



Effects of taro powder on the properties of wheat flour and dough

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Abstract

This work aimed to investigate the effect of taro powder on the quality of wheat flour products. The water and starch content, whiteness, pasting properties, texture, microstructure, rheological properties of dough and water distribution in dough were analyzed. Taro powder significantly increased the peak viscosity, trough viscosity, final viscosity and setback value in the gelatinization process of flour, reduced the breakdown value, and increased the gelatinization temperature. Taro flour showed the ability to improve the farinographical properties and gelatinizing properties of flour. Adding taro flour reduces the development time and softness of the dough while increasing water absorption. The starch content, peak viscosity and water absorption of the mixed flour were the highest when the proportion of taro powder was increased to 25%. As the amount of taro powder increases, the color and hardness of the mixed flour dough become deeper, and the moisture inside the dough becomes less easily lost. The addition of taro powder may make the dough less resistant to mechanical blending and slightly less viscoelastic, but the gluten structure is smoother. In short, when the added amount of taro powder is 20% or 25%, it can meet the processing conditions.

Keywords: taro powder; wheat flour; rheological properties; moisture state; microstructure.

Practical Application: Improvement the quality and nutrition of wheat dough blends with taro powder.

1 Introduction

Taro, an underground bulb of araceae plants, is mainly produced in Asia, Africa, Oceania and America. Currently, thousands of varieties of taro are cultivated worldwide (Aboubakar et al., 2010; Aprianita et al., 2009). Taro is the main food for people living in African and Pacific Island countries. Mazon et al. (2020) reported that taro and roselle were the best known unconventional food plants (UFP) species for holistic and hedonic evaluation of the ice cream, but only 19.4% people stated they had the custom of eating these plants. Compared with other tubers and root plants, taro has a higher nutritional value. Taro is rich in starch and dietary fiber. The starch particle size of taro is small, and the average particle size of the different varieties of taro range from approximately 1-5.19 μm . Taro starch shows smooth and irregular shapes, from rounded shapes to polygons (Aboubakar et al., 2008). The different sizes of taro starch granules may lead to differences in physical properties in the heating gelatinization process of taro starch, especially the absorbent and swelling power of taro starch (Adebawale & Lawal, 2004). González Victoriano et al. (2021) stated that the sticking properties of the starch play an important role in the quality of the product, because the starch provides the structure-forming properties. This behaviour is related to the macromolecules' tendency to re-associate and interact after gelatinization, resulting in organized structures that delay starch swelling and solubilization during cooking. Taro is not only a good source of carbohydrates and dietary fiber but also acts a medicinal plant. Crude protein contents of taro flours ranged between 2–4%. Taro (Amadumbe) protein is rich in essential amino acids such as lysine (5.3 g/100 g) and leucine (9.1 g/100 g) (Hilary Van Wyk & Oscar Amonsou, 2021).

Since ancient times, taro has been famous for its curative effects. It has medicinal purposes such as improving the stomach and intestines, nourishing the spleen and stomach, curing loose knots in the abdomen, and treating ailments such as swelling, psoriasis and injuries as a result of burns (Ahmed et al., 2010). In recent years, with the improvement of the dietary requirements of consumers, taro has been widely used in food processing, such as bread, cake, infant auxiliary food, etc. (Himeda et al., 2012). Taro can improve the rheological properties and texture properties of food, while also giving it a good taste.

At present, the rheological properties and gelatinization properties of dough have received more attention at home and abroad. The texture of dough plays a decisive role in the sensory of quality in final products (González Victoriano et al., 2020). As a traditional staple food in China, noodles have a long history and occupy a very important position in the dietary structure of the population. In recent years, with the improvement of living standards, many consumers have increased requirements on the taste and quality of pasta. With traditional pasta no longer meeting the need of the population, more attention has been given to the nutritional value and safety of noodles (Tattiyakul et al., 2006; Aboubakar et al., 2008). Currently, a growing number of studies are evaluating the effects of wheat flour and alternative flour mixtures on the nutritional and functional properties of foods, such as quinoa flour and portulaca oleracea leaf powder. As expected, the dough and product quality were improved under certain dosage (Kurek & Sokolova, 2019; Sadeghzadeh Benam et al., 2021). In this study, wheat flour was used as the raw

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material in mixtures with taro flour at different proportions to make dough. By analyzing the physical and chemical properties of the mixed powder, as well as the thermodynamic and mechanical characteristics, texture characteristics, moisture distribution and microstructure of the dough, the processing quality of taro and wheat flour dough was obtained. It is expected to produce taro-wheat compound nutritional flour products with high nutritional value and good taste.

