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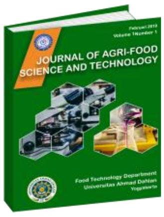

# The Effect of Foaming Agent and Whipping Time on Albedo Characteristics of Watermelon Flour

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## ABSTRACT

*The fruit's rind is one of the natural waste products that can support nutrients like carbohydrates, proteins, and lipids. Reused rind contributes significantly to the effective handling of this fruit's byproduct. Processing watermelon rind into powder by lowering water content and activity is an alternative to extending its shelf life. The flour form is easier and more suitable for application in multiple processing food products such as snacks, beverages, bread, and pasta. This study contributed to verifying the optimal state for foam mat drying using concentrations of foaming agent in the form of egg albumin (10, 15, 20), foam stabilizer in the form of CMC with concentrations of 1 %, and whipping time (5, 7, and 9 minutes). Subsequently, the samples will be analyzed on bulk density, WSI, hygroscopicity, L* value, a* value, b* value of total phenol and antioxidants activity, and the maximum antioxidant content of watermelon albedo flour using a Completely Randomized design with 2 factorials resulting in nine treatments with three replications. Based on the outcome, the bulk density of the resulting watermelon albedo flour ranges from 0.25-0.50 gr/cm$^{-3}$ and 0.11-0.26%. of WSI; 22.63-28.18g/100g$^{-1}$ of hygroscopicity; 1.92-4.67% of total phenol; 47.48-66.59% of L*value; 3.74-6.11% of a*value; 5.47-16.08% of b*values and 6.80- 25.26% RSa of antioxidants activity. The best treatment for antioxidant activity was 25.26% RSA using 10% of the foaming agent and whipping time in 9 minutes. These findings have implications for the food industry because they suggest that treatments can influence the properties of watermelon albedo flour.*



## 1. INTRODUCTION

Watermelon (*Citrullus lanatus*) begins in southern Africa and has spread broadly to nations with tropical climates, including Indonesia. The substance and juice of the watermelon are commonly expended by the open, whereas the skin and seeds reach 30% of the overall natural product and are the strongest waste. A study by Al-Sayed & Ahmed 2013 showed that watermelon byproducts are an imperative source of protein, dietary fiber, and cancer prevention agents. Happening, particularly pectin, cellulose, citrulline, and other phytochemical compounds. Reused rind contributes significantly to effectively handling this fruit's byproduct (Din et al., 2022). Adding citrulline-rich rind to the product enhances the pastilles' nutrient value, given that rind provides appealing sources of natural antioxidants and dietary fibre. Watermelon skin includes a total phenol content of both (0.248 mg mL-1) and a high capacity to rummage free radicals. Watermelon skin has antioxidant properties and serves as a source of characteristic citrulline, but is frequently disposed of as squander since it tastes flat. The natural product skin has minerals that are not found in other natural products, such as lycopene and beta-carotene which are good for eye wellbeing (Figuerola et al, 2005). The citrulline in watermelon rinds encounters antioxidant activity, which aids in battling oxidative stress, a phenomenon causally associated with the development of various diseases (Din et al, 2022). The amount of watermelon rind waste has been increasing during the last 10 years and is expected to continue to increase in line with population growth and economic activity.

The rind of the fruit is one of nature's natural waste products, which can support nutrients like carbohydrates, proteins, and lipids. Therefore, the potential for its use in the food sector is still very large, not only to be left as waste polluting the environment. Albedo can be referred to as the middle layer (mesocarp) of the watermelon, which is located between the outer epidermis (exocarp) and inner epidermis (endocarp). Albedo is the thickest and most colorful part of the fruit's white skin. Like other soft plant tissues, albedo watermelon is also composed of pectin (Kalie, 2001). According to Guoyao et al., (2007) found citrulline in the flesh, skin, and skin/pulp of watermelon. More citrulline is found in watermelon skin, about 60 percent compared to the flesh. Processing Watermelon rind into powder by reducing water content and activity is an alternative to extending its shelf life. The flour form is easier and more suitable for application in multiple processing food products such as snacks, beverages, bread, and pasta.

