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Formulation Strategies for Mayonnaise-Type Sauces: The Role of Hydrocolloid Combinations

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INTRODUCTION & AIM

The modern food industry is actively researching alternative sources of protein to replace traditional animal ingredients. In particular, the use of plant mixtures such as soybean meal and mustard powder is promising due to their unique composition. They contain not only protein emulsifiers, but also additional components, in particular polysaccharides, which act as natural structuring agents and thickeners. In addition, the use of casein instead of egg yolk is not only effective, but also allows the creation of hypoallergenic products with lower microbiological risks. The aim of this study was to investigate the substitution of egg yolk in mayonnaise-type sauces with alternative protein components and to optimize the hydrocolloid composition for improved stability and rheological properties.

SAMPLES FORMULATION

This study investigated the possibility of replacing egg yolk in mayonnaise sauce technology with alternative protein components. Plant proteins were used as emulsifiers and structure formers: mustard powder and soy flour, as well as a composition based on casein and dry cream powder. The influence of ratio of potato starch, carboxymethylcellulose (CMC), pectin, and xanthan gum (0–1% each) on the properties of low-fat mayonnaise formulations (30% oil content) was examined.

Table 1. Samples Formulation

Component (Chemical/General Name)	M1	M2	M3	M4
Sunflower Oil	30.00	30.00	30.00	30.00
Casein	2.00	2.00	2.00	2.00
Soy Flour	1.00	1.00	1.00	1.00
Dry Cream / Dairy Powder	1.00	1.00	1.00	1.00
Mustard Powder	1.00	1.00	1.00	1.00
Sugar	1.50	1.50	1.50	1.50
Salt	1.00	1.00	1.00	1.00
Sodium Bicarbonate	0.05	0.05	0.05	0.05
CMC (Carboxymethylcellulose)	0.50	0.50	0.30	–
Pectin NH	0.50	0.50	0.40	0.70
Xanthan Gum	0.50	–	0.30	0.30
Potato Starch	–	0.5	–	–
Acetic Acid, 5M Solution	3.14	3.14	–	–
Vinegar, 9%	–	–	8.00	8.00
Lactic Acid	–	–	0.40	0.40
Water	42.19	42.19	46.95	46.95
Total	100.00	100.00	100.00	100.00

