UDC 664.346:351.773
ISSN 1330-9862

original scientific paper

(FTB-1121)

Sensory Quality of Standard and Light Mayonnaise during Storage

*Romana Karas, Marlena Skvarča and Božidar Žlender**

University of Ljubljana, Biotechnical Faculty, Department of Food Science and Technology, Jamnikarjeva 101, SI-1111 Ljubljana, Slovenia

Received: November 26, 2001
Accepted: April 10, 2002

Summary

The effects of ingredients on the quality and stability of two kinds of mayonnaise after it has been stored in a refrigerator (t = 5–8 °C) and at room temperature (t = 20–25 °C) were examined in this research. Fresh mayonnaise samples were examined by sensory analysis (analytical descriptive test) and physico-chemical analyses (pH, acid and peroxide values) first after being stored for one month and then after two months. The effects of individual factors were examined and the results were statistically valued. The results show that fresh standard mayonnaise containing 75 % of oil as opposed to low-fat mayonnaise (light mayonnaise containing 49 % of oil) gained higher grades for most sensory attributes. Storage temperature, storage time and type of mayonnaise influence significantly ($P \leq 0.001$) the stability, homogeneity, mouth feeling, acid odour and flavour, rancidity, pH, acid and peroxide values. At any point of storage and under both temperature regimes, the samples of light mayonnaise had lower pH value and higher acid value in comparison with standard mayonnaise. Regardless of storage conditions irrespective of the recipe for their preparation, pH value was declining, whereas acid and peroxide values increased in all types of mayonnaise. Some meaningful statistically significant correlations ($r > 0.70$) exist between sensory and physico-chemical parametres of mayonnaise.

Key words: mayonnaise, storage, deterioration, sensory attributes, physico-chemical parameters

Introduction

Mayonnaise is oil in water (o/w) emulsion (*1,2*). Although its shelf life is limited, mayonnaise is an important foodstuff both for culinary art and in food industry. Hence from the nutritional standpoint, composition and stability of mayonnaise are essential factors. Standard recipes are based on mayonnaise with 40 to 80 % of oil. However, demand for low-fat mayonnaise has been rising. To produce light mayonnaise, fat from the basic formula for the preparation of mayonnaise shall be replaced by other ingredients while preserving its viscosity, texture, mouth feeling, taste and flavour to a highest possible degree. Conventional wisdom tells us that flavour of food with low fat content or fat-free ones differs considerably in flavour from food with normal fat content. Food with a high fat content produces a pleasant, smooth flavour, which can even linger on the palate long after eating it. Viscosity of the aqueous phase in low-fat mayonnaise is increased by additives (hydrocolloids), which increase density and contribute to stability of the emulsion by avoiding coalescence (*3,4*).

When planning commercial production of mayonnaise, attention should be paid to the size and shape of

* Corresponding author; Phone: ++ 386 (0) 1 42 31 161; Fax: ++ 386 (0) 1 25 66 296; E-mail: bozidar.zlender@bf.uni-lj.si

particles of basic ingredients (*5,6*). Furthermore, the distribution of particles during the disperse phase should be considered since it affects its texture (*6*) defined as density, smoothness (softness) and creaminess (*7*). The distribution of oil or water in mayonnaise also results in characteristic flavour (*8,9*), due to the fact that lipofile aromatic components are concentrated in the lipid phase.

Mayonnaise has a low pH value (3.7–4.2) (*3,10*) and water activity (0.93–0.95) (*10,11*). By adding acetic acid to prevent growth of vegetative cells of pathogen microorganisms (3) and potassium sorbate as an antifungal agent (*11*), microbiological deterioration of mayonnaise is controlled. Examination the relations between ingredients and pH value of mayonnaise showed that salt and sugar decrease pH value of mayonnaise, while oil, mustard and pepper increase it (12).

During storage mayonnaise may be affected by a number of factors causing deterioration (physical destabilisation, chemical oxidation, hydrolysis and microbiological), which interact. With ageing mayonnaise becomes thinner, while storage at high temperature leads to dissociation of mayonnaise emulsion (*1,13*). Due to oxidative decomposition of different ingredients of mayonnaise (particularly oil), rancidity and other undesired odours and tastes appear (*14,15*). Also the concentration and the type of used salt have a highly significant influence on auto-oxidation (*16*). A high content of salt in the aqueous phase has decisive influence in controlling microbiological deterioration of mayonnaise. Therefore, the determination of the peroxide value is commonly done by means of method for the establishment of the oxidation degree and the quantity of free fatty acids is used to determine the degree of hydrolysis (*17*). Lipid oxidation and hydrolysis in mayonnaise at temperatures between 2 and 5 °C are significantly slower than at temperatures between 4 and 10 °C (*18*) and the degree of flavour deterioration was higher in mayonnaise with normal oil content than in low-fat mayonnaise (*11*). Stability of mayonnaise is also affected by temperature, oil content and the type of packing material examined by numerous researchers (*4,11,19*).

The paper is part of a wider research where we have studied the influence of the composition on quality and stability (shelf life) of mayonnaise by means of sensory, physico-chemical, microbiological, rheological and instrumental analyses. Our efforts focus on highlighting the problems associated with storage and its impact on sensory quality as well as certain changes affecting physico-chemical characteristics of mayonnaise with different oil content.