By collaborating with foaming or stabilizing agents, foam mat drying assists in converting liquid or semi-solid food to stable foam. This method is less complicated and expensive than spray and freeze drying. By collaborating with foaming agents or stabilizing agents, foam mat drying aids in the conversion of liquid or semi-solid food to stable foam. This method is less complicated and expensive than spray and freeze drying. Foam mat drying allows for lower temperatures and shorter drying times, which aids in preserving nutrients in vegetables. Foam mat dried powders can be easily reconstituted into juice powdered (Sangamithra et al., 2015). Foam-mat dried products have gained popularity in recent years due to their simplicity in drying. Foamed materials dry faster than non-foamed materials, especially in the final drying stages (Hossain et al., 2021).

This study contributed to verifying the optimal state for foam mat drying using concentrations of foaming agent in the form of egg albumin (10, 15, 20), foam stabilizer in the form of CMC with concentrations of 1 %, and whipping time (5, 7, and 9 minutes). Subsequently, the samples will be analyzed on bulk density, WSI, hygroscopicity, L* value, a* value, b* value of total phenol and antioxidants activity, and the maximum antioxidant content of watermelon albedo flour.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The primary materials in this study are watermelon albedo fee of mechanical wounds from Fruit Market Gamping, Yogyakarta. Watermelon is then preserved as a complete fruit at room temperature. Each watermelon can produce 300 to 400g of albedo of watermelon. CMC (Carboxyl Methyl Cellulose) was purchased at Alfa Kimia Store, and egg albumin was purchased at Inti Sari Store. The material used for analysis aquadest, 1,1-Diphenyl-2-

Picrylhyrazil (DPPH) solutions alcohol 95%, H2SO4 0,25N, PP indicator, boric acid 4% solutions, red metallic indicator 0,1N, NAOH 32% solutions 0,3N, HCL 0,1 N.

The tools used in this study were a centrifuge, desiccator, blender (Philips), mixer (Philips), oven (Memmert), 80 mesh sieve, thermometer, stove (Rinnai), petri dishes.

### 2.2. Research Methods

This study used a Completely Randomized design with 2 factorials. The treatment in this study was the proportion of foaming agent with egg albumin (10.15 and 20%), whipping time (5, 7, 9 minutes), and adding by CMC 1% with nine treatments and three replications. There were 27 experimental units. These are, A1( 10% of foaming agent, 5 minutes of whipping time), A2(15% of foaming agent, 5 minutes of whipping time), A3(20% of foaming agent 5 minutes of whipping time), A4( 10% of foaming agent, 7 minutes of whipping time), A5(15% of foaming agent, 7 minutes of whipping time), A6(20% of foaming agent, 7 minutes of whipping time), A7( 10% of foaming agent, 9 minutes of whipping time), A8( 15 % of foaming agent, 9 minutes of whipping time), A9( 20% of foaming agent, 9 minutes of whipping time). The parameters measured were bulk density, WSI, Hygroscopicity, L*value, a*value, b*value, total phenol, and antioxidant activity.

The data acquired were analyzed using the analysis of variance (ANOVA). Then, if the outcome of the assessment shows a differentiation, a further test via Duncan's Multiple Range Test (5%) is executed.

## 3. RESULT AND DISCUSSION

### 3.1. Bulk Density

Bulk density is used to estimate the quality of the material (Figuerola et al., 2005). Bulk density is a reliable indicator of structural alterations that take place during food processing, and it may have an impact on the powder's flowability and instantaneity characteristics (Farid et al., 2022). A powder's low bulk density suggests that it has good flowability and no caking tendency (Carr, 1965). Based on Table 1, the bulk density of watermelon albedo flour was carried out by adding egg albumin as a foaming agent at 10, 15, and 20% with a whipping time treatment of 5, 7, and 9 minutes. The bulk density of the resulting watermelon albedo flour ranges from 0.25–0.50 $gr/cm^{-3}$. The lowest bulk density was acquired with A1 treatment, adding 10% foaming agent and with 5 minutes of whipping time, namely of 0,25 $gr/cm^{-3}$. The highest bulk density was acquired with the A9 treatment of adding 20% egg albumin foaming agent and with 9 minutes of whipping time treatment, namely 0.50 $gr/cm^{-3}$. Statistical analysis One Way ANOVA showed that the difference variation of foaming agent and whipping time with the addition of CMC 1%, showed a significant difference to the value of bulk density. It can be seen that the test was continued with DMRT(Duncan) test which showed a difference in variation of treatment. These was communicated by Khamjae and Rojanakorn., 2018 that The bulk density decreased gradually with increasing foaming agent concentration (in this study, soy protein isolate) and whipping time, reaching a plateau and then increasing. This behaviour could be explained by two phenomena: (1) the weakening of air bubbles as a result of prolonged whipping, and (2) an increase in total solids, which raises the mixture viscosity above the limited viscosity at which more air bubbles can be easily integrated into the foam structure.