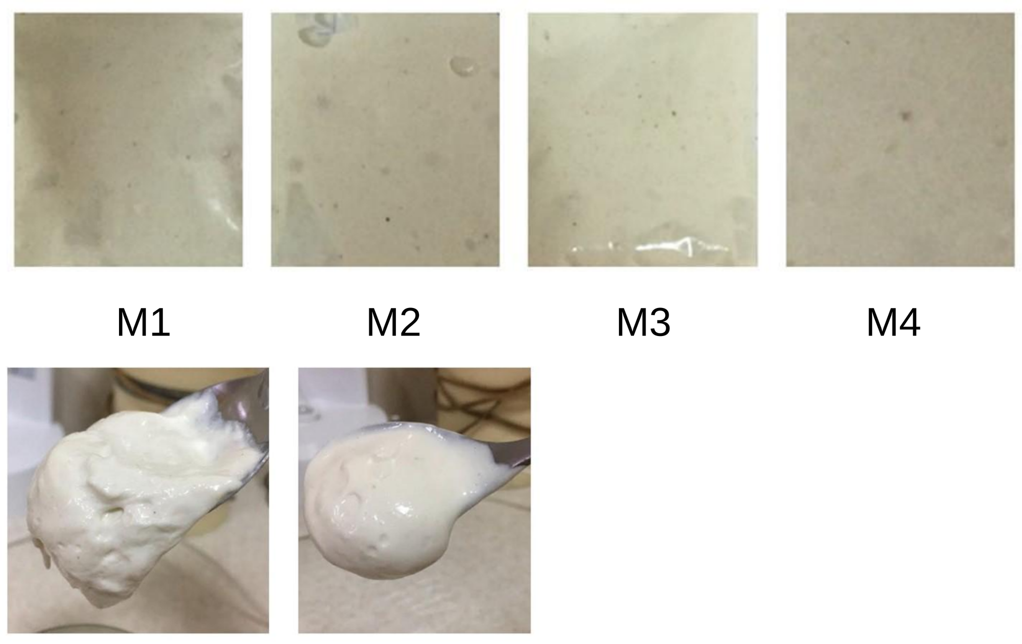


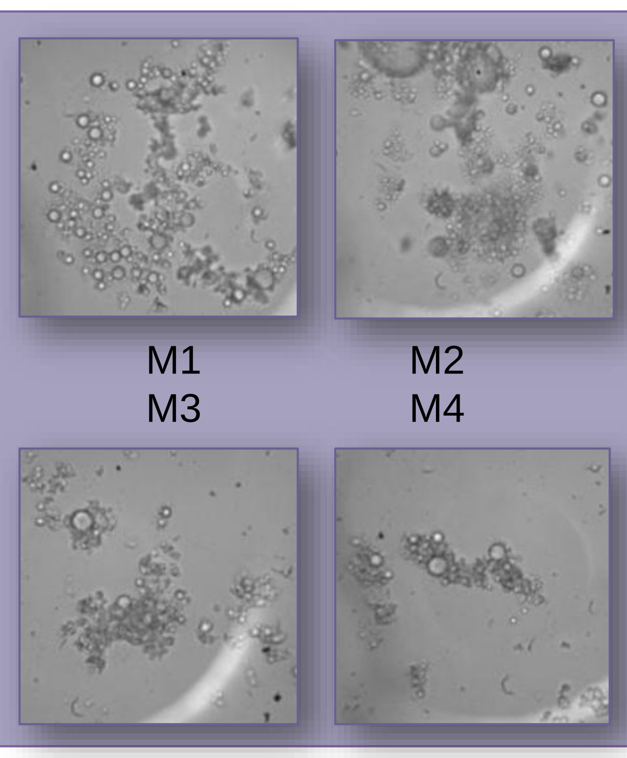
Figure 2. Visual Appearance of Mayonnaise Samples

METHODS

The following methods were used to analyse the samples: particle size determination by microscopy (Micromed microscope with an integrated camera 1k Pixelink and a 60x objective) and laser diffraction (PCA-1190 Anton Paar), viscometry (ViscoQC -300) and potentiometry (pH-150MI). Sedimentation and thermal stability tests revealed high resistance of all samples (98-99%) both after 24 h and following 20–30 days of storage. Optical microscopy confirmed the homogeneity of the structure, with individual dispersed particles of 100–150 µm corresponding to inclusions of plant protein additives.

RESULTS & DISCUSSION

In the diluted micrographs **(Fig.2)**, oil droplets are visualized, surrounded by a significant amount of finer droplets, which may be the result of partial protein flocculation and the formation of polysaccharide-protein complexes adsorbed onto the surface of the oil droplets. The undeniable advantage of microscopy over laser diffraction is the possibility of visualizing the research results; however, the determination of particle size is limited by the resolution of the microscope used, whereas laser diffraction helps to obtain a significantly more complete understanding of the system's composition.



