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Effect of Edible Coating of Aromatized Biopolymer on Spatial Distribution of Fat in Gel Emulsion

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ABSTRACT

This study aimed to evaluate the effect of aromatized thin-layer biopolymers on sensory perception in gel emulsions with spatial distribution of fat. An edible coating technique was used with Wijsman butter and cheese-cheese aromas to enhance fat perception without compromising other sensory attributes. Homogeneous gels with 20% fat content were applied with scented and unscented thin-layer biopolymers and then analyzed using the hedonic organoleptic method involving hardness, suppleness, color (transparency), and aroma parameters. The results showed that the scented thin-film biopolymer improved panelists' acceptance of fat aroma perception (score of 7.8), compared to the unscented biopolymer (score of 5.5). Panelists' acceptance of hardness, suppleness, and gel transparency did not differ significantly between the flavored and unscented treatments (values ranged from 7.1 to 7.9). This suggests that the addition of aroma can improve the perception of fat without affecting the physical quality of the gel. The use of aromatized thin-layer biopolymers can be an effective strategy to improve the sensory quality of low-fat food products, which is relevant in efforts to address the prevalence of overnutrition. This study contributes to the development of healthy food technology while maintaining consumer preferences for product texture and visuals.

INTRODUCTION

Indonesia is currently faced with multiple nutrition problems, namely undernutrition that has not been fully addressed and overnutrition or obesity that continues to increase. Both problems can occur in all age groups, including children under five, school-age children, and adolescents. This condition affects life expectancy and the quality of public health, as both undernutrition and overnutrition are closely related to the risk of non-communicable diseases (NCDs) and infections. Data from the 2018 Basic Health Research (RISKESDAS) shows that the nutritional status of adults over 18 years old is dominated by obesity, although the problem of undernutrition has not been resolved. The prevalence of obesity in 2013 was recorded at 14.8% and increased to 21.8% in 2018, while the prevalence of hypertension increased from 25.8% to 34.1%.

The main causes of this increase are lifestyle changes that tend to consume processed foods with high sugar, salt, and fat content, and a lack of physical activity. In addition, obesity is influenced by internal factors such as genetics, as well as external factors such as unhealthy diet and environment (Chou and Chen, 2017). Research on high school students in Makassar also showed an association between energy, fat, and carbohydrate intake with the incidence of obesity

(Permanasari and Aditianti, 2017). Overcoming this problem requires innovative strategies that can reduce the prevalence of NCDs without compromising food sensory acceptability.

One possible solution is to increase the perceived intensity of fat in low-fat foods through a combined method of spatial distribution of fat in the food matrix and aromatized thin-layer biopolymers. Spatial distribution of fat enables heterogeneous distribution of fat in the food matrix, which can enhance flavor intensity despite low fat content (Holm, Wendin, and Hermansson, 2009; Mosca *et al.,* 2010). This technique is also effective for enhancing saltiness perception by heterogeneously distributing salt in bread and salty snacks (Noort *et al.,* 2010). On the other hand, the use of aromatised thin-layer biopolymers as aroma carriers can enhance sensory perception by placing aroma compounds on food surfaces (Nakao *et al.,* 2013a; 2013b). The addition of congruent aromas such as vanilla aroma to enhance sweetness or cocoa aroma to strengthen bitterness in chocolate drinks has been shown to be effective (Labbe *et al.,* 2009). Similar techniques have also been reported to enhance the perception of salty and fatty flavours through the addition of sardine and butter aromas (Syarifuddin *et al.,* 2016).

There have been many studies on the spatial distribution of fat and thin-layer biopolymers (Mosca *et al.,* 2010; Noort *et al.,* 2010; Nakao *et al.,* 2013a; 2013b; Marcuzzo *et al.,* 2010), but studies that combine the two methods have not been reported. Therefore, this study is important to be conducted as an effort to develop healthy low-fat foods that have sensory qualities that are acceptable to the public. The aim of this study was to investigate the relationship between spatial distribution of fat and aromatised thin-layer biopolymers in improving fat perception and sensory quality of low-fat foods.

RESEARCH METHODS

This study evaluated the effect of edible coating of aromatized biopolymer on the spatial distribution of fat in gel emulsion. The research process includes a series of stages, including edible coating for the application of biopolymer coating and sensory analysis to measure the organoleptic characteristics of the treated samples.