2 Materials and methods

2.1 Materials

The wheat flour used in this work was purchased from One Plus One Natural Flour Co., Ltd. (Xinxiang, China); fresh taro and salt were purchased from a local market (Xinxiang, Henan Province, China). All other reagents are analytically pure.

2.2 Preparation of the mixed flour

Fresh taro was selected, washed, peeled and cut into thin slices, dried at 40–45 °C, and crushed with a universal crusher through a 100-mesh sieve. Taro flour was mixed with wheat flour at proportions of 5%, 10%, 15%, 20%, 25% and 30%. Wheat flour without taro mixed in was used as the control.

2.3 Determination of whiteness of the mixed flour

The sample was put into a container of a certain volume, the surface was flattened, and the color of the mixed powder was determined by a cr-40 chromometer (Agama-Acevedo et al., 2011). L^* value represents brightness and whiteness, the larger the value, the whiter it is; A^* means “red green degree”, the larger the value, the redder; B^* stands for “yellow blue degree”, the larger the value, the more yellow.

2.4 Mixolab test

The pasting properties of dough were measured after adding water under the influence of both stirring force and temperature. Experimental instrument parameters: Chopin + experimental protocol; Dough weight: 75 g; Torque: 1.1 N.m (± 0.05 N.m); Speed: 80 r/min (Cashman & Flynn, 1999).

2.5 Rapid Viscosity Analyzer (RVA)

A RVA fast viscosimeter was used in the experiment. Three grams of mixing powder and 25 ml deionized water were weighed and mixed evenly in the aluminum box of the fast viscosity analyzer (Simsek & El, 2012). The following procedures were followed: the temperature was kept at 50 °C for 1 min, then the temperature was raised to 95 °C at a rate of 6 °C/min for 5 min, then the temperature was lowered to 50 °C at a rate of 6 °C/min for 2 min, the stirring rate within the first 10 s was 960 r/min, and then the viscosity was tested at a stirring rate of 160 r/min.

2.6 Texture Plus Analysis (TPA)

Structural characteristics of TPA (two chewing tests): By simulating the chewing motion of the human mouth, the solid

and semisolid samples were compressed twice. Each sample dough with different amounts of taro powder added above was used for each measurement. The dough was pressed into 1 cm thick dough piece by a dough press, and then the dough pieces were cut into 10 cm $\times$ 10 cm pieces of dough (Luo et al., 2014). Using a P/36 probe to determine the dough texture. The parameters were: pretest speed, 2 mm/s; test speed, 1 mm/s; posttest, 1 mm/s, compression rate, 50%, trigger force 5 g. After determination, the texture of each dough was analyzed.

2.7 Low-field Nuclear Magnetic Resonance (LF-NMR)

Using the variable-temperature magnetic resonance imaging analyzer, the magnet is maintained at a constant temperature of 32 °C through the temperature control system (Dobraszczyk & Morgenstern, 2003). The test parameters were: the magnet frequency was 20 MHz, the 90° pulse time P1 was 6.52 seconds, the 180° pulse time P2 was 13.04 seconds, the number of test samples TD = 300028, the monitoring sample frequency SW = 100 kHz, the sample detection interval TW = 5000, the number of repeats NS = 32, the analog gain RG1 = 20, the digital gain DRG1 = 3, the preamplifier PRG = 0.

2.8 Scanning Electron Microscopy (SEM)

An appropriate amount of dough was selected and frozen at -40 °C. Then, the central part of the frozen dough was cut into 1~2 mm slices with a razor blade and put into a freeze dryer for drying. After drying, the samples were fixed on the metal sample table with conductive double-sided adhesive tape, the impurities on the surface of the samples were brushed off by an ear washing ball, and the cross section was observed after vacuum spraying of palladium in the carrier chamber of an electron microscope. A total of 1500 and 2000 representations of each sample were used for observation, and the representative microstructure of the dough was photographed (Wang et al., 2013).