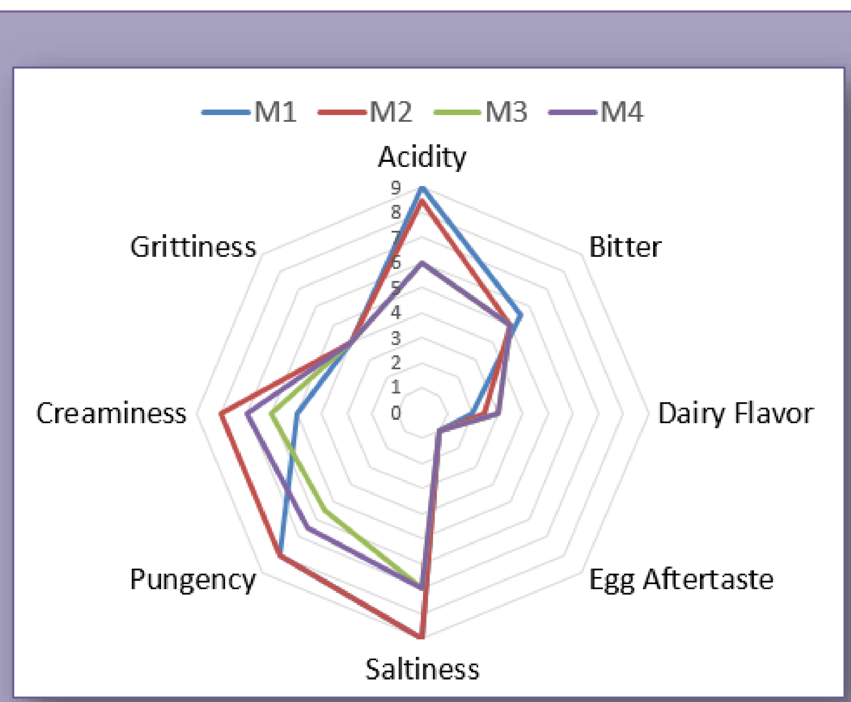


Figure 2. Micrographs of Mayonnaise Sauce Samples.
Figure 3. Sensory Profile (Profilogram) of the Investigated Mayonnaise Sauces.

RESULTS & DISCUSSION

The profilogram shows **(Fig.3)** that samples 1 and 2 are characterized by higher values for the parameters 'acidity - saltiness - pungency,' although the content of salt and mustard is the same in all of them. This may be directly related to the ability of human receptors to 'mix' salty and sour flavors and perceive them as a common level of a specific taste, while the sharp flavor of acetic acid, in turn, adds to the sensation of pungency. Samples 3 and 4, in which the quantity of acetic acid was lower and a acidity regulator – lactic acid – was added, exhibit significantly better characteristics; their flavor is softer and more balanced. The aftertaste of eggs and cream is weakly expressed in all samples. At the same time, the tasters noted a slight 'grittiness' (or 'graininess'), which may be caused by particles of mustard and soy flour. Overall, sample 3 made the best impression on consumers.

Sample	Microscopy	Laser Diffraction, 150 rpm
	Particle Size, mkm	Particle Size, mkm
M1	4.99	4.72
M2	4.50	4.32
M3	4.00	3.92
M4	2.82	3.60