Materials and Methods

The experiment is based on input material provided by two kinds of commercial mayonnaise (vacuum homogenisation) of Slovenian manufacturers:

1. Standard mayonnaise containing 75 % of vegetable oil, and

2. Light mayonnaise containing 49 % of vegetable oil and added stabilising agent.

Both types of mayonnaise contain egg yolk, vinegar, mustard, sugar, spices and preservatives (Na-benzoate 0.1 % and K-sorbate 0.1 %). The mayonnaise samples were aseptically packed in controlled atmosphere in glass packaging (jars of 310 g) and closed with twist-off lids. Immediately after preparation, the samples were transported to the laboratory using a cold chain. They were stored for one and two months at two temperature regimes: in a refrigerator at the temperature between 5 and 8 °C (t_1) and at room temperature between 20 and 25 °C (t_2).

When examining the samples, the focus was on stability and effect of composition on the quality of the tested mayonnaise. Fresh mayonnaise and mayonnaise after being stored for two months were analysed on sensory qualities, pH, acid and peroxide values. The measurement of pH value and sensory analysis were also carried out after one month of storage. The experiment was conducted in three repetitions and the results were statistically evaluated.

Sensory analysis

For the purpose of evaluating sensory qualities, a commission composed of three qualified and experienced tasters trained in the field of emulsions was appointed, while sensory attributes of coded mayonnaise samples were tasted in a standard sensory laboratory (in order to guarantee objectivity as far as the sample brand names are concerned). The samples were evaluated by the same sensory commission. Strict confidentiality rules were observed during testing.

All testing posts in the sensory laboratory had identical conditions. The room temperature was approximately 20 °C and relative humidity was between 60 and 75 %. Lighting of the room was also the same throughout the experiment. The commission were given representative mayonnaise samples of 5 g placed on white china plates. The sensory commission assessed the samples separately one by one in groups composed of 6 samples. To neutralise the taste, the commission used the middle part of white bread and tepid lemon-flavoured water (concentration 1 %). The break between the groups to be tasted was one hour. At all times of tasting of the stored mayonnaise, fresh standard mayonnaise was provided as reference sample. The test had three rounds, meaning that each mayonnaise sample had been prepared by following the same recipe in three batches.

For the purpose of evaluation, the commission decided in favour of and applied the analytical-descriptive test on the basis of a preliminary testing. The analysis was performed by scoring sensory attributes by assigning a non-structured scale from 1 to 7 points, where higher score means more expressed attribute. Sensory descriptors of mayonnaise are the following:

- *Appearance:* colour hue (intensity of yellow colour), stability of emulsion, shine
- *Odour:* odour characteristic, acid odour
- *Flavour:* flavour characteristic, acid flavour, after taste, saltiness, rancidity
- *Texture:* density, homogeneity, mouth feeling
- Overall acceptability

Table 1. Basic statistical parameters, sources of variability and their significance

	Statistical parameter						Sources of variability (significance)						
	N	$\bar{x}$	Min	Max	SD	KV (%)	M	t	τ	R	P	M*t*τ	Rsd
Sensory attributes (1–7 points)													
Colour hue[1]	108	3.73	2.00	5.00	0.64	17.23	***	ns	***	ns	ns	ns	0.34
Stability	108	6.44	4.50	7.00	0.72	11.12	***	***	***	*	ns	***	0.38
Shine	108	5.79	4.50	7.00	0.70	12.16	***	ns	***	ns	*	ns	0.31
Density[1]	108	4.70	3.00	5.50	0.71	15.04	***	**	***	ns	ns	*	0.39
Homogeneity	108	5.68	4.50	7.00	0.69	12.24	***	ns	***	ns	ns	***	0.33
Mouth feeling	108	5.47	4.00	6.50	0.93	17.07	***	ns	**	ns	**	***	0.45
Odour characteristic	108	5.51	4.50	7.00	0.44	7.98	***	ns	***	ns	**	ns	0.33
Acid odour	108	2.55	1.50	4.00	0.69	27.19	***	ns	**	***	ns	***	0.51
Flavour characteristic	108	5.31	4.00	6.50	0.60	11.29	***	***	***	ns	*	ns	0.45
Acid flavour[1]	108	4.69	4.00	6.00	0.59	12.60	***	ns	***	***	**	***	0.40
After taste	108	1.26	1.00	2.00	0.37	29.47	***	*	*	ns	ns	*	0.28
Saltiness[1]	108	4.00	3.00	4.50	0.26	6.39	***	ns	***	*	***	ns	0.20
Rancidity	108	1.30	1.00	3.50	0.62	47.47	**	***	***	ns	ns	***	0.33
Overall acceptability	108	5.32	4.00	6.50	0.59	10.99	***	***	***	ns	ns	ns	0.43
Physico-chemical parameters													
pH value	36	4.06	3.27	4.38	0.37	9.11	***	***	***	ns	ns	***	0.03
Acid value (mL NaOH/g)	48	7.19	5.36	11.13	1.73	24.02	***	***	***	***	ns	***	0.18
Peroxide value (mmol O_2/kg)	48	1.57	0.53	3.18	0.95	60.59	***	***	***	***	ns	***	0.16

N – number of tests; $\bar{x}$ – average value; Min – minimum value; Max – maximum value; SD – standard deviation; KV (%) – coefficient of variability; M – effect of mayonnaise; t – effect of temperatures; τ – effect of time; R – effect of repetition (batch); P – effect of assessor or parallel; M*t*τ – triple interaction (effect of mayonnaise type, storage temperatures and storage time); *** ($P \le 0.001$) – statistically very highly significant; ** ($P \le 0.01$) – statistically highly significant; * ($P \le 0.05$) – statistically significant; ns ($P > 0.05$) – statistically non-significant; Rsd – residual standard deviation; [1] – 4.00 points – optimal expressed sensory attribute.