2.9 Statistical analysis

The data are presented as average values of at least three repeated measurements and were analyzed by one-way analysis of variance (ANOVA) and Duncan's tests (SPSS 16.0 Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

3 Results and discussion

3.1 Color of the mixed powder

The effect of adding taro powder on the color of mixed flour was compared with the blank samples, which have higher L^* values and whiter colors. The L^* value of the pure taro powder is low, and the b value is also high, resulting in a darker color, such that the whiteness of the mixed powder gradually decreases with the increase with the addition on taro powder. Generally, when the whiteness index of flour is greater than 45, people's consumption and shelf life will not be affected (Belghith Fendri et al., 2016). As seen from Table 1, the brightness and whiteness of the mixed taro powder show a decreasing trend with increasing amount of added taro powder. The “red–green

degree” varies unsteadily in the range of 0~20% of added taro powder but increases in the range of 20% ~ 30% of added taro powder. To ensure the nutritional value of taro powder in the mixture and that the whiteness of the mixture was not too low, 25% of the added amount was chosen to ensure the quality of the mixture and edible.

3.2 Farinograph parameters by Mixolab

The dough stabilization time is an important index to reflect the kneading resistance of the dough and measure the characteristics of the flour. Generally, the longer the dough stabilization time is, the better the toughness of the dough, and the stronger the gluten strength is, the better the dough processing performance. Dough formation time is an important parameter for wheat flour components to absorb water to form dough and an important evaluation index for flour processing quality. In general, the longer the dough takes to form, the stronger the gluten and the better the dough (Mert et al., 2006). The degree of protein weakening indicates the rate of destruction of the dough in the process of stirring, that is, the ability to withstand mechanical stirring, which represents the strength of the gluten. The greater the degree of weakening, the weaker the gluten, the easier the dough is to flow, and the poorer the operating performance.

From Table 2, with the increase of taro powder content, ranging from 0~30% taro powder, the stable time change trend of mixed flour dough is relatively gentle, with little variation. The stable time had and the rub resistance of the dough mixed powder showed no clear change. This phenomenon may be associated with the nonstarch polysaccharides in taro powder. Water-soluble glue of nonstarch polysaccharides increased the gluten content and quality of the mixed powder, and the dietary fiber decreased the gluten content and quality of the nonstarch polysaccharide mixture flour. As shown in Table 2, the formation time of the dough gradually decreases as the increase of taro flour increases when the proportion of taro flour is in the range of 0~30%. Therefore, in the actual processing of taro flour noodles, from the point of view of the formation time of mixed flour dough, if the high dough formation time is required and the nutritional value of taro flour needs to be considered, then the appropriate amount of taro flour to be should range from 20% to 30% (Silva et al., 2012).

According to the definition of Tamara, the C2 value in the monitoring map of Mixolab indicates the degree of protein weakening in the process of mechanical force and heating. The smaller C2 is, the greater the degree of protein weakening. From Table 2, it can be seen that with the increase in taro powder, the degree of weakening of the mixed flour shows a decreasing trend. C2 values of mixed flour decreases from 0.386 N.m to 0.283 N.m., indicating that adding taro powder to wheat flour will increase the degree of protein weakening of the mixed flour and reduce the evaluation value. The main reason is that taro flour does not contain gluten protein (Dvořáček et al., 2019). With the addition of taro flour, the gluten characteristic of mixed flour is weakened, such that the gluten protein content in flour is relatively reduced, and the gluten network structure is poor compared with the raw wheat flour.

Table 1. Effect of taro powder on color and starch content of mixed powder.

Taro flour / %	L*	b*
0	92.88 ± 0.21a	12.43 ± 0.17ab
5	86.82 ± 0.35b	11.89 ± 0.31bc
10	85.23 ± 0.39c	12.76 ± 0.19a
15	83.18 ± 0.31d	12.19 ± 0.14abc
20	82.41 ± 0.32e	11.72 ± 0.19c
25	81.51 ± 0.52f	11.71 ± 0.50c
30	80.42 ± 0.33g	12.26 ± 0.38abc

The values were mean ± standard error (n = 3). Different letters in the same column indicate significant difference (P < 0.05).

