.5±0.67	7.4±0.18	7.8±1.07	7.8±0.84	7.8±0.61
30 Day	Control	8.2±0.37	7.9±0.90	8.0±1.13	7.8±0.86	8.2±0.35	7.9±0.58
	S	7.7±0.35	7.4±0.54	7.3±0.34	7.7±0.92	7.8±0.47	7.8±0.83
45 Day	Control	8.1±0.30	7.7±0.93	7.8±1.13	7.8±0.30	8.1±0.38	7.9±0.48
	S_2	7.7±0.82	7.3±0.38	7.2±0.34	7.8±0.85	7.8±0.13	7.7±0.81
60 day	Control	8.0±0.41	7.5±0.69	7.6±1.03	7.7±0.94	8.0±0.46	7.8±1.06
	S_2	7.7±0.53	7.2±0.0.82	7.1±0.73	7.8±1.08	7.7±0.56	7.6±1.23

***values are average of three observations and represented as mean ± SD**.

Colour and appearance were observed to be slightly decreased from 8.3 to 8.0 and 7.8 to 7.7 over storage tenure of control and low-fat mayonnaise respectively. Taste exhibits decreasing trend in control mayonnaise (8.1 to 7.5) as well as standardize low-fat mayonnaise (7.5 -7.2). Flavour had shown decreasing tend for control mayonnaise (8.2 to 7.6) as well as standardize low-fat mayonnaise (7.4 to 7.1) may be due to increase in the FFA and saturates leading to rancid flavour. There was no significant difference in consistency and mouth-feel in low-fat mayonnaise sample over storage time of 60 days, because starch acts as stabilizer and holds texture. There was minor change in overall acceptability with slight reduction in sensory points which indicates product acceptability at the end of storage tenure. Due to the addition of tapioca starch and xanthan gum exhibits higher stability and preserves the sensory characteristics over time.

Table 7: Effect of tapioca starch as fat replacer on emulsion stability of mayonnaise during storage tenure.

Storage time	Stability (%)	
Sample	**Control**	**low-fat**
0 day	89.59±0.40	98.70±0.25
15 day	85.19±0.93	97.96±0.75
30 day	82.72±1.21	97.38±0.11
45 day	80.47±0.73	96.47±0.33
60 day	79.71±0.21	96.02±0.13

***values are average of three observations and represented as mean ± SD.**

The emulsion stability of mayonnaises, control and low-fat mayonnaise on 0 days were 89.59% and 98.70% respectively. Emulsion stability is necessary for preventing droplet amalgamation, flocculation, and creaming. Emulsion stability of mayonnaises exhibited decreasing trend over the storage time. The emulsion stability decreased dramatically in control as 85.19%, 82.72%, 80.47% and 79.71% from 15days to 60 days' period. In case of standardize low-fat mayonnaise, emulsion stability was decreased from 98.70% to 96.02%, which shown comparative better stability than control sample. Similar trend was observed by Ariizumi et al. 2016 [2]. This decrease in emulsion stability may be due to the presence of catalytic enzymes, oxygen and light causes degradation of the structure of mayonnaise. Lipase speeds up the hydrolysis reaction and releases fatty acids, glycerol, and other alcohols by dissolving the ester bonds in lipids and fats [16]. Lipases with a wider range of specificity that are active at low temperatures and are stable within alkaline conditions as well as when exposed to chelating and oxidising agents.

Table 8: Effect of storage on microbial parameters of standardized low-fat mayonnaise with tapioca starch

Storage time	TPC (cfu/g)		Yeast & Molds (cfu/g)		Coliform (cfu/g)		Salmonella (cfu/25g)	
Sample	Control	low-fat	Control	low-fat	Control	low-fat	Control	low-fat
0 day	ND	ND	ND	ND	ND	ND	ND	ND
15 day	ND	ND	ND	ND	ND	ND	ND	ND
30 day	ND	ND	ND	ND	ND	ND	ND	ND
45 day	ND	ND	ND	ND	ND	ND	ND	ND
60 day	ND	ND	ND	ND	ND	ND	ND	ND

***values are average of three observations and represented as mean ± SD.**

Control mayonnaise and standardize low-fat mayonnaise samples were investigated for total bacterial count, Yeast and mold count, Coliform count and Salmonella detection during storage tenure to establish safety of products. The results are depicted in table 7. During storage tenure of 60 days' total bacterial count, Yeast and mold count, Coliform count and Salmonella were not detected in control and low fat mayonnaise. This is attributed to presence of acetic acid, sodium benzoate and citric acid present in products. Additionally, starch paste heat treatment for gelatinization and egg pasteurization in presence of acids and preservatives also prevented microbial growth during storage of 60 days. This indicated 60 days as safe storage tenure for standardized low-fat mayonnaise.