Physico-chemical analyses

- *pH value* was measured directly using a pH meter (Testosterm 2300) with combined glass electrode.
- *acid value* (AV) was determined by using 5.0 g of thoroughly stirred mayonnaise which was mixed with 100 mL of distilled water. Titration was carried out with 0.1 M NaOH using as indicator 1 % ethanol solution of phenolphtalein.

$$AV = \frac{V \cdot 10}{m} \qquad /1/$$

V = volume of 0.1 M solution of NaOH (mL)

m = mass of mayonnaise sample (g)

- Determination of *peroxide value* (PV) using the modified method according to (*17,20,21*).

Extraction of oil from mayonnaise

To approximately 10 g of mayonnaise in an Erlenmeyer flask about 25 mL of ether was added. The flask was covered and the mixture was stirred for 15 min. Then 5 g of anhydrous sodium sulphate was added in order to remove water from the mixture. Samples were filtered using a folded filter paper into a flask with a round bottom and ether was evaporated in a Devarot apparatus (Elektromedicina – Ljubljana).

Statistics

Statistical analysis was conducted on the data using statistical software package SAS-STAT (*22*). Analysis of variance for all attributes was done using the least square method in the general linear model procedure (GLM). The statistical model for sensory and physico-chemical parameters includes the effect of the mayonnaise composition (M), storage temperature (t), storage time (τ), repetition (R), and assessor parallel (P).

$$y_{ijklmn} = \mu + M_i + t_j + \tau_k + R_l + P_m + e_{ijklmn} \qquad /2/$$

where y_{ijklmn} is the measured value, μ population mean, M_i the effect of mayonnaise composition (i = S – standard; i = L – light), t_j = effect of storage temperatures (j = 1: 5–8 °C; j = 2: 20–25 °C), τ_k effect of storage time (k = 0: time 0; k = 1: after one month; k = 2: after two months), R_l effect of repetition (l = 1–3), P_m = effect of assessor or parallel (m = 1–3), e_{ijklmn} random error. The mean value for experimental groups was calculated using the LSM procedure ($P \le 0.05$) (*22*). The correlation coefficient within sensory and physico-chemical parameters is calculated using CORR with SAS (*22*).

Results and Discussion

The results of sensory and physico-chemical analyses are shown in Tables 1–5.

Coefficient of variability and sources of variability

Among all sensory attributes on the basis of KV (%), rancidity shows the greatest fluctuations, but not in the difference between minimum and maximum value, while saltiness varies less than other attributes (Table 1). A high degree of variability was associated with peroxide value, while pH value was less variable.

All sensory attributes and physico-chemical parameters of mayonnaise were significantly affected by the mayonnaise type and storage time. Storage temperature affected significantly only the physico-chemical parameters and some sensory attributes.

Calculated interactions showed that the type of mayonnaise together with temperature and storage time significantly influence most of the rheological and flavour sensory qualities and all valued physico-chemical parameters, which is confirmed by the findings (*4,11,19*).

Effect of type of mayonnaise

Fresh mayonnaise

A comparison between fresh standard mayonnaise containing 75 % of oil and light mayonnaise with 49 % of oil showed statistically significant differences in colour hue, shine, density, homogeneity, mouth feeling, acid odour and flavour, after taste, overall acceptability and acid value ($P \leq 0.001$), as well as in odour characteristic ($P \leq 0.05$) (Table 2).

Colour of light mayonnaise was evaluated as too pale and dense, mainly due to thickening agents, which is confirmed by the findings (*3,4,6*). In standard mayonnaise there was strong acid odour, which was also reflected on acid flavour, whereas in light mayonnaise it was less pronounced. After taste in fresh standard mayonnaise was not detected, but it was clearly perceived in light mayonnaise. The distribution of oil in mayonnaise also affected a number of sensory attributes, such as flavour (*8,9*). Fresh standard mayonnaise samples were better evaluated than light ones in terms of shine, homogeneity, mouth feeling and overall acceptability.

Acid value of fresh light mayonnaise was higher than of standard one. Fresh mayonnaise samples did not differ in pH and peroxide values. pH value of our mayonnaise types was similar to data refered by (*10,11*).

Mayonnaise after cold storage

After *one month* of cold storage at 5–8 °C, mayonnaise samples with different oil content differed significantly in colour hue, shine, density, homogeneity and mouth feeling ($P \leq 0.001$), as well as in the flavour characteristic ($P \leq 0.01$) and stability, odour characteristic and saltiness ($P \leq 0.05$) (Table 2).

In comparison with fresh mayonnaise samples, the colour hue of standard mayonnaise was assessed near ideal (4.00 points), while light mayonnaise samples were rather pale. Shine and homogeneity improved in all mayonnaise types although standard mayonnaise had a better score than the light one. Density of standard mayonnaise had an optimal score, light mayonnaise samples were evaluated as too thick. After one month of storage, density of all mayonnaise samples decreased probably due to change of emulsion structure.

After *two months* of cold storage the most significant differences between two types of mayonnaise were noted ($P \leq 0.001$) in colour hue, shine, density, odour characteristic, acid and peroxide values, while the differences in homogeneity ($P \leq 0.01$) were less distinct, and the least differences were noted regarding stability, mouth feeling, acid flavour and saltiness ($P \leq 0.05$).