Table 2. Test results of stabilization time, formation time and protein weakening degree of mixed flour dough with different amounts of taro powder.

Taro flour / %	Stable time /min	Form the time/min	C2/N.m
0	7.63 ± 0.15cb	3.99 ± 0.11a	0.38 ± 0.01a
5	8.87 ± 0.15a	1.17 ± 0.11cb	0.32 ± 0.02b
10	7.30 ± 0.11dc	1.35 ± 0.19b	0.41 ± 0.01a
15	6.97 ± 0.15ed	1.00 ± 0.11dc	0.23 ± 0.07c
20	6.84 ± 0.36e	1.15 ± 0.06dcb	0.26 ± 0.06c
25	7.83 ± 0.24b	0.94 ± 0.05d	0.24 ± 0.02c
30	6.290 ± 0.18f	1.08 ± 0.11dc	0.24 ± 0.03c

The values were mean ± standard error (n = 3). Different letters in the same column indicate significant difference (P < 0.05).

3.3 Pasting properties of dough by using mixolab

The difference value of C3-C2 in the spectrum of the Mixolab analyzer indicates the gelatinization characteristic of the starch, which is one of the indices to characterize the viscoelasticity of the dough. The larger the difference between C3-C2 is, the stronger the gelatinization characteristics of the starch and the larger the viscosity. As shown in Table 3, with the increase in additional taro powder, the difference between C3-C2 of the mixed powder decreased from 1.113 N.m to 0.888 N.m. The results showed that the starch gelatinization characteristics of the mixed taro powder decreased with the increase of added taro powder, the peak viscosity of the dough decreased gradually, the expansion degree of starch particles decreased, and the ability of the binding water decreased. This phenomenon may be due to the high amylose content in the starch of taro powder, and in starch gelatinization, the peak viscosity of the dough is negatively correlated with amylose content (Codină et al., 2019). Therefore, with the addition of taro powder, the viscosity of the mixed paste tends to decrease. Starch gelatinization is essentially a process in which water molecules enter starch granules and the hydrogen bonds between starch molecules in the crystalline phase and amorphous phase break, destroying the associative state of starch molecules and dispersing it in water. It can be seen from Table 3 that the variation trend of the differences between C3-C4 is essentially the same, which increases at first and then decreases, indicating that the addition of taro powder reduces the thermal stability of starch paste of the mixed powder. However, when the content of taro powder reaches 15%, the difference between C3-C4 increases to 0.445 N.m, indicating that the starch

gelatinization heat stability of the mixed powder is enhanced (Liu et al., 2014). The difference between C5-C4 represents the reversibility of starch, which means that during the gradual cooling process of gelatinized starch, the molecular kinetic energy decreases, and the dense and highly crystallized starch molecular microbundles between adjacent molecules lose their solubility. If the value of C5-C4 is smaller, the starch is less likely to be recycled. As seen from Table 3, with the increase in the amount of taro powder added, the C5-C4 value of the mixed powder decreased from 0.647 N.m to -1.264 N.m. The decrease in the regeneration value indicates that the addition of taro powder improves the stability of cold paste and delays the regeneration of the flour products.

3.4 Pasting properties

Viscosity refers to the resistance of a fluid to flow in the same direction, that is, the internal friction between molecules in the fluid. The greater the internal friction between molecules, the greater the viscosity, resulting in a stronger gel strength. The pasting properties of the mixed powder were measured by a rapid viscosity analyzer (RVA) (Garimella Purna et al., 2011). As shown in Table 4, with increasing of taro powder content, the peak viscosity, peak time, valley viscosity, final viscosity and retrogradation value increase gradually. Grain viscosity represents the stability of cooking or hot paste of the broken starch at cooking temperature. The higher the grain viscosity is, the higher the stability of the mixed powder after heating. With the increase in taro powder content, the grain viscosity increases, and the stability of the mixed powder after heating also increases. The damage value is related to the strength of expanded starch grains, demonstrating the stability of the sample starch paste when heated. The smaller the damage value, the stronger the stability and shear resistance of the paste during