IV. Conclusion

The tapioca starch as fat replacer successfully incorporated in mayonnaise to enhance its functional value. The fat content of standardized mayonnaise observed to be less (24.49%) compared to full fat mayonnaise which is found to be important achievement of research work. The finished product recorded moisture content as 47.24%, protein content as 4.65%, ash content as 1.81%, and carbohydrates as 21.82%. The emulsion stability of tapioca starch incorporated mayonnaise samples was observed to be better than control sample (89.59%). Texture analysis indicates that the low-fat mayonnaise processed with tapioca starch at 40% tapioca starch is closer to the control values in terms of adhesiveness, chewiness, springiness, and gumminess. This S2 sample (40% starch) was selected as standardized low-fat sample and further it studied for shelf life. During storage, an increase in chemical parameters such as acidity, peroxide value, and acid value was observed with a similar tendency in both the standardized mayonnaise and the control mayonnaise. In the 60-day storage study, total bacterial count, Yeast and mold count, coliform count, and Salmonella were not detected in the control mayonnaise and the standardized low-fat mayonnaise. This is attributed to the presence of acetic acid, sodium benzoate and citric acid in the products. In addition, heat treatment of starch paste was gelatinized and pasteurization of eggs was carried in presence of acids and preservatives, this prevents microbial growth during 60 days of storage. The texture and viscosity as a rheological property shown the similar behaviour of formulated low-fat mayonnaise to the control variant, and the standardized mayonnaise has the advantage of higher emulsion stability and can preserve the sensory characteristics over storage.

V. References

1) Ali, T. M., Waqar, S., Ali, S., Mehboob, S., & Hasnain, A. (2015). Comparison of textural and sensory characteristics of low-fat mayonnaise prepared from octenyl succinic anhydride modified corn and white sorghum starches. *Starch-Stärke*, *67*(1-2), 183-190.
2) Ariizumi, M., Kubo, M., Handa, A., Hayakawa, T., Matsumiya, K., & Matsumura, Y. (2017). Influence of processing factors on the stability of model mayonnaise with whole egg during long-term storage. *Bioscience, biotechnology, and biochemistry*, *81*(4), 803-811.
3) Bajaj, R., Singh, N., & Kaur, A. (2019). Properties of octenyl succinic anhydride (OSA) modified starches and their application in low fat mayonnaise. *International journal of biological macromolecules*, *131*, 147-157.