After two months of storage, colour hue was very close to that of a fresh mayonnaise. Shine improved during storage and became glossier and more pronounced in standard mayonnaise. Density of mayonnaise decreased, and while standard samples remained too thick, light mayonnaise approached optimal me-

Table 2. Effect of the type of mayonnaise on their sensory attributes and physico-chemical parameters

Storage temperature	t_1			t_1						t_2					
Storage time	τ_0			τ_1			τ_2			τ_1			τ_2		
Type of mayonnaise	S	L	Sign.	S	L	Sign.	S	L	Sign.	S	L	Sign.	S	L	Sign.
Sensory attributes (1–7 points)															
Colour hue[1]	4.39	3.39	***	3.94	2.94	***	4.28	3.11	***	4.22	3.00	***	4.33	3.39	***
Stability	7.00	7.00	–	5.89	6.33	*	6.67	7.00	*	5.50	6.22	**	5.17	6.50	***
Shine	6.22	4.94	***	6.44	5.17	***	6.56	5.33	***	6.67	5.39	***	6.28	5.33	***
Density[1]	4.50	5.44	***	4.06	5.22	***	4.39	5.33	***	3.78	5.17	***	3.78	4.78	**
Homogeneity	6.17	4.78	***	6.56	5.06	***	6.11	5.44	**	6.44	5.06	***	5.94	5.61	**
Mouth feeling	6.44	4.11	***	6.06	5.11	***	6.17	5.33	*	5.94	5.06	***	6.17	4.72	***
Odour characteristic	5.61	5.17	*	6.11	5.67	*	5.67	5.11	***	5.50	5.78	ns	5.61	5.17	***
Acid odour	3.17	1.89	***	2.28	2.06	ns	2.67	3.06	ns	2.44	2.72	ns	2.33	2.94	*
Flavour characteristic	5.67	5.28	ns	6.06	5.56	**	5.11	5.06	ns	5.17	5.50	ns	4.94	4.39	***
Acid flavour[1]	5.28	4.22	***	4.39	4.22	ns	4.83	5.28	*	4.33	4.83	ns	4.56	4.78	ns
After taste	1.00	1.61	***	1.06	1.39	ns	1.06	1.06	ns	1.67	1.17	**	1.06	1.44	*
Saltiness[1]	3.78	3.89	ns	4.00	4.17	*	4.00	4.17	*	4.17	4.00	ns	4.00	4.17	*
Rancidity	1.00	1.00	–	1.00	1.00	-	1.56	1.22	ns	1.28	1.00	*	1.61	2.89	***
Overall acceptability	5.94	5.28	***	5.56	5.28	ns	5.61	5.17	ns	4.78	5.33	**	5.33	4.39	***
Physico-chemical parameters															
pH value	4.36	4.32	ns	4.33	4.27	ns	4.22	4.16	ns	3.76	3.89	*	3.43	3.28	*
Acid value (mL NaOH/g)	5.66	6.55	***	–	–	–	6.49	6.98	***	–	–	–	8.55	11.07	***
Peroxide value (mmol O_2/kg)	0.67	0.77	ns	–	–	–	1.73	2.55	***	–	–	–	2.54	2.86	**

t_1 = 5–8 °C; t_2 = 20 – 25 °C; τ_0 – fresh mayonnaise (tests start); τ_1 – one-month storage; τ_2 – two-months storage; S – standard mayonnaise; L – light mayonnaise; *** ($P \leq 0.001$) – statistically very highly significant; ** ($P \leq 0.01$) – statistically highly significant; * ($P \leq 0.05$) – statistically significant; ns ($P > 0.05$) – statistically non-significant; [1] – 4.00 points – optimal expressed sensory attribute.

dium density. Standard mayonnaise had more characteristic odour than light one.

Acid value increased strongly in all samples, standard mayonnaise had lower acid and peroxide values in comparison with light mayonnaise. In comparison with standard mayonnaise, after both storage times and temperatures, light mayonnaise with greater water content, contained more bacteria according to standard plate count, among which lactic acid bacteria. Because of the activity of lactic acid bacteria, pH value of mayonnaise during storage was declining, while the acid value was rising (our unpublished data).

Mayonnaise after storage at room temperature

After *one month* of storage at room temperature (20–25 °C), two types of mayonnaise differed significantly in majority of analysed attributes except in odour and flavour components (Table 2). Light mayonnaise became pale, and also in standard mayonnaise the hue of yellow colour was less expressive but shine improved in both types of mayonnaise. Major changes occurred regarding density, which dropped significantly, primarily in standard mayonnaise becoming sensorially unacceptable. Light mayonnaise samples were assessed as being excessively dense. Storage at room temperature leads to dissociation of mayonnaise emulsion, which is in accordance with published data (*1,13*). After one month of storage at room temperature, light mayonnaise had better mouth feeling than fresh samples although it was still inferior to standard mayonnaise.

After *two months* of storage at room temperature, both types of mayonnaise were altered considerably ($P \leq 0.001$) in colour hue, stability, shine, mouth feeling, odour characteristic, flavour characteristic, rancidity, overall acceptability and acid value. The type of mayonnaise had a statistically significant effect on density, homogeneity and peroxide value ($P \leq 0.01$), as well as on acid odour, after tastes, saltiness, and pH value ($P \leq 0.05$).

After two months of storage, colour hue improved with respect to one month of storage in all mayonnaise samples and approached values of fresh mayonnaise. Stability of light mayonnaise was better than of standard samples, where it decreased from one month to the next. Standard mayonnaise had a more distinct shine in comparison with light mayonnaise. After two months of storage, standard mayonnaise had better mouth feeling in comparison with one month of storage at the same temperature, while light mayonnaise deteriorated. Odour characteristics of mayonnaise types after two months of storage at room temperature were equally evaluated as in the fresh samples. Flavour characteristic strongly deteriorated in all samples of mayonnaise. High storage temperature strongly influenced rancidity with storage time (the same as in ref. *14,15,18*), and it was even more pronounced in light mayonnaise. Overall acceptability was assessed as significantly higher in standard mayonnaise in comparison with light mayonnaise.

After two months of storage, mayonnaise types with different oil content differed in acid value, which sharply increased in light mayonnaise.