the heating process, and the more stable it will be under thermal and mechanical action (Mohammed et al. 2012). As seen from Table 4, with the increase in the amount of taro powder added, the damage value gradually decreases, and the stability of the mixed powder under thermal and mechanical effects increases. The ability of gelatinizing materials to form gels after cooling is determined by the final viscosity, which is affected by the retrogradation ability of the soluble amylose during the cooling stage. According to the analysis of the final viscosity, the higher the content of taro powder in the mixed powder, the higher the final viscosity, and the easier it is for the mixed powder to form the gel. The difference between the final viscosity and the valley viscosity is the retrogradation value, which is caused by the association of linear amylose molecules in the cooling stage and reflects the gluing capacity or retrogradation degree of the starch. The higher the retrogradation value, the worse the thermal stability of the gel, but the stronger the gel, meaning the more taro powder you have, the easier it is to harden and age during the cooling process (Charoenrein & Preechathamawong, 2012). The gelatinization temperature is the lowest temperature at which the starch expands and breaks after gelatinization, reflecting the difficulty of gelatinization (Pu et al., 2017; Zhu et al., 2001). With the increase in the content of taro powder in the mixed powder, the gelatinization temperature increases gradually, and the peak time also increases, indicating that the higher the content of taro powder in the mixed powder is, the harder the gelatinization of the mixed powder.

When the added amount of taro powder was 25%, the peak viscosity was the highest, and the damage value was low. This indicates that the mixed powder containing 25% taro powder has the strongest water absorption. When the amount of taro powder added was between 20% and 30%, the viscosity of the grain, the final viscosity and the retrogradation value were relatively high.

Table 3. Test results of Mixolab of starch mixed with different amounts of taro powder.

Taro flour / %	C3-C2/N.m	C3-C4/N.m	C5-C4/N.m
0	1.107 ± 0.117cb	0.383 ± 0.097dcb	0.616 ± 0.040ba
5	1.168 ± 0.009b	0.683 ± 0.004a	0.408 ± 0.052c
10	1.308 ± 0.032a	0.264 ± 0.099dc	0.649 ± 0.035a
15	1.046 ± 0.094dc	0.517 ± 0.190ba	0.523 ± 0.103cba
20	0.982 ± 0.028ed	0.396 ± 0.092cb	0.443 ± 0.079cb
25	0.916 ± 0.040e	0.326 ± 0.143dcb	0.385 ± 0.233c
30	1.194 ± 0.011b	0.181 ± 0.047d	-1.249 ± 0.022d

The values were mean ± standard error (n = 3). Different letters in the same column indicate significant difference (P < 0.05).

Table 4. Effects of different amounts of taro powder on the viscosity of mixed flour.

Taro flour / %	Peak	trough	Breakdown	Final	Setback	Peak Time	Pasting Temp
0	781.67 ± 3.78e	221.67 ± 3.05g	553.33 ± 8.02a	673.67 ± 11.15f	452.33 ± 15.01f	4.77 ± 0.17e	82.09 ± 0.22f
5	794.67 ± 7.09e	265.00 ± 6.24f	529.67 ± 3.21b	772.33 ± 9.07e	516.33 ± 30.08e	5.00 ± 0.01d	83.05 ± 0.08e
10	829.00 ± 4.35d	342.00 ± 13.07e	483.33 ± 9.50c	973.00 ± 13.74d	621.00 ± 22.51d	5.13 ± 0.05d	84.00 ± 0.12d
15	850.33 ± 17.09c	421.00 ± 8.88d	420.33 ± 5.03d	1072.67 ± 49.66c	667.00 ± 7.55c	5.29 ± 0.04c	85.33 ± 0.31c
20	911.67 ± 14.64b	503.00 ± 12.53c	408.00 ± 13.45d	1150.67 ± 64.70b	714.33 ± 10.26ba	5.47 ± 0.047b	85.77 ± 0.35c
25	953.66 ± 7.63a	564.66 ± 14.57b	381.33 ± 15.04e	1262.00 ± 53.01a	736.66 ± 8.32a	5.47 ± 0.06b	86.47 ± 0.44b
30	943.67 ± 8.38a	605.00 ± 4.58a	342.67 ± 4.76f	1307.00 ± 6.55a	701.33 ± 6.02b	5.64 ± 0.05a	87.36 ± 1.81a

The values were mean ± standard error (n = 3). Different letters in the same column indicate significant difference (P < 0.05).

