The effect of types and concentration of fillers on the quality of whey protein products

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Abstract. Whey is a liquid residual from cheese production with high protein content. The high protein content causes whey to be used in the formulation of functional ingredients for food and beverage products, such as formula milk, sports supplements, and pharmaceuticals. The goal of the study was to determine the effect of types and fillers concentration on the quality of whey protein products using a spray dryer. The study involved the optimization of types and concentrations of different fillers on whey protein production and quality analysis by chemical and organoleptic tests. This study used a randomized block design with two factors. Factor A (type of filler) and B (concentration of filler) consisted of three levels, with two replications. Factor A was A1 = maltodextrin, A2 = pectin, and A3 = gum Arabic, while factor B was B1 = 1%, B2 = 1.5% and B3 = 2%. Maltodextrin, pectin, and gum Arabic at 1% concentration resulted in the best whey protein through the spray drying process. Organoleptic test results with hedonic quality obtained optimum results in the treatment of 1% maltodextrin filler. Therefore, 1% maltodextrin could be applied in the whey protein production. Meanwhile, the analysis of chemical quality showed that the content of water, ash, protein, fat, and carbohydrates were 4.4%; 7.76%; 11.23%; 3.58%, and 73.82%, respectively.

1. Introduction
The residual liquid separated from the curd in the making process of cheese, tofu, and butter is called whey (1). Whey has the potential as a waste, but also as a useful by-product because it is nutritional validity, functional activities, cost-effectiveness, and bioactive peptides(2)(3). As a waste, whey can be treated into several products including wheygurd, nata de whey, and whey protein (4). The whey composition, consists of total solids: 6.94 ± 0.35%; lactose: 4.53 ± 0.17%; total protein: 0.69 ± 0.03% and mineral salts: 0.57 ± 0.12% (5). The advances in technology increases whey utilization in many applications. Approximately 50% of the total produced-whey, converted into value-added products (6). Whey may be used for food and beverage production as whey protein (7). Whey protein has high nutritional quality and is utilized as a functional food ingredient. Enzymatic hydrolysis of whey protein can build up in the immune systems, cardiovascular, nervous, and gastrointestinal (8). The hydrolysis of whey protein can reduce allergenicity. Therefore, it could be used as an ingredient in many products, mainly for preventing nutrition-related diseases, such as food intolerance and allergies (9). The production of whey protein could be done through the spray drying method. Whey protein concentrate that is produced through the spray drying process has many advantages; ease of product
handling, storage, transportation, and better quality (10). Particle sizes of whey protein will affect the sensory properties of the product and its application to food products (11). Some materials are applicable as fillers in the spray drying process. Pectin (12), maltodextrin, and gum arabic (13) are common fillers used in industries. Therefore, the objectives of the present study were to determine the optimum types and concentrations of different fillers on whey protein production and quality analysis by chemical and organoleptic tests.

2. Materials and Methods
   The study was conducted in the Indonesian Center for Agricultural Postharvest Research and Development (ICAPRD), Bogor. Materials were used included whey, maltodextrin, pectin, gum arabic, aquadest, sulfuric acid, ethanol, chloride acid, form ranking test, and other materials for chemical analyses. Whey was obtained from the cheese-making process at Mahesa Perkasa Farm, Depok. Tools and equipment were used included a spray dryer, analytical balance, freezer, homogenizer, stirrer, thermometer, and glassware for analyses.

2.1. Research Methods
   Whey from the cheese production was mixed with several fillers, namely maltodextrin, gum arabic, and pectin. Whey and fillers were mixed using a homogenizer. The addition ratio of fillers, maltodextrin, pectin, and gum Arabic, 1; 1.5 and 2% of each, respectively. The whey mixture was placed in a spray dryer to obtained whey powder. The spray dryer uses an inlet temperature of 170 °C and an outlet temperature of 80 °C. Whey protein from the spray drying process was characterized. Chemical characterization was done including water content, ash content, fat, protein, and carbohydrate. The best three chemical characterization results were selected for organoleptic testing. Organoleptic testing was carried out using a hedonic test and the hedonic quality of whey protein. As much as 35 panelists were used in the organoleptic test.

   The hedonic scale was conducted using 5-points hedonic among others color, flavor, and taste (14). The hedonic scales were used ranging from really dislike (1), dislike (2), rather like (3), like (4), really like (5). The scale of hedonic quality for color starts from white (5), slightly yellowish-white (4), yellowish-white (3), slightly yellowish (2), and yellowish (1). The flavor was very creamy (5), creamy (4), slightly creamy (3), not creamy (2), and very not creamy (1).