Based on the results in Table 1, the addition of a foaming agent in the form of egg albumin has an effect on changing the density of the powder. Based on the dense powder in bulk, the compact texture of the traditional hot air-drying powder, which was caused by the shrinkage phenomena, may be explained by the powder's dense morphology (Mounir and Allaf, 2017). In differentiation, the open, permeable structure resulting from the incorporation of the air bubbles into the foam structure, as well as the opening of better pores, may be related to the low bulk density of hot air foam mat drying powder (Djaeni et al., 2015); Franco et al., 2016) as well as the opening of better pores and the arrangement of new apertures due to the development and the movement of the moisture from the product's center towards its outside surface, amid the drying operation (Sankat and Castaigne, 2004). The existence of a drying temperature in the manufacture of powder facilitates an increase in the rate of evaporation, which causes structural damage and fragmentation, resulting in a powder with a lower density (Munawar et al., 2020). The watermelon albedo powder is made by drying it at 50°C.

Table 1. Bulk density, WSI and hygroscopicity of watermelon albedo flour

| Treatment | Foaming agent (%) | Whipping time (minutes) | Bulk density ($g/cm^{-3}$) | WSI (%) | Hygroscopicity $g/100g^{-1}$ |
|---|---|---|---|---|---|
| A1 | 10 | 5 | $0.25^{a}$ | $0.21^{b}$ | $22.70^{bc}$ |
| A2 | 15 | 5 | $0.26^{b}$ | $0.24^{c}$ | $25.63^{cd}$ |
| A3 | 20 | 5 | $0.26^{b}$ | $0.26^{c}$ | $23.67^{ab}$ |
| A4 | 10 | 7 | $0.29^{c}$ | $0.25^{c}$ | $23.18^{e}$ |
| A5 | 15 | 7 | $0.30^{f}$ | $0.24^{c}$ | $26.70^{bc}$ |
| A6 | 20 | 7 | $0.31^{d}$ | $0.25^{c}$ | $25.16^{bc}$ |
| A7 | 10 | 9 | $0.34^{e}$ | $0.17^{a}$ | $25.31^{bc}$ |
| A8 | 15 | 9 | $0.46^{g}$ | $0.19^{ab}$ | $22.63^{a}$ |
| A9 | 20 | 9 | $0.50^{h}$ | $0.11^{b}$ | $27.28^{de}$ |

Based on Duncan's results from the test with a significance level of 0.05, different letter notations (a, b, or c) indicate significant differences.

Table 2. Total Phenol, L*value, a*value, b* value of watermelon albedo flour

| Treatment | Foaming agent (%) | Whipping time (minutes) | L*value | a*value | b*value |
|---|---|---|---|---|---|
| A1 | 10 | 5 | $64.85^{g}$ | $3.94^{ab}$ | $15.17^{f}$ |
| A2 | 15 | 5 | $63.52^{f}$ | $3.74^{a}$ | $14.83^{e}$ |
| A3 | 20 | 5 | $66.59^{h}$ | $4.53^{d}$ | $16.08^{h}$ |
| A4 | 10 | 7 | $63.27^{f}$ | $5.75^{g}$ | $15.10^{f}$ |
| A5 | 15 | 7 | $61.25^{d}$ | $6.09^{h}$ | $14.36^{d}$ |
| A6 | 20 | 7 | $62.42^{e}$ | $5.38^{f}$ | $15.57^{g}$ |
| A7 | 10 | 9 | $47.48^{a}$ | $4.11^{bc}$ | $5.47^{a}$ |
| A8 | 15 | 9 | $49.77^{b}$ | $4.97^{e}$ | $7.25^{b}$ |
| A9 | 20 | 9 | $53.10^{c}$ | $6.11^{i}$ | $10.28^{c}$ |

Based on Duncan's results from the test with a significance level of 0.05, different letter notations (a, b, or c) indicate significant differences. L* denotes lightness; a*value denotes redness; b* denotes yellowness.