Edible Coating

The application of aromatized thin-layer biopolymer solution on fat spatial distribution gel was carried out by the edible coating method. Edible coating is a thin edible layer applied to the surface of food in liquid form. The application process is carried out by immersing the food product into a solution of structural matrix-forming substances such as carbohydrates, proteins, lipids, or a combination of all three (Galus and Kadzińska, 2015). This method has the potential to carry active ingredients, including antimicrobial agents, anti-browning agents, colors, spices, nutrients, aromas, and flavors. In the implementation, a homogeneous fat spatial distribution gel with 20% fat concentration was chosen to be applied with a thin-layer biopolymer solution. The gel was cut to a size of 20 x 20 x 13 mm (length x width x height). Next, the gel samples were immersed in the thin-layer biopolymer solution for 2 minutes according to the treatment and then dried. After the coating process was complete, the coated gels were stored at 4°C before sensory analysis. The research flow chart is shown in Figure 1.

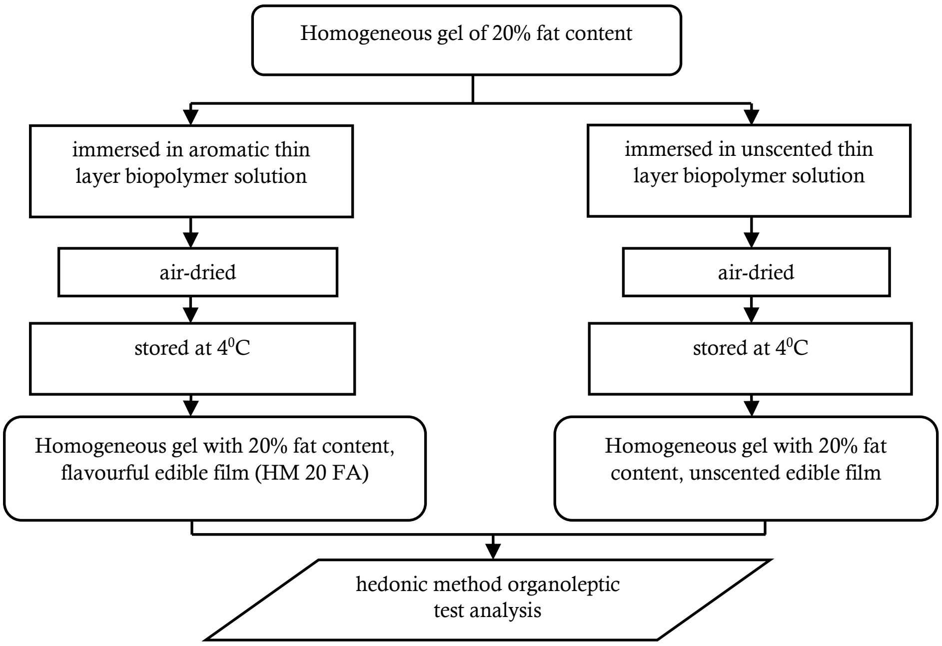

Figure 1. Flowchart of Research on Aromatized Thin Layer Biopolymer Gel Emulsion

Sensory Evaluation

Sensory evaluation was conducted using the hedonic method to measure panellists' liking for the tested samples. Before carrying out the organoleptic test on the main samples, which were fat spatial distribution gel coated with aromatized and unscented edible coating, panellists first participated in the triangle test. In this triangle test, panellists were presented with three samples, where one sample was different from the others, and panellists had to identify the different sample. The samples used in this test had the aroma of Wiseman butter and cheese. Only panelists who managed to answer correctly in the triangle test were selected to proceed to the organoleptic test stage. In the hedonic test procedure, panellists were given samples and a questionnaire to assess the level of liking. The panelists were asked to give a score according to the level of liking using a scale of 1-9, with the following criteria: 1 for 'Strongly dislike,' 2 for 'Strongly dislike,' 3 for 'Dislike,' 4 for 'Somewhat dislike,' 5 for 'Neutral,' 6 for 'Somewhat like,' 7 for 'Like,' 8 for 'Strongly like' and 9 for 'Strongly like.' The parameters assessed in the hedonic test include hardness, chewiness, color (transparency), and aroma. This assessment provides information on the sensory quality of the edible coating-treated fat spatial distribution gel.