Effects of storage temperature

Standard mayonnaise

Table 3 shows a statistically significant increase ($P \leq 0.01$) of pH value of one-month cold stored standard mayonnaise. In addition, cold storage also significantly increases ($P \leq 0.05$) odour, flavour, acid odour and acid

Table 3. Effect of storage temperature on sensory attributes and physico-chemical parameters of mayonnaise

Type of mayonnaise	S						L					
Storage time	τ_1			τ_2			τ_1			τ_2		
Storage temperature	t_1	t_2	Sign.	t_1	t_2	Sign.	t_1	t_2	Sign.	t_1	t_2	Sign.
Sensory attributes (1–7 points)												
Colour hue[1]	3.94	4.22	ns	4.28	4.33	ns	2.94	3.00	ns	3.11	3.39	**
Stability	5.89	5.50	ns	6.67	5.17	***	6.33	6.22	ns	7.00	6.50	**
Shine	6.44	6.67	ns	6.56	6.28	ns	5.17	5.39	ns	5.33	5.33	ns
Density[1]	4.06	3.78	ns	4.39	3.78	**	5.22	5.17	ns	5.33	4.78	**
Homogeneity	6.56	6.44	ns	6.11	5.94	ns	5.06	5.06	ns	5.44	5.61	ns
Mouth feeling	6.06	5.94	ns	6.17	6.17	ns	5.11	5.06	ns	5.33	4.72	**
Odour characteristic	6.11	5.78	*	5.67	5.61	ns	5.67	5.50	ns	5.11	5.17	ns
Acid odour	2.28	2.72	*	2.67	2.33	ns	2.06	2.44	ns	3.06	2.94	ns
Flavour characteristic	6.06	5.50	*	5.11	4.94	ns	5.56	5.17	ns	5.06	4.39	**
Acid flavour[1]	4.39	4.83	*	4.83	4.56	ns	4.22	4.33	ns	5.28	4.78	**
After taste	1.06	1.17	ns	1.06	1.06	ns	1.39	1.67	ns	1.06	1.44	*
Saltiness[1]	4.00	4.00	–	4.00	4.00	-	4.17	4.17	ns	4.17	4.17	–
Rancidity	1.00	1.00	–	1.56	1.61	ns	1.00	1.28	*	1.22	2.89	***
Overall acceptability	5.56	5.33	ns	5.61	5.33	ns	5.28	4.78	*	5.17	4.39	***
Physico-chemical parameters												
pH value	4.33	3.89	**	4.22	3.43	***	4.27	3.76	**	4.16	3.28	***
Acid value (mL NaOH/g)	–	–	–	6.49	8.55	***	–	–	–	6.98	11.07	***
Peroxide value (mmol O_2/kg)	–	–	–	1.73	2.54	***	–	–	–	2.55	2.86	***

t_1 = 5–8 °C; t_2 = 20–25 °C; τ_1 – one-month storage; τ_2 – two-months storage; S – standard mayonnaise; L – light mayonnaise; *** ($P \leq 0.001$) – statistically very highly significant; ** ($P \leq 0.01$) – statistically highly significant; * ($P \leq 0.05$) – statistically significant; ns ($P > 0.05$) – statistically non-significant; [1] – 4.00 points – sensory expressed optimal attribute.

flavour. All these attributes were better evaluated after storage at a lower temperature.

After two months, standard mayonnaise types stored at different temperatures showed significantly altered ($P \leq 0.001$) stability, pH, acid and peroxide values and also significantly ($P \leq 0.01$) affected density. Cold stored samples were in comparison with those stored at room temperature more dense and stabile, they had a higher pH value, lower acid and peroxide values.

Light mayonnaise

One month of storage of light mayonnaise under two temperature regimes had a statistically significant influence on pH value ($P \leq 0.01$) as well as on rancidity and overall acceptability ($P \leq 0.05$) (Table 3). Cold stored samples had a higher pH value, better overall acceptability, whereas rancidity developed at higher temperature.

After two months of storage at different temperatures, the samples of light mayonnaise showed significant differences as regards rancidity, overall acceptability, pH, acid and peroxide values ($P \leq 0.001$), colour hue, stability, density, mouth feeling, flavour characteristic and acid flavour ($P \leq 0.01$) as well as after taste ($P \leq 0.05$). Cold stored samples had better sensory quality for the majority of evaluated attributes: lower acid and peroxide values, lower rancidity, better overall acceptability and higher pH value than mayonnaise stored at room temperature.

Table 4. Effect of storage time on sensory attributes and physico-chemical parameters of mayonnaise