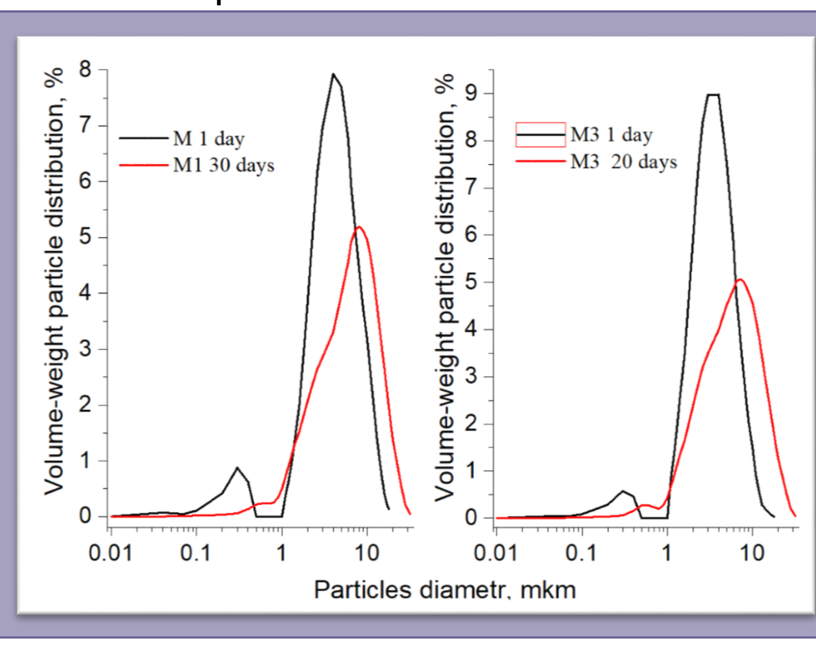
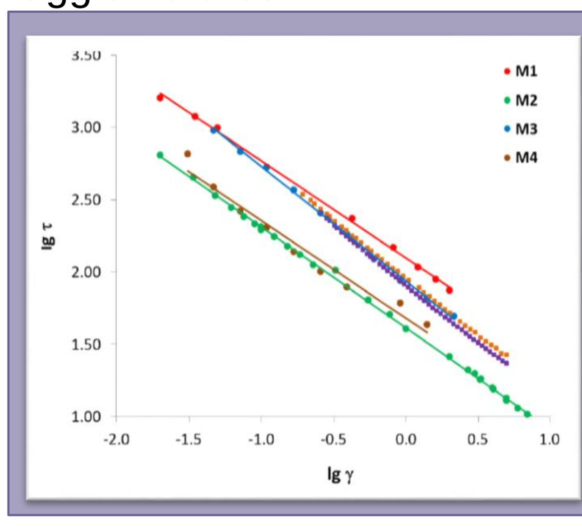


Table 2. Emulsion Particle Sizes Determined by Different Methods (1 day after preparation).
Figure 3. D[4, 3] Distribution for Samples M1 and M3 after Long-Term Storage (30 and 20 Days, Respectively).

The particle size distribution D [4,3] exhibited a bimodal profile, with peaked at 0.1–1 µm and 2–8 µm, indicating efficient homogenization of the emulsions. Storage experiments (near 30 days) demonstrated an increase in particle size by 1.4–1.6 times and a decrease in viscosity, likely due to flocculation and aggregation of polysaccharide clusters into larger agglomerates.



Sample	τ_{stat}, Pa	τ_{dynam}, Pa
M1	112	58,23
M2	Not Reached	-
M3	158	41.88
M4	Not Reached	-

Figure 4. Dependence of Viscosity on Shear Rate for Mayonnaise Samples (in Double Logarithmic Coordinates).
Table 3. Values of Static and Dynamic Yield Stress Determined for the Samples.

The viscosity of all investigated samples decreases with increasing shear rate in the range of 0.02 – 2.00 s^{-1}, as presented in the **Fig.4**. In the low shear region, samples M1 and M3 exhibit higher viscosity, while samples M2 (in which CMC is replaced by starch) and M4 (which is without a thickener) exhibit lower viscosity. The yield stresses were calculated using the Herschel-Bulkley model for this rates region, and the values are physically meaningful only for M1 and M3, indicating their behavior as viscoplastic solids with the presence of a yield point. For the other samples, a negative value for the critical shear stress was obtained, which has no physical sense. Thus, these samples behave as viscoelastic liquids. Experimental confirmation of these conclusions is provided by the experiment to determine the static shear stress or yield stress of the mayonnaise samples (**Table 3**).

CONCLUSION

Among the tested formulations, the sample M3 containing 0.3% CMC, 0.3% xanthan gum, and 0.4% pectin showed the most favorable physicochemical and sensory properties, highlighting the synergistic effect of hydrocolloid blends in stabilizing reduced-fat mayonnaise-type emulsions.

FUTURE WORK / REFERENCES

1. Smittle R. B. Microbiological safety of mayonnaise, salad dressings, and sauces produced in the United States: A review. *Journal of Food Protection*. 2000. Vol. 63, No. 8. P. 1144–1153. doi: 10.4315/0362-028x-63.8.1144.
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