4) Breuninger, W. F., Piyachomkwan, K., & Sriroth, K. (2009). Tapioca/cassava starch: production and use. In *Starch* (pp. 541-568). Academic Press.
5) Chang, C., Li, J., Li, X., Wang, C., Zhou, B., Su, Y., & Yang, Y. (2017). Effect of protein microparticle and pectin on properties of light mayonnaise. *LWT-Food Science and Technology*, *82*, 8-14.
6) Codex Alimentarius Commission. Proposed Draft Revised Standard for Mayonnaise 2001.
7) Depree, J. A., & Savage, G. P. (2001). Physical and flavour stability of mayonnaise. *Trends in Food Science & Technology*, *12*(5-6), 157-163.
8) Gaikwad, M. P., Syed, H. M., & Shinde, D. D. (2017). To study the physico-chemical properties of flavoured mayonnaise. *Journal of Pharmacognosy and Phytochemistry*, *6*(5), 06-09.
9) Golchoobi, L., Alimi, M., Shokoohi, S., &Yousefi, H. (2016). Interaction between nanofibrillated cellulose with guar gum and carboxy methyl cellulose in low-fat mayonnaise. *Journal of Texture Studies*, *47*(5), 403-412.
10) Hong, Y., Liu, G., Zhou, S., Gu, Z., Cheng, L., Li, Z., & Li, C. (2016). Influence of guar gum on the in vitro digestibility of tapioca starch. *Starch-Stärke*, *68*(3-4), 339-347.
11) Karas, R., Skvarča, M., &Žlender, B. (2002). Sensory quality of standard and light mayonnaise during storage. *Food Technology and Biotechnology*, *40*(2), 119-127.
12) Kim, R. J., Kim, H. J., Shim, D., & Suh, M. C. (2016). Molecular and biochemical characterizations of the monoacylglycerol lipase gene family of Arabidopsis thaliana. *The Plant Journal*, *85*(6), 758-771.
13) Liu, H., Xu, X., & Guo, S. H. (2007). Reológico, textura y sensorialespropiedades de mayonesabajaengrasa con diferente mimetics. *LWT-Food grasaCiencia y Tecnología*, *40*, 946-954.
14) Manzocco, L., Calligaris, S., Anese, M., &Nicoli, M. C. (2016). Determination and prediction of shelf life of oils/fats and oil/fat–based foods. In *Oxidative stability and shelf life of foods containing oils and fats* (pp. 133-156). AOCS Press.
15) Medina-Marroquín, L. A., Vásquez-Chicata, A., &Bellido-Valencia, O. (2018). Estimating the shelf life of a mayonnaise made from sachainchi (PlukenetiaVolubilis l.) oil and duck (Anasplatyrhynchos l.) egg yolk. *Carpathian Journal of Food Science & Technology*, *10*(4).
16) Melani, N. B., Tambourgi, E. B., & Silveira, E. (2020). Lipases: from production to applications. *Separation & Purification Reviews*, *49*(2), 143-158.
17) Messina, M., Shearer, G., & Petersen, K. (2021). Soybean oil lowers circulating cholesterol levels and coronary heart disease risk, and has no effect on markers of inflammation and oxidation. *Nutrition*, *89*, 111343.
18) Mun, S., Kim, Y. L., Kang, C. G., Park, K. H., Shim, J. Y., & Kim, Y. R. (2009). Development of reduced-fat mayonnaise using 4αGTase-modified rice starch and xanthan gum. *International journal of biological macromolecules*, *44*(5), 400-407.
19) Park, J. J., Olawuyi, I. F., & Lee, W. Y. (2020). Characteristics of low-fat mayonnaise using different modified arrowroot starches as fat replacer. *International journal of biological macromolecules*, *153*, 215-223.
20) Prabhakaran, D., Jeemon, P., & Roy, A. (2016). Cardiovascular diseases in India: current epidemiology and future directions. *Circulation*, *133*(16), 1605-1620.
21) Pradhananga, M., & Adhikari, B. (2015). Sensory and quality evaluation of mayonnaise and its effect on storage stability. *Sunsari Technical College Journal*, *2*(1), 48-53.
22) Rahbari, M., Aalami, M., Kashaninejad, M., Maghsoudlou, Y., &Aghdaei, S. S. A. (2015). A mixture design approach to optimizing low cholesterol mayonnaise formulation prepared with wheat germ protein isolate. *Journal of food science and technology*, *52*, 3383-3393.
23) Thaiudom, S., &Khantarat, K. (2011). Stability and rheological properties of fat-reduced mayonnaises by using sodium octenyl succinate starch as fat replacer. *Procedia Food Science*, *1*, 315-321.
24) Wang, W., Hu, C., Sun, H., Zhao, J., Xu, C., Ma, Y., ... & Hou, J. (2022). Physicochemical properties, stability and texture of soybean-oil-body-substituted low-fat mayonnaise: Effects of thickeners and storage temperatures. *Foods*, *11*(15), 2201.
25) Wang, Y., Zheng, H., Li, Y., Li, B., & Chen, Y. (2015). One step procedure for desalting salty egg white and preparing fat analogue and its application in mayonnaise. *Food Hydrocolloids*, *45*, 317-326.
26) Worrasinchai, S., Suphantharika, M., Pinjai, S., &Jamnong, P. (2006). β-Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. Food hydrocolloids, 20(1), 68-78.
27) Zhu, F. (2015). Composition, structure, physicochemical properties, and modifications of cassava starch. *Carbohydrate polymers*, *122*, 456-480.