Data Analysis

Data from oil-in-water (O/W) emulsion characterisation tests and spatial distribution of fat in gel emulsions were analysed using analysis of variance (ANOVA), followed by Duncan's test at a significance level of $p < 0.05$. The characterisation of the aromatized thin-layer biopolymer and the application of the aromatized thin-layer biopolymer solution on the fat spatial distribution gel were analysed by t-test. All data analyses were performed using SPSS Statistics 26 software.

RESULTS AND DISCUSSION

Flavoured Biopolymer Edible Coatings

The spatial distribution of fat in gel emulsions coated with thin-layer biopolymers is the final stage of this research. The gel emulsion used had a homogeneous fat content of 20% and was coated with thin-layer biopolymers containing aroma (Wijsman butter and cheese) and biopolymers without aroma as a control. This study aimed to evaluate the effect of aromatized biopolymer coating on improving the perception of fat in homogeneous gel emulsion. The analysis was conducted using the hedonic organoleptic test to assess several important parameters, namely hardness, color (transparency of the edible coating), chewiness, and aroma.

This assessment used a 9-point scale, where scores were 1 (Strongly dislike), 2 (Strongly dislike), 3 (Dislike), 4 (Somewhat dislike), 5 (Neutral), 6 (Somewhat like), 7 (Like), 8 (Strongly like), and 9 (Strongly like).

The organoleptic test results showed that the gel emulsion coated with aromatised biopolymers scored higher on the aroma and fat perception aspects compared to the unscented control. This indicates that the presence of aroma in the biopolymer coating can improve the sensory acceptability of the gel emulsion product (as shown in Table 1).

Table 1. Organoleptic Test Results of Spatial Distribution Gel of Fats Wrapped in Thin Layer Biopolymer

Treatments	Organoleptic Test			
	Hardness	Colour (transparency)	Chewiness	Aroma
GHM 20 FA	7,1^{a}	7,9^{a}	7,2^{a}	7,8^{a}
GHM 20 FNA	7,2^{a}	7,8^{a}	7,2^{a}	5,5^{b}

Description: GHM 20 FA = Homogeneous gel of 20% fat content, aromatic edible film (Wijsman butter and cheeses)
GHM 20 FNA = Homogeneous gel of 20% fat content, unscented edible film
Note: ^{a},^{b},Different superscripts in the same column indicate differences (P<0.05).

Table 1 presents the complete organoleptic assessment scores for each parameter. Based on these results, there was a trend towards a significant increase in the aroma parameter in gels using flavored biopolymers compared to those without aroma. The transparency of the edible coating layer also affected the visual perception of the gel emulsion, where biopolymers with good transparency allowed the spatial distribution of fat to appear more consistent. Overall, the application of flavored thin-layer biopolymers to homogeneous gel emulsions proved to be effective in enhancing fat perception, which has positive implications for consumer preference for the product.

Hardness of Gel

Gel hardness is an important parameter that reflects the solid or compact structure of the gel with the spatial distribution of fat coated by the thin layer biopolymer. Gel hardness testing was conducted through the organoleptic method using a hedonic test. In this test, panellists were asked to press the gel until it disintegrated using a finger, then give an assessment on a questionnaire based on a 9-point hedonic scale, where 1 indicates 'Strongly dislike' and 9 indicates 'Strongly like'. Table 1 presents the results of gel hardness evaluation with various treatments. The results showed that the homogeneous gel with 20% fat content coated with edible film without aroma (GHM 20 FNA) had the highest score of 7.2, indicating that the gel was liked by the panellists. The homogeneous gel treatment with 20% fat content coated with aromatic edible film (GHM 20 FA) obtained a score of 7.1, which also indicated that the gel was liked by the panellists.

Analysis of variance showed that there was no significant difference between the GHM 20 FNA and GHM 20 FA treatments. In other words, the addition of DIVA Food Essence flavoured with Wijsman butter and cheese did not significantly affect the level of acceptability of the gel coated with thin layer biopolymer (Figure 2).