### 3.2. Water Solubility Index (WSI)

The WSI measures the amount of dissolvable elements discharged from the sample (Dehghannyaet al., 2018). WSI is an imperative factor in showing the capacity of the powder to blend homogeneously in water (Sifat et al., 2021). Water solubility index (WSI) analysis on watermelon albedo flour was carried out by adding egg albumin as a foaming agent at 10, 15, and 20% with whipping time treatments of 5, 7, and 9 minutes. The water solubility of the resulting watermelon albedo flour can be seen in Table 1, which ranges from 0.11-0.26%. The highest WSI was obtained in the treatment of adding 20% egg albumin foaming agent and in the 5-minute whipping time treatment, namely 0.26%. The lowest bulk density was acquired with A1 treatment, adding 20% of foaming agent and with 5 minutes of whipping time, namely, 0,11%. In the previous study on tomato powder, When the foaming agent level was increased, the exterior area that formed the bubbled fluid increased due to the incorporation of more air (Belal et al., 2022). Foam mat-dried powder that exhibits greater foam expansion increases the powder's penetrability, thus boosting its ability to solubility(Shaari et al., 2017). This is related to the high solubility caused by the amount of fiber and protein in the watermelon plant itself (Munawar et al., 2020). Low water content reduces powder adhesion and increases the surface area, resulting in binding by water (Chegini and Ghobadian, 2005).

The ability of dry food ingredients to absorb water is evaluated based on the calculation of the water solubility index, where the value obtained is related to the capacity of the food ingredients to be hydrated (Barbosa-Cánovas and Juliano, 2005). When the foaming agent concentration expanded, it came about in the more prominent surface range of the foamed juice by consolidating more air Thirupathi & Rajkumar (2008). According to Munawar, in 2020, a low water solubility value will indicate a better rehydration capacity. The presence of free hydroxyl groups in the foaming agent facilitates the adsorption of water molecules from the surrounding environment, which affects the value of the Water Absorption Index (Harmayani et al., 2011; Shaari et al., 2017).

### 3.3. Hygroscopicity

A food powder's hygroscopicity, which is related to its physical, chemical, and microbiological soundness, was its ability to hold onto water from an environment with relative humidity higher than the equilibrium dampness substance. The knowledge of these things' hygroscopic nature is fundamental, especially when it comes to drying, packaging, and capacity conditions. (Le Oliviera et al., 2014). Hygroscopicity analysis of watermelon albedo flour was carried out by adding egg albumin as a foaming agent at 10, 15, and 20% with a whipping time treatment of 5, 7, and 9 minutes.

The hygroscopicity of the resulting watermelon albedo flour can be seen in Table 1, which ranges from 22.63-28.18 $g/100g^{-1}$. The highest hygroscopicity was obtained with A9 in the treatment of adding egg albumin foaming agent at 20% and with the treatment of 9 minutes of whipping time, namely 28.18 $g/100g^{-}$. The lowest hygroscopicity was acquired with A1 treatment, adding 10% foaming agent and with 5 minutes of whipping time, namely 22.70 $g/100g^{-}$. Based on Table 1, there was an increase in foaming agents due to increasing hygroscopicity. This is added by the statement that Shaari et al., 2017 because the polar conformation in the Egg albumin structure elevates the powder's capacity to attract water molecules when in contact with the air surrounding it, foam mat-dried powder possessed a higher hygroscopicity value than spray-dried powder. Hygroscopicity is related to the ability to absorb water in food, whereas high hygroscopicity means greater water absorption. This indicates that there is more water physically bound by the solid matrix Field (Figura & Teixeira, 2007). According to Bhandari (2012), hygroscopicity is connected to amorphous structures because these molecules are more porous and open to outside influences. Thus, due to its hygroscopic nature, which readily absorbs water, this results in an amorphous structure that is easily sticky and promotes clumping.