2.2. Research Design
   The research design used a randomized block design with two factors. Factors A (a type of filler) and B (concentration of filler) consisted of three levels, with two replications. Factor A was A1 = maltodextrin, A2 = pectin, and A3 = gum arabic, while factor B was B1 = 1%, B2 = 1.5% and B3 = 2%. Data obtained was analyzed using F-test in four programs of SAS 9.1. The significance of variables was identified using Duncan Multiple Range Test (DMRT) at a level of 5%. The data of the organoleptic test were analyzed using the MINITAB 16 software with Kruskall Wallis non-parametric analysis.

3. Results and Discussion
   3.1. Chemical Characteristics of Whey
   The analysis showed that the main components of whey were lipid and protein as presented in Table 1. The protein content was 0.73%, it means that in 100 g of whey contained 0.73 g protein. Whereas (15) reported the total whey protein reached 0.54%, and 0.45 ± 0.05% (w/w) (16). There are differences in protein content. It can be caused by the raw material used and the cheese-making process. Differences in the cheese-making process will affect the functionality of the whey produced (17).
Table 1. Chemical characteristics of whey

| No | Parameter | Content (%) |
|----|-----------|-------------|
| 1  | Lipid     | 1.94        |
| 2  | Protein   | 0.73        |
| 3  | pH        | 4.93        |

3.2. Optimization Production of Whey Protein

3.2.1. Water Content

Water content was an important parameter for functional food or beverage products. High water content influences the shelf life of food or beverage products due to the growth of microorganisms. The water content of whey protein products ranged from 2.66-5.89% as presented in Table 2. The value is corresponding with powdered milk products (18) and whey protein (19) with maximum water content is 5%. There is an exception for pectin fillers with concentrations of 1.5% and 2%.

Table 2 showed that fillers concentrations of 1, 1.5, and 2% did not significantly influence the water content of whey protein. The addition of different concentrations of maltodextrin had a significant effect on water content, while pectin and gum arabic did not show a significant effect. The difference in fillers and concentrations did not significantly affect the water content. The highest water content was found in pectin as a filler with a concentration of 2% with an average value of 5.89. However, the lowest water content was obtained on 2% maltodextrin as a filler with an average value of 2.66.

Table 2. The water content of whey protein using different types and concentrations of fillers.

| Filler Treatment | Concentrations(%) | Means |
|------------------|-------------------|-------|
|                  | 1                 | 1.5   | 2     |
| Maltodextrin     | 4.40aa            | 3.46aba| 2.66ba| 3.51a  |
| Pectin           | 3.77a             | 5.55aa| 5.89aa| 5.07a  |
| Gum Arabic       | 3.72aa            | 3.66aa| 3.56aa| 3.64a  |
| Means            | 3.96a             | 4.22a | 4.04a |       |

Remark: the numbers followed by the same lowercase letters in the same column or the same capital letter on the same line indicate that they are not significantly different based on further DMRT tests at the level of 5%. Lowercase for fillers interactions, uppercase for concentration interactions.

3.2.2. Ash Contents

Ash is an inorganic substance obtained from the combustion of organic material. Ash content is closely related to the mineral content in the material or product. The minerals contained in a material namely organic salt and inorganic salt. Minerals can also be in the form of complex organic compounds and making it difficult to determine the amount of minerals in their original form. Therefore it is usually done by determining the remains of burning mineral salts by ashing. The purpose is to determine the parameters of the nutritional value of the food ingredients. The value of ash content corresponding to the inorganic contained.

The ash content of whey protein ranged from 7.12 to 8.12%, this value still fulfills the codex standard with a maximum limit of 9.5% (19). The result presented in Table 3 showed that fillers concentrations of 1, 1.5, and 2% did not significantly affect the ash content. The addition of maltodextrin as a filler had a significant effect on ash content, but pectin and gum arabic did not show a significant effect. The statistical analysis showed that the pectin concentration of 1% resulted in the highest value of 8.12, however, the lowest was obtained from 2% maltodextrin was 7.17. The concentration of filler has a significant effect on ash content.
### Table 3. Ash content of whey protein using different types and concentrations of fillers.