Storage temperature	t_1				t_2			
Storage time	τ_0	τ_1	τ_2	Sign.	τ_0	τ_1	τ_2	Sign.
				STANDARD MAYONNAISE				
Sensory attributes (1–7 points)								
Colour hue[1]	4.39^{b}	3.94^{a}	4.28^{b}	*	4.39^{a}	4.22^{a}	4.33^{a}	ns
Stability	7.00^{b}	5.89^{a}	6.67^{b}	***	7.00^{c}	5.50^{b}	5.17^{a}	***
Shine	6.22^{a}	6.44^{ab}	6.56^{b}	ns	6.22^{a}	6.67^{b}	6.28^{a}	**
Density[1]	4.50^{b}	4.06^{a}	4.39^{ab}	ns	4.50^{b}	3.78^{a}	3.78^{a}	***
Homogeneity	6.17^{a}	6.56^{b}	6.11^{a}	*	6.17^{ab}	6.44^{b}	5.94a	**
Mouth feeling	6.44^{a}	6.06^{a}	6.17^{a}	ns	6.44^{b}	5.94^{a}	6.17^{ab}	*
Odour characteristic	5.61^{a}	6.11^{b}	5.67^{a}	*	5.61^{a}	5.78^{a}	5.61^{a}	ns
Acid odour	3.17^{b}	2.28^{a}	2.67^{ab}	**	3.17^{b}	2.72^{ab}	2.33^{a}	**
Flavour characteristic	5.67^{b}	6.06^{b}	5.11^{a}	**	5.67^{b}	5.50^{b}	4.94^{a}	***
Acid flavour[1]	5.28^{c}	4.39^{a}	4.83^{b}	***	5.28^{b}	4.83^{ab}	4.56^{a}	**
After taste	1.00^{a}	1.06^{a}	1.06^{a}	ns	1.00^{a}	1.17^{a}	1.06^{a}	ns
Saltiness[1]	3.78^{a}	4.00^{b}	4.00^{b}	*	3.78^{a}	4.00^{b}	4.00^{b}	ns
Rancidity	1.00^{a}	1.00^{a}	1.56^{b}	**	1.00^{a}	1.00^{a}	1.61^{b}	***
Overall acceptability	5.94^{a}	5.56^{a}	5.61^{a}	ns	5.94^{b}	5.33^{a}	5.33^{a}	**
Physico-chemical parameters								
pH value	4.36^{b}	4.33^{b}	4.22^{a}	***	4.36^{c}	3.89^{b}	3.43^{a}	***
Acid value (mL NaOH/g)	5.66	–	6.49	***	5.66	–	8.55	***
Peroxide value (mmol O_2/kg)	0.67	–	1.73	***	0.67	–	2.54	***
				LIGHT MAYONNAISE				
Sensory attributes (1 – 7 points)								
Colour hue[1]	3.39^{b}	2.94^{a}	3.11^{ab}	*	3.39^{b}	3.00^{a}	3.39^{b}	*
Stability	7.00^{b}	6.33^{a}	7.00^{b}	***	7.00^{b}	6.22^{a}	6.50^{a}	**
Shine	4.94^{a}	5.17^{ab}	5.33^{b}	*	4.94^{a}	5.39^{b}	5.33^{b}	*
Density[1]	5.44^{b}	5.22^{a}	5.33^{ab}	ns	5.44^{b}	5.17^{ab}	4.78^{a}	**
Homogeneity	4.78^{a}	5.06^{a}	5.44^{b}	**	4.78^{a}	5.06^{a}	5.61^{b}	***
Mouth feeling	4.11^{a}	5.11^{b}	5.33^{b}	***	4.11^{a}	5.06^{c}	4.72^{b}	***
Odour characteristic	5.17^{a}	5.67^{b}	5.11^{a}	**	5.17^{a}	5.50^{b}	5.17^{a}	*
Acid odour	1.89^{a}	2.06^{a}	3.06^{b}	***	1.89^{a}	2.44^{b}	2.94^{b}	**
Flavour characteristic	5.28^{ab}	5.56^{b}	5.06^{a}	ns	5.28^{b}	5.17^{b}	4.39^{a}	***
Acid flavour[1]	4.22^{a}	4.22^{a}	5.28^{b}	***	4.22^{a}	4.33^{a}	4.78^{b}	*
After taste	1.61^{b}	1.39^{b}	1.06^{a}	**	1.61^{a}	1.67^{a}	1.44^{a}	ns
Saltiness[1]	3.89^{b}	4.17^{a}	4.17^{a}	***	3.89^{a}	4.17^{b}	4.17^{b}	*
Rancidity	1.00^{a}	1.00^{a}	1.22^{b}	**	1.00^{a}	1.28^{a}	2.89^{b}	***
Overall acceptability	5.28^{a}	5.28^{a}	5.17^{a}	ns	5.28^{c}	4.78^{b}	4.39^{a}	***
Physico-chemical parameters								
pH value	4.32^{c}	4.27^{b}	4.16^{a}	***	4.32^{c}	3.76^{b}	3.28^{a}	***
Acid value (mL NaOH/g)	6.55	–	6.98	**	6.55	–	11.07	***
Peroxide value (mmol O_2/kg)	0.77	–	2.55	***	0.77	–	2.86	***

t_1 = 5–8 °C; t_2 = 20–25 °C; τ_0 – fresh mayonnaise (test start); τ_1 – one-month storage; τ_2 – two-months storage; *** ($P \leq 0.001$) – statistically very highly significant; ** ($P \leq 0.01$) – statistically highly significant; * ($P \leq 0.05$) – statistically significant; ns ($P > 0.05$) – statistically non-significant; [a,b,c]- average value within individual group are not significant ($P > 0.05$); [1] – 4.00 points – optimal expressed sensory attribute.

Effect of storage time

Standard mayonnaise

The storage time in the case where the samples were kept in a cold place (t_1 = 5–8 °C) had a significant effect (P ≤ 0.001) on stability, acid flavour, pH, acid and peroxide values (Table 4). The length of storage at room temperature (t_2 = 20–25 °C) had a significant influence (P ≤ 0.001) on mayonnaise stability, density, flavour characteristic, rancidity, pH, acid and peroxide values.

At a higher storage temperature, stability of standard mayonnaise was deteriorating throughout the storage, while at a lower temperature, it occurred only after the first month. Acid flavour of mayonnaise lowered significantly after the first month in the refrigerator, but increased again after the second month. pH value declined markedly at higher storage temperature, whereas acid and peroxide values increased.

After the first month of storage of standard mayonnaise at room temperature, its density decreased, which was preserved even after the second month of storage. During storage flavour characteristic and overall acceptability deteriorated. Rancidity in mayonnaise was detected only after two months of storage.