### 3.4. L*value

Color is a marker of quality parameters assessed by consumers and is basic within the acknowledgment of the nourishment product (Leon et al., 2006). Colors, considered one of the most crucial manufacturing parameters in dried products, have a major effect on both their desirable and ultimate cost (Shaari et al., 2017). L* value denotes the lighter color of products (Setiaboma et al., 2018). L*value analysis on watermelon albedo flour was carried out by adding egg albumin as a foaming agent at 10, 15, and 20% with a whipping time treatment of 5, 7, and 9 minutes. The lightness of the resulting watermelon albedo flour can be seen in Table

2, which ranges from 47.48–66.59%. The highest lightness was obtained in the A3 treatment of adding 20% of egg albumin foaming agent and with the treatment of 5 minutes of whipping time, namely 66, 59%. The lowest lightness was obtained in the A7 treatment of adding 20% egg albumin foaming agent and 9 minutes of whipping time, namely 47.48%. This was additionally revealed in the research by La et al., (2017), when various types and quantities of foaming agents were added to beetroot samples, the redness value increased. After drying, the redness value of all beetroot powder increased, resulting in a lighter red color. An upper concentration of foaming agent had more prominent delicacy esteem than lower egg albumin concentrations (Asokapandian et al., 2016; Kadam et al., 2010). The foam mat dried corn flour became darker in color. This may be due to non-enzymatic browning and caramelization, which happens in nourishments that are comprised primarily of sugar and protein content while in warm treatment.

### 3.5. a*value

A*value analysis on watermelon albedo flour was carried out by adding egg albumin as a foaming agent of 10, 15, and 20% with whipping time treatment for 5, 7, and 9 minutes. The redness of the resulting watermelon albedo flour can be seen in Table 2, which ranges from 3.74 to 6.11%. The highest redness was obtained in the A9 treatment of adding egg albumin foaming agent of 20% and in the treatment of 9 minutes of whipping time, namely 6.11%. The lowest redness was obtained in A2 by adding 10% egg albumin foaming agent and 9 minutes whipping time, namely 3.74%. According to Belal et al., (2022), heating will cause the color to become redder. Another study denoted that redness in fruit leather could also be explained by the surface area being dried and stored at a high temperature (Kurniadi et al., 2022). In addition, the addition of egg albumin and CMC will increase the red color. By heating and adding egg albumin, CMC causes pigment degradation and non-enzymatic reactions that produce a redder color (Table 2). The enhancement of a foaming agent and blending or whipping time to end 9 minutes will produce the highest redness, namely 6.11%.

### 3.6. b*value

Yellowness analysis on watermelon albedo flour was carried out by adding egg albumin as a foaming agent of 10, 15, and 20% with whipping time treatment for 5, 7, and 9 minutes. The yellowness content of the resulting watermelon albedo flour can be seen in Table 2, which ranges from 5.47–16.08%. The highest yellowness was obtained in the A3 treatment with the addition of 20% egg albumin foaming agent and 5 minutes of whipping time treatment, namely 16.08%. The lowest yellowness was obtained in the A7 treatment with the addition of 10% egg albumin egg foaming agent and 9 minutes of whipping time, namely 5.47%. The color of this watermelon albedo powder becomes more yellow due to heating during drying. There is a difference in yellowness with the addition of a foaming agent and whipping time. Therefore, heating causes sensitivity to pigment; heating causes oxidation so that the pigment changes color to red (Rahman, 1999). On the other hand, This may be a sign of non-enzymatic browning or caramelization of the sugar (Teoh et al., 2016).

### 3.7. Total Phenol

Analysis of total phenol in watermelon albedo flour was carried out by adding egg albumin as a foaming agent of 10, 15, and 20% with whipping times of 5, 7, and 9 minutes. The total phenol content in the resulting watermelon albedo flour can be seen in Table 3, which ranges from 1.92-4.67%. The highest Total phenol was obtained in the A7 treatment of adding egg albumin foaming agent of 10% and with the treatment of 9 minutes of whipping time, namely 4.67%. The lowest total phenol was obtained in the A3 treatment of adding egg albumin 20% and 5 minutes whipping time, namely 1.92%. In the previous pineapple powdered research, Increased Egg albumin concentration resulted in a greater area on the surface of the foamed juice, leading to a shorter drying time and less degradation of heat-sensitive particles (Shaari et al., 2017) and in the study, an comparable pattern for phenolic content in dried foam mat of mixed vegetable powder (Veerapandian et al., 2015). The results of this investigation seemed to vary from previous studies in that increasing egg albumin did not increase phenol content as it did in the previous study (Sifat et al., 2021), and increasing whipping time also increased total phenol content. The difference in the total amount of phenol occurs due to the degradation due to the heating of the bioactive components. Cell rupture during preparation and shaking results in the liberation of bound phenolic compounds; the duration of shaking results in an increase in total phenol. However, the effect of whipping time may be interpreted by the observation that intemperate whipping may result in a dwindle in the total flavonoid substance and total phenolic content due to the oxidation of these compounds by the air integrated into the foam morphology and their warm debasement by heat produced through the long whipping time an exploratory perception (Farid et al., 2022).