| Filler Treatment | Concentrations(%) | Means  |
|------------------|-------------------|--------|
|                  | 1                 | 1.5    | 2      |        |
| Maltodextrin     | 7.76<sup>aa</sup> | 7.62<sup>aba</sup> | 7.58<sup>ba</sup> | 7.51<sup>a</sup> |
| Pectin           | 8.12<sup>aa</sup> | 7.80<sup>aa</sup>  | 7.66<sup>ba</sup> | 7.86<sup>a</sup> |
| Gum Arabic       | 7.95<sup>aa</sup> | 7.71<sup>aa</sup>  | 7.57<sup>ab</sup> | 7.74<sup>a</sup> |
| Means            | 7.94<sup>a</sup>  | 7.12<sup>ab</sup> | 7.46<sup>b</sup>  |        |

Remark: the numbers followed by the same lowercase letters in the same column or the same capital letter on the same line indicate that they are not significantly different based on further DMRT tests at the level of 5%. Lowercase for fillers interactions, uppercase for concentration interactions.

#### 3.2.3. Lipid Content

The result presented in Table 4 showed that lipid content ranges from 2.01 - 5.03%. (18) reported that lipid content on lean milk powder with ranging from 1.5 - 26%. CODEX does not have a standard for lipid content on whey protein (19). The filler concentration of 1 and 1.5% had no significant effect on the lipid content of whey protein, while the filler concentration of 2% had a significant effect. The addition of fillers and different concentration treatment did not significantly affect lipid content.

### Table 4. Lipid content of whey protein using different types and concentrations of fillers.

| Filler Treatment | Concentrations(%) | Means  |
|------------------|-------------------|--------|
|                  | 1                 | 1.5    | 2      |        |
| Maltodextrin     | 3.58<sup>aa</sup> | 4.58<sup>aa</sup> | 5.03<sup>ba</sup> | 4.39<sup>a</sup> |
| Pectin           | 2.01<sup>aa</sup> | 3.10<sup>aa</sup>  | 2.57<sup>ab</sup> | 2.56<sup>a</sup> |
| Gum Arabic       | 3.48<sup>aa</sup> | 3.58<sup>aa</sup>  | 2.98<sup>ab</sup> | 3.34<sup>a</sup> |
| Means            | 3.03<sup>a</sup>  | 3.74<sup>a</sup>  | 3.53<sup>a</sup>  |        |

Remark: the numbers followed by the same lowercase letters in the same column or the same capital letter on the same line indicate that they are not significantly different based on further DMRT tests at the level of 5%. Lowercase for fillers interactions, uppercase for concentration interactions.

#### 3.2.4. Protein Contents

Table 5 showed the protein content of whey protein using different types and concentrations of fillers. The highest protein content was obtained from whey protein using 1 % of pectin as a filler with a value of 11.24%. The lowest value was recovered from 2% of maltodextrin with a value of 10.6%. The protein content of WPC produced using different types of fillers was fulfills CODEX standard ranges from 10.67 - 11.24%. According to the codex standard, whey powder product has a minimum protein content of 10% (19). Based on statistical analysis, the concentrations of fillers did not significantly affect the levels of whey protein. The addition of maltodextrin fillers had a significant effect on protein content, while pectin and gum arabic fillers had no significant effect on protein levels. The fillers and concentrations did not significantly affect the protein content on the whey protein product. The spray drying process can be used to produce whey protein with a protein content of more than 10%.
Table 5. The protein content of whey protein using different types and concentrations of fillers.

| Filler Treatment | Concentrations(%) | Means  |
|------------------|-------------------|--------|
|                  | 1     | 1.5   | 2     |
| Maltodextrin     | 11.23a | 10.67ab | 10.67ab | 10.79a |
| Pectin           | 11.24a | 11.022a | 10.93a  | 11.06a |
| Gum Arabic       | 10.90a | 10.71a  | 10.78a  | 10.79a |
| Means            | 11.12a | 10.80a  | 10.77a  |        |

Remark: the numbers followed by the same lowercase letters in the same column or the same capital letter on the same line indicate that they are not significantly different based on further DMRT tests at the level of 5%. Lowercase for fillers interactions, uppercase for concentration interactions.

3.2.5. Carbohydrate Contents

Carbohydrate content data as represented in Table 6 showed that the concentrations of fillers have no significant effect. The addition of fillers had no significant effect also. The fillers and concentration differences did not significantly affect carbohydrate content. (19) and (18) have not standard for carbohydrate content in whey protein.