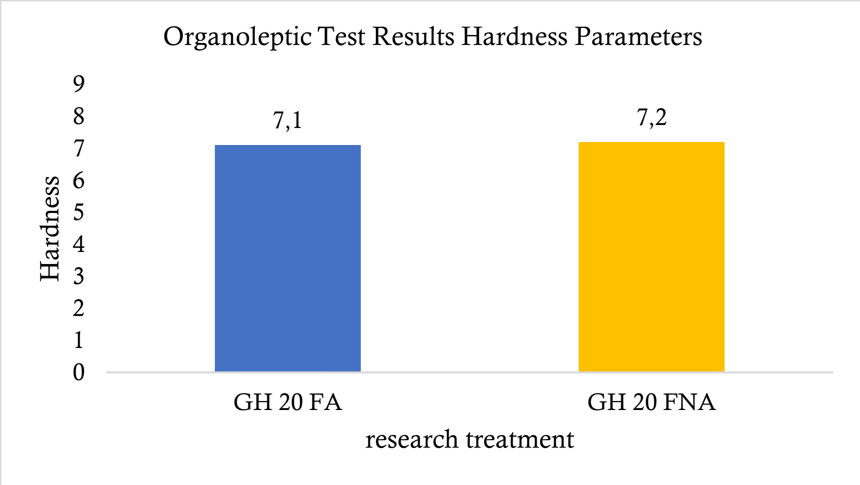

Figure 2. Organoleptic Test Results Gel hardness parameter Spatial Distribution of Fats Wrapped in Thin Layer Biopolymer.

Figure 2 reinforces these results, where the GHM 20 FNA and GHM 20 FA treatments scored 7.2 and 7.1, respectively. The insignificance of this difference indicates that both the flavored and unflavored edible films have similar effectiveness in affecting the spatial distribution of fat in the gel and its hardness. These results confirm that the use of flavoured biopolymer edible coatings does not negatively affect the mechanical structure of the gel, and can therefore be used flexibly according to sensory preferences.

Colour (Transparency)

Color is an important aspect in determining consumer acceptance of food products. In this study, the transparency of edible film was used as a color parameter to evaluate the visual quality of the gel emulsion. Color not only serves as a quality indicator but also reflects the freshness and maturity of the product. Organoleptic testing was conducted using the hedonic method to assess the transparency of a homogenous gel with 20% fat content coated with aromatized edible film (GHM 20 FA) and unaromatized edible film (GHM 20 FNA). Panellists were asked to observe the samples with their sense of sight and give a rating using a scale of 1-9, where 1 indicates 'extremely dislike' and 9 indicates 'extremely like.'

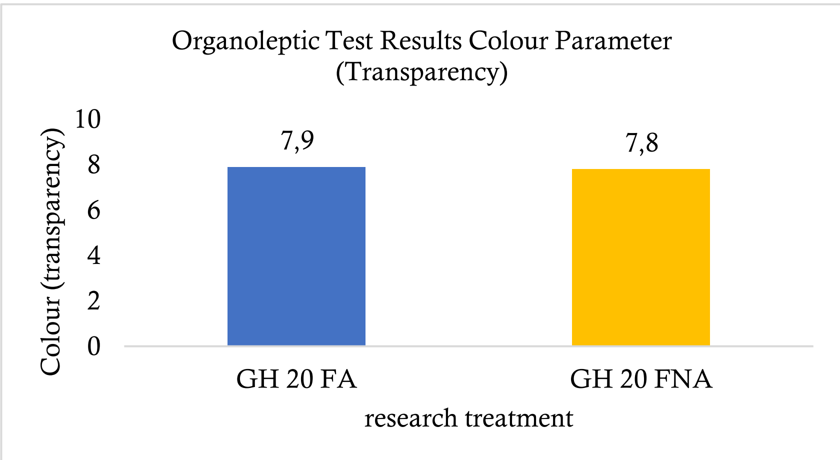

Figure 3. Organoleptic Test Results Colour Parameter (Transparency) of Thin Layer Biopolymer Coated Fat Spatial Distribution Gel

Figure 3 show the organoleptic test results related to the spatial distribution of fat in the two types of gels. The evaluation results showed that the homogeneous gel with aromatised edible film (GHM 20 FA) received a mean score of 7.9 (highly preferred), while the homogeneous gel with unscented edible film (GHM 20 FNA) received a mean score of 7.8 (highly preferred).