Light mayonnaise

Storage time had a significant impact (P ≤ 0.001) on stability, mouth feeling, acid odour and flavour, saltiness, pH and peroxide values for samples stored at t_1 = 5–8 °C (Table 4). When stored at room temperature (t_2 = 20–25 °C), the storage time had a significant influence (P ≤ 0.001) on homogeneity, mouth feeling, flavour characteristic, rancidity, overall acceptability, pH, acid and peroxide values.

After one month of cold storage, stability of light mayonnaise deteriorated, while after two months it was at the same level as stability of fresh mayonnaise. During storage, mouth feeling improved, acid odour and flavour increased, while pH value dropped, particularly at higher temperature, probably due to activity of Lactic acid bacteria. After a two-month storage, peroxide value of mayonnaise increased, particularly at higher temperature accelerating lipid oxidation.

The homogeneity was improved and the flavour characteristic deteriorated in light mayonnaise after storage at room temperature. Rancidity and acid value in mayonnaise increased, while overall acceptability decreased.

Correlations

Table 5 shows that mayonnaise shine is in negative correlation with density and in positive correlation with homogeneity. Consequently, it means that mayonnaise with better shine is also less thick and more homogenous. Shine and homogeneity are in positive correlation with the mouth feeling. Mayonnaise with more pronounced acid odour had a higher acid flavour. Rancidity is in negative correlation with pH value meaning that lipid oxidation increased in more acid conditions. There is a positive correlation between rancidity and acid value or peroxide value. Negative correlations exist between the overall acceptability of the mayonnaise and the acid value, which results in a high score for overall acceptability in mayonnaise with low acid value. The acid value is in positive correlation with the peroxide value, and both are in negative correlation with the pH value.

Table 5. Selected (r > 0.70) correlation coefficients between certain quality parameters of mayonnaise

		Correlation coefficient
Shine *vs.*	Density	– 0.73***
	Homogeneity	0.78***
Density *vs.*	Homogeneity	– 0.71***
Mouth feeling *vs.*	Shine	0.71***
	Homogeneity	0.76***
Acid odour *vs.*	Acid flavour	0.74***
Rancidity *vs.*	pH value	– 0.72***
	Acid value	0.84***
	Peroxide value	0.72***
Overall acceptability *vs.*	Acid value	– 0.71***
pH value *vs.*	Acid value	– 0.93***
	Peroxide value	– 0.79***
Acid value *vs.*	Peroxide value	0.79***

*** (P ≤ 0.001) – statistically highly significant.

Calculated high correlations between chemical indicators of lipid degradation in mayonnaise (acid and peroxide values) and their sensory attributes of rancidity give an indication of appropriate selected chemical methods.

Microstructure of mayonnaise with different oil content

The microstructure (microscope: AMR LEITZ 1605 T) of fresh standard mayonnaise shows smaller oil droplets and their better dispersion in comparison with fresh light mayonnaise with greater content of water phase (Figs. 1 and 2) what confirms the findings of other researches (*1,2*).

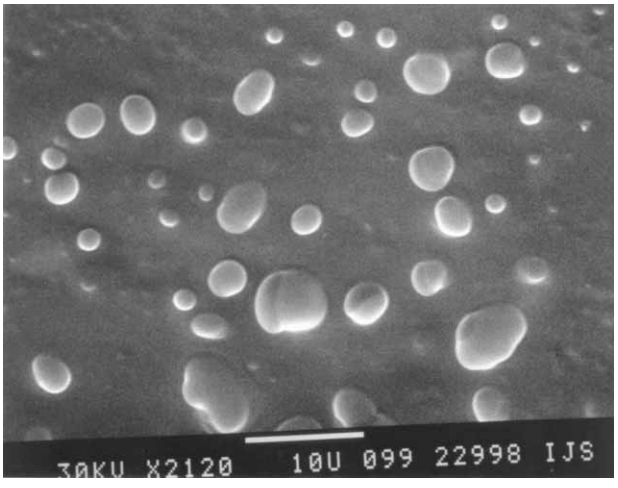

Fig. 1. Microstructure of fresh standard mayonnaise (× 2120)

Conclusions

The results of sensory and physico-chemical analyses of mayonnaise lead to the following conclusions:

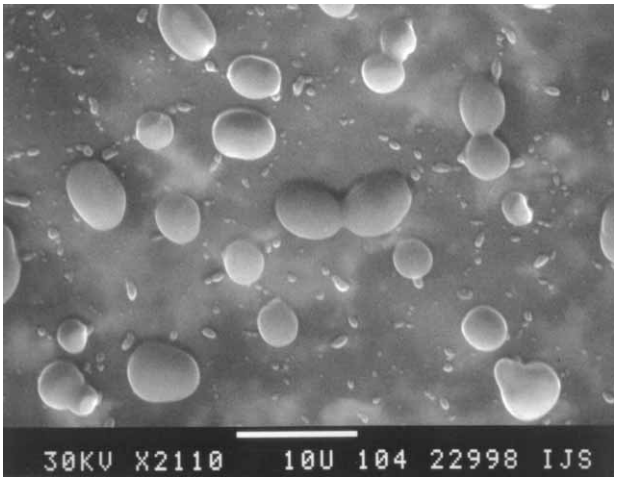

Fig. 2. Microstructure of fresh light mayonnaise (× 2110).

Fresh standard mayonnaise containing 75 % of oil in comparison with light mayonnaise (49 % of oil) had significantly better score for its sensory attributes (shine, homogeneity, mouth feeling, after tastes, overall acceptability).

Storage had an adverse impact on colour hue, stability, density, saltiness, and overall acceptability of all mayonnaise samples already after one month of storage.