Table 6. Carbohydrate content of whey protein using different types and concentrations of fillers.

| Filler Treatment | Concentrations(%) | Means  |
|------------------|-------------------|--------|
|                  | 1     | 1.5   | 2     |
| Maltodextrin     | 73.82AA | 73.47AA | 73.92AA | 73.74A |
| Pectin           | 73.49AA | 73.76AA | 72.86AA | 73.43A |
| Gum Arabic       | 74.00AA | 73.76AA | 75.65AA | 74.46A |
| Means            | 73.77A  | 73.72A  | 74.14A  |        |

Remark: the numbers followed by the same lowercase letters in the same column or the same capital letter on the same line indicate that they are not significantly different based on further DMRT tests at the level of 5%. Lowercase for fillers interactions, uppercase for concentration interactions.

3.3. Organoleptic Characteristics of Whey

The organoleptic test is the analysis of products using a sensing device for parameters of color, aroma, and taste. Organoleptic testing using human senses is the main tool for measuring product acceptance (20). The human senses include the quality of appearance, flavor, taste, and texture as well as several other factors needed to evaluate the products (18). The organoleptic test can be done by hedonic quality test.

Sensory evaluation should be performed to know whether the sample is acceptable to consumers in terms of taste. Sensory evaluation tests were carried out using 5 points of hedonic scale. The hedonic test can be defined as a relationship to or associated with satisfaction and to measure directly the degree of preference or acceptance of the product by panelists (14). Sensory acceptance testing can be employed during the development and optimization processes as a means of assessing variant suitability in a hedonic fashion and involves anywhere from 25 to 75 individuals (21). The hedonic test was used to measure the preference level of products. Statistical analysis of panelist’s response to the level of whey protein preference by using the non-parametric Kruskall Wallis is shown in Table 7.

Based on the data presented in Table 7 showed that the color and flavor for all treatments were preferred by the panelists. No significant differences among all treatments. Based on the recorded value for the taste, panelists preferred maltodextrin as filler compared to other treatments, as seen from the higher median value.
Table 7. The hedonic test of whey protein using several fillers on the spray drying process

| Treatments         | Color | Flavor | Taste |
|--------------------|-------|--------|-------|
|                    | Median | Ranking | Median | Ranking | Median | Ranking |
| Maltodextrin 1%    | 4^a    | 48,6    | 3^a    | 48,6    | 4^a    | 64,4    |
| Pectin 1%          | 4^a    | 58,1    | 3^a    | 58,3    | 3^b    | 47,4    |
| Gum Arabic 1%      | 4^a    | 52,3    | 3^a    | 52,2    | 3^b    | 47,1    |
| H = 1,71           |        |         | H = 1,81 |        | H = 7,39 |        |
| P = 0,425          |        |         | P = 0,405 |        | P = 0,025 |        |

Remark: the numbers followed by the same lowercase letters in the same column on the same line indicate that they are not significantly different.

To find out the personal impression of the panelists to the color of whey protein specifically could be done by hedonic quality test. Quality determines the level of perfection of the product properties. The results of the whey protein hedonic quality test are shown in Table 8. The panelists favored the color and flavor of hedonic quality test for all treatments. There were no significant differences between treatments. However, panelists preferred the taste of 1% maltodextrin as filler compared to others, and it was indicated by the highest-ranking value. Based on hedonic quality and hedonic quality tests, the addition of 1% maltodextrin is the best filler for whey protein production through the spray drying process.

Table 8. Quality test of hedonic whey protein using several fillers in spray drying

| Treatment          | Color | Flavor | Taste |
|--------------------|-------|--------|-------|
|                    | Median | Ranking | Median | Ranking | Median | Ranking |
| Maltodextrin 1%    | 4^a    | 48,1    | 4^a    | 51,5    | 4^a    | 67,2    |
| Pectin 1%          | 4^a    | 56      | 4^a    | 54,2    | 4^b    | 48,3    |
| Gum Arabic 1%      | 4^a    | 54,8    | 4^a    | 53,2    | 4^b    | 43,5    |
| H = 1,36           |        |         | H = 0,14 |        | H = 11,89 |        |
| P = 0,56           |        |         | P = 0,93 |        | P = 0,003 |        |

Remark: the numbers followed by the same lowercase letters in the same column on the same line indicate that they are not significantly different.

4. Conclusion
Maltodextrin, pectin, and gum Arabic at 1% concentration resulted in the best whey protein through the spray drying process. Organoleptic test results with hedonic and hedonic quality obtained optimum results in the treatment of 1% maltodextrin filler. Therefore 1% concentration of maltodextrin can be applied in the whey protein production.

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