The t-test conducted showed no significant difference between the GHM 20 FA and GHM 20 FNA samples ($p > 0.05$). This indicates that the addition of DIVA Food Essence with wijsman butter and cheese aroma to the edible film did not affect the visual transparency of the gel. Both scented and unscented edible films had similar transparency levels, which resulted in relatively similar organoleptic ratings from panellists. Factors that affect the transparency of edible films include the thickness of the layer and the amount of solids that make up the film. This is in line with the research of McHugh *et al.* (1994), which states that an increase in edible film thickness will increase light diffusion, causing the edible film to appear cloudier and less bright. Thus, thicker edible films tend to have low transparency and provide a less attractive visual appearance.

Chewiness

Chewiness is one of the texture parameters that play an important role in the assessment of consumer preference and acceptance. Chewiness is defined as the ability of a food product to return to its original shape after pressure, before the product breaks (Montolalu *et al.,* 2017). In this study, the analysis of gel chewiness with spatial distribution of biopolymer-coated fat was conducted using an organoleptic test with the hedonic method. The panelist pressed and observed the gel using a finger, then gave an assessment on the questionnaire provided. The rating scale used was a 1-9 scale, with details: 1 (Strongly dislike), 2 (Strongly dislike), 3 (Dislike), 4 (Somewhat dislike), 5 (Neutral), 6 (Somewhat like), 7 (Like), 8 (Strongly like), and 9 (Strongly like).

The results of the organoleptic test on the suppleness of homogeneous gel with 20% fat content wrapped with flavored (GHM 20 FA) and unflavored (GHM 20 FNA) edible films are shown in Table 1. Both treatments obtained the same chewiness value of 7.2, indicating a high level of liking from the panellists. The t-test results indicated no significant difference between the two treatments (GHM 20 FA and GHM 20 FNA). Thus, the addition of DIVA Food Essence, flavoured with Wijsman butter and cheese, to the edible film did not affect the elasticity of the biopolymer-coated gel.

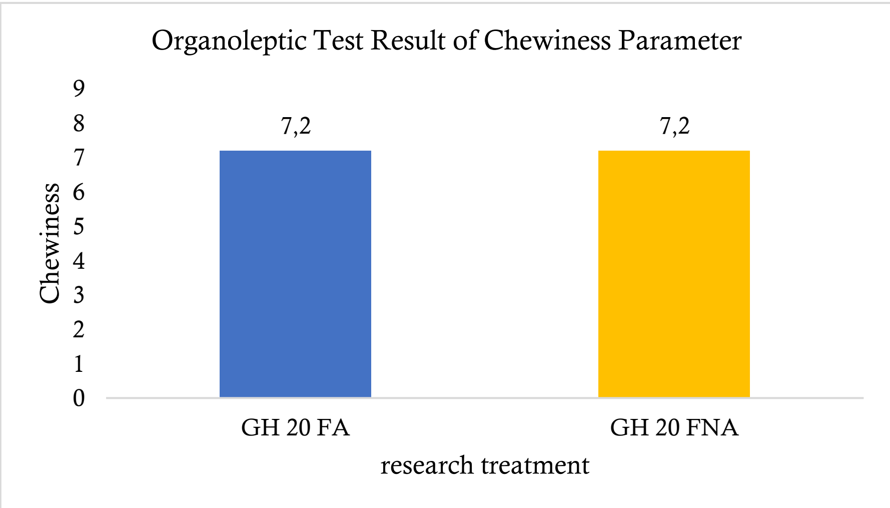

Figure 4. Oganoleptic Test Results Gel Succulence Parameters Spatial Distribution of Fats Wrapped in Thin Layer Biopolymer

Similar results were also shown in the analysis of variance (Figure 4), where there was no significant difference between the homogeneous gel of 20% fat content with flavored (GHM 20 FA) and unflavored (GHM 20 FNA) edible films. In other words, the presence of aroma on the edible film did not affect the acceptability of the gel with spatial distribution of fat.

Aroma

Consumer acceptance of food products is generally influenced by three main aspects, namely aroma, texture, and flavor. Modern consumers not only demand products that have delicious flavors but are also healthy and of high quality (Andriot *et al.,* 2000). Blake (2006) stated that aroma is an important quality attribute that determines acceptance or rejection of a food product. In this study, the spatial distribution of fat in the gel coated with aromatized biopolymer edible coating was analyzed using an organoleptic test using the hedonic method. Panelists were asked to rate the aroma of the gel using a scale of 1-9, where a score of 1 indicates ‘extremely dislike’ and a score of 9 indicates ‘extremely like.’ Table 1 and Figure 5 present the organoleptic test results for the aroma parameter of the gels with two treatments: homogeneous gel with 20% fat content wrapped in aromatized edible film (GHM 20 FA) and homogeneous gel with 20% fat content wrapped in unscented edible film (GHM 20 FNA).