Both types of mayonnaise showed better emulsion stability after two months of storage but worse flavour components compared to samples stored for one month.

Light mayonnaise had a lower pH value and a higher acid value in comparison with standard mayonnaise. During storage, regardless of conditions, pH value of both types of mayonnaise was declining, while the acid value was rising.

Storage temperature, time and the type of mayonnaise had a very highly significant impact on stability, homogeneity, mouth feeling, acid odour and flavour, rancidity, pH, acid and peroxide values.

Peroxide value increased in all mayonnaise samples after being stored for two months irrespective of the storage temperature.

Some meaningful statistically significant correlations ($r > 0.70$) between sensory and physico-chemical parametres of mayonnaise exist.

The results of sensory and physico-chemical analyses of mayonnaises indicate to the lower quality and stability of light mayonnaise.

The results of the study examining the effects of individual factors on stability of mayonnaise have shown that the approach to the problem is highly complex. By storing mayonnaise at room temperature, sensory and chemical qualities of product soon deteriorate. Therefore, it is essential to keep mayonnaise at temperature between 5 and 8 °C, in order to better preserve its sensory attributes and physico-chemical parametres.

Reference

1. D. J. McClements, K. Demetriades, *Crit. Rev. Food Sci. Nutr. 38* (1998) 511–536.
2. D. J. McClements: *Food Emulsions: Principles, Practise, and Techniques*, CRC Press, Boca Raton (1999) p. 378.
3. M. Arnell, *Livsmedelsteknik, 32* (1990) 36–38.
4. L. Daugaard, *Food Mark. Technol. 7* (1993) 8–10.
5. M. Peleg: Physical Characteristics of Food Powders. In: *Physical Attributes of Foods*, M. Peleg, E. B. Bagley (Eds.), AVI Publishing Co., Westport (1983) pp. 293–324.
6. J. Giese, *Food Technol. 49* (1995) 54–63.
7. M. Dickie, J. L. Kokini, *J. Food Sci. 48* (1983) 57–65.
8. P. Lillford, J. M. V. Blanshard: *Food Structure and Behaviour*, Academic Press, London (1987) p. 291.
9. J. Giese, *Food Technol. 48* (1994) 106–116.
10. J. Chirife, M. S. Vigo, R. G. Gomez, G. J. Favetto, *J. Food Sci. 54* (1989) 1658–1659.
11. C. Martinez, A. Mucci, M. J. Santa Cruz, G. Hough, R. Sanchez, *J. Sens. Stud. 13* (1998) 331–346.
12. R. Xiong, G. Xie, A. S. Edmondson, *Food Control, 11* (2000) 49–56.
13. M. Pons, M. J. Galotto, S. Subirats, *Food Hydrocol. 8* (1994) 389–400.
14. T. J. Weiss: Mayonnaise and Salad Dressings. In: *Food Oils and their Uses*, AVI Publishing Co., Westport (1983) pp. 211–246.
15. C. Jacobsen, *J. Agric. Food Chem. 47* (1999) 4917–4926.
16. S. T. Lahtinen, B. K. Ndabikunze, *Lebensm. – Wiss. + Technol. 23* (1990) 99–100.
17. Official Methods of Analysis, AOAC, 15th ed., Arlington (1990) 956–957.
18. L. Stefanov, *Lebensmittelindustrie, 36* (1989) 207–208.
19. R. G. Krishnamurthy, Vernon C. Witte: Cooking Oils, Salad Oils and Oil-Based Dressings. In: *Bailey's Industrial Oil and Fat Products*, Y. H. Hui (Ed.), John Wiley & Sons, Inc., New York, 3 (1996) pp. 193–210.
20. J. Trajković, M. Mirić, J. Baras, S. Šiler: *Analize životnih namirnica*, Tehnološko-metalurški fakultet, Univerzitet u Beogradu, Beograd (1983) pp. 400–425.
21. Standard Methods for the Analysis of Oils, Fats and Derivatives, IUPAC, Oxford (1987) p. 347.
22. SAS / STAT Users Guide. SAS Institute Inc., Cary (1990) pp. 891–1230.

Senzorska kakvoća standardne i lagane majoneze tijekom skladištenja

Sažetak

Ispitan je utjecaj sastojaka na kakvoću i stabilnost dviju vrsta majoneza nakon skladištenja u hladnjaku (t = 5–8 °C) i na sobnoj temperaturi (t = 20–25 °C). Uzorci svježe majoneze ispitani su senzorskom (analitički opisni test) i fizikalno-kemijskom analizom (pH, kiselinski i peroksidni broj), najprije nakon mjesec dana skladištenja, a zatim nakon dva mjeseca. Ispitan je utjecaj pojedinih činitelja, a rezultati su statistički obrađeni. Rezultati pokazuju da je svježa standardna majoneza sa 75 % ulja, za razliku od majoneze s manje masnoće (lagana majoneza sadržava 49 % ulja), bolje ocijenjena prema svim senzorskim značajkama. Temperatura i vrijeme skladištenja te vrsta majoneze bitno utječu ($P \leq 0{,}001$) na stabilnost, homogenost, okus u ustima, kiselinski miris, okus, užeženost, pH te kiselinski i peroksidni broj. U bilo kojem trenutku skladištenja i pod oba temperaturna uvjeta uzorci su lagane majoneze imali manju pH-vrijednost i viši kiselinski broj u usporedbi sa standardnom majonezom. Bez obzira na uvjete skladištenja i načine njihove priprave dolazi do snizivanja pH-vrijednosti te povisivanja kiselinskog i peroksidnog broja. Postoji određena značajna statistička korelacija ($r > 0{,}70$) između senzorskih i fizikalno-kemijskih parametara majoneze.