Table 3. Total phenol and antioxidant activity of watermelon albedo flour

| Treatment | Foaming agent (%) | Whipping time (minutes) | Total phenol (%) | Antioxidants Activity (% RSA) |
|---|---|---|---|---|
| A1 | 10 | 5 | 3.07[d] | 13.87[b] |
| A2 | 15 | 5 | 2.29[a] | 7.57[a] |
| A3 | 20 | 5 | 1.92[a] | 6.80[a] |
| A4 | 10 | 7 | 3.72[c] | 18.02[e] |
| A5 | 15 | 7 | 2.76[b] | 16.74[d] |
| A6 | 20 | 7 | 2.67[b] | 15.02[c] |
| A7 | 10 | 9 | 4.67[e] | 25.26[h] |
| A8 | 15 | 9 | 4.20[f] | 21.73[g] |
| A9 | 20 | 9 | 4.12[fg] | 19.52[f] |

Based on Duncan's results from the test with a significance level of 0.05, different letter notations (a, b, or c) indicate significant differences.

### 3.8. Antioxidant Activity (%RSA)

The antioxidant characteristics of nourishment materials are linked to the presence of bioactive compounds in high amounts (Farid et al., 2022). Antioxidant analysis on watermelon albedo flour was carried out by adding egg albumin as a foaming agent of 10, 15, and 20% with whipping time treatment for 5, 7, and 9 minutes. The antioxidant activity of the resulting watermelon albedo flour can be seen in Table 3, which ranges from 6.80 to 25.26% RSa. The highest antioxidant content was obtained in the A7 treatment with the addition of 10% egg albumin foaming agents and with a 9-minute whipping time treatment, namely 25.26% RSA. The lowest antioxidant activity content was obtained in the A3 treatment with the addition of 10% egg albumin foaming agent and 9 minutes whipping time, namely 6.80%RSA. This goes against research on strawberry powder, which shows that as the foaming agent, namely protein isolate, expands, so does the antioxidant content, whereas as the whipping time increases, so does the antioxidant content. Meanwhile, in this study, the opposite occurred: as whipping time increased, the antioxidant content correspondingly decreased (Farid et al., 2023). With an increase in whipping time, it will produce a high antioxidant content. According to Sifat et al., 2021, Increases in whipping time tend to increase the percentage of inhibition, with an increased duration of whipping time in order to obtain optimal-quality powder while maintaining antioxidant content.

## 4. CONCLUSIONS

Furthermore, we wanted to see how different foaming agent concentrations and whipping times affected the properties of watermelon albedo flour. The findings of the research variations in foaming agent concentration and whipping time have a significant effect on the measurements of bulk density, WSI, hygroscopicity, L* value, a* value, b* value total phenol, and antioxidants activity. Based on the outcome, the bulk density of the resulting watermelon albedo flour ranges from 0.25-0.50 gr/cm$^{-3}$; WSI values ranged from 0.11-0.26%; hygroscopicity values ranged from 22.63-28.18 g/100g$^{-1}$.; L*values ranged from 47.48–66.59%; a*values ranged from 3.74-6.11%; b*values ranged from 5.47-16.08%; total phenol values ranged from 1.92-4.67% and RSa of antioxidants activity value ranged from 6.80-25.26%. The best treatment for antioxidant activity was 25.26% RSA using 10% of the foaming agent and whipping time in 9 minutes. Notably, the 10% foaming agent treatment with a 9-minute whipping time produced the highest antioxidant activity (25.26% RSA). These findings have implications for the food industry because they suggest that treatments can influence the properties of watermelon albedo flour. Manufacturers may be able to produce flour with improved functional characteristics, such as increased solubility, antioxidant content, and color attributes, by optimizing these parameters.

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