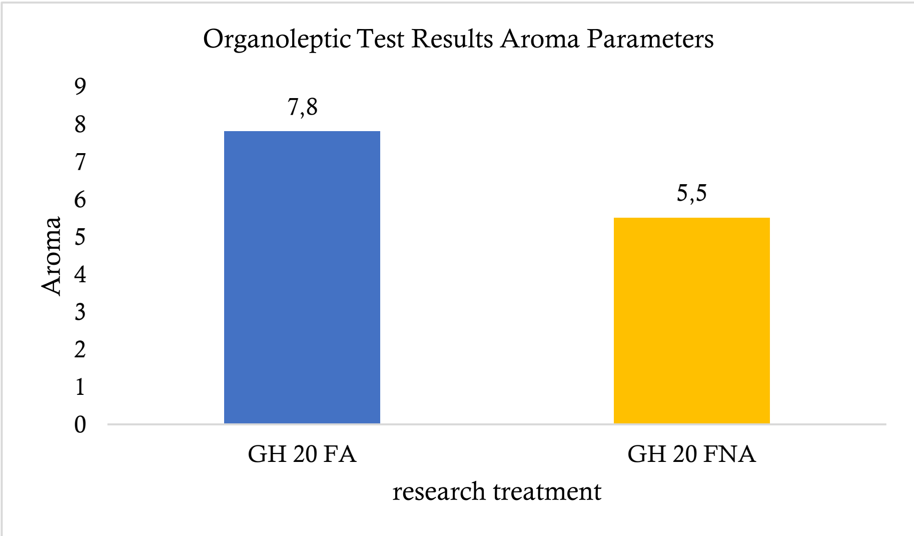

Figure 5. Organoleptic Test Results Gel Aroma Parameters Spatial Distribution of Thin Layer Biopolymers

Figure 5 shows that GHM 20 FA scored 7.8, which means it was highly favored by the panellists. In contrast, GHM 20 FNA only scored 5.5, indicating a neutral judgment. The results of statistical analysis using the T-test showed a significant difference between the two treatments. Thus, the addition of DIVA Food Essence flavoured with Wijsman butter and cheese to the edible film was shown to increase the acceptance of the panellists towards the aroma of the fat spatial distribution gel.

This result is in line with previous research that shows that the addition of food aroma can improve food sensory perception. Labbe *et al.* (2009) reported that the addition of vanilla and cocoa aromas improved the perception of sweetness and bitterness in chocolate drinks. In addition, Lawrence *et al.* (2009) found that the aroma of sardines and ham can increase the perception of saltiness despite low salt concentration. Another study by Syarifuddin *et al.* (2016) reinforced these findings by stating that sardine and butter aromas associated with saltiness and fat can increase saltiness perception through changes in the texture of cheese models. Furthermore, Jagadish *et al.* (2009) showed that blending vanilla compounds in a low-density polyethylene (LDPE) matrix can improve the sensory quality of packaged foods. Ruijschop *et al.* (2010) also reported that the addition of multicomponent strawberry aroma to yogurt products increased feelings of fullness. This is reinforced by the research of Syarifuddin *et al.* (2020), who found that products with vanilla aroma had higher aroma intensity.

CONCLUSION

Based on the results of this study, it can be concluded that the use of aromatised thin-layer biopolymers was able to improve panelists' acceptance of the perception of fat aroma in the fat spatial distribution gel (GHM2). The application of this edible coating did not reduce the panelists' acceptance of textural attributes, such as hardness and chewiness, and did not affect the color perception of the gel. Thus, aromatized thin-layer biopolymers can be an effective solution to improve the sensory quality of fat spatial distribution gel emulsions without compromising their physical characteristics. Further research is recommended to explore the type and concentration of aroma in different biopolymers in order to optimize the sensory perception and spatial distribution of fat in gel products. In addition, evaluation of aroma stability during storage and effect on product shelf life should also be considered for industrial scale application.

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