This indicates that the viscosity and paste stability of the mixed taro powder in this range were significantly reduced, while the paste stability was improved (Zhang et al., 2011).

3.5 TPA

Texture instruments are often used to evaluate some important quality indicators of dough. There are many test modes and parameters, such as hardness and cohesion in TPA mode, which are related to the sensory quality of dough. The higher the hardness number, the harder the dough. The higher the cohesion value is, the softer the dough (Wang et al., 2016). Table 5 shows that with the increase in taro powder, the hardness of the dough first increases, then decreases, and then increases slightly, in the range of 5% to 30%, with the lowest at 25%. The hardness of the dough is mainly determined by the denatured gluten network, and the more gluten in the dough, the higher the hardness. Compared with other groups, the increase in hardness when the additional amount of taro flour was in the range of 5% ~ 20% may be due to the increase in gluten network structure in the dough from the protein in taro flour. The lower hardness of the dough when taro powder is added at 25% is likely because taro powder destroys the gluten network structure, making it less rigid (Yoo & Jane, 2002). In addition, dough adhesiveness slowly reduced with the increase of adding amount of taro powder, which may be due to the low water imbibition of the taro powder; since it is not easy for water molecules to enter the interior of the starch granules when taro powder content is higher, the resulting dough adhesiveness increases.

3.6 LF-NMR

As shown in Figure 1, there are two peaks on each curve, representing two forms of water in the sample. Each sample T2 can be divided into two regions: T2 (P1) and T2 (P2). Among them, the peak value of T2 (P1) is between 4 and 7 ms, and the peak value of T2 (P2) is between 50 and 90 ms. The P1 region represents the water that binds with proteins, starch granules, sugars and other macromolecules and is called binding water (Kristiawan et al., 2018). Most of the water in this region is not mobile. The P2 region represents the water exchanged with the gluten protein and starch particles and is located in the interstitium between the gluten protein network and the starch particles. The water in this region is the most easily flowing. Compared with the inverse relaxation curve of the dough without taro powder, the addition of taro powder did not increase the number of peaks of the dough relaxation curve but only changed the

position of the peaks. The peaks of T2 (P1) and T2 (P2) moved significantly to the left, indicating that the binding water in the group behind the taro powder increased and the free water flow decreased (Zaidul et al., 2006).

3.7 SEM

Environmental scanning electron microscopy (ESEM) is a new electronic optical instrument developed in the past 30 years that can truly reflect the shape of the observed object. The effect of taro powder on the microstructure of dough is shown in Figure 2. In the dough without taro powder, the large and small starch particles were densely arranged and evenly distributed in the protein network. As the amount of taro powder added increased, the gluten network of the dough became looser, with small starch grains increasing and large starch grains decreasing and becoming more compact (Zarena et al., 2012). Other substances, such as nonstarch polysaccharides, in taro flour make the gluten structure smoother and have large stomata, but the structure is slightly looser. This indicates that the addition of taro powder may weaken the resistance to mechanical blending of the dough and that the viscoelasticity of the dough is slightly weaker. This may be because the starch grains of the taro powder are smaller, so the dough gathers more small molecules. There are many filamentous protein networks in wheat dough, but the filamentous protein network breaks after taro powder is added, which may be because some gluten proteins are destroyed after

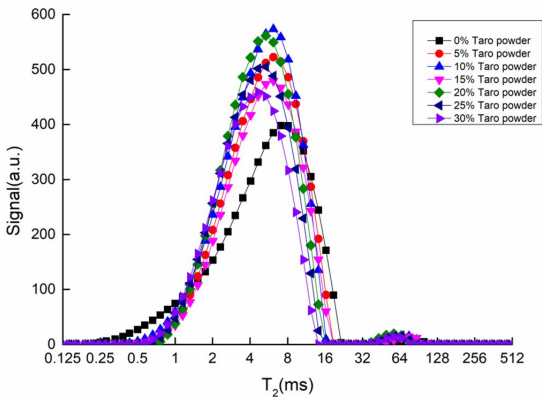


Figure 1. Values from T₂ spectrums of dough prepared with wheat flour-KGM blends.

Table 5. Effect of taro powder on dough texture.

Taro flour / %	Hardness	Resilience	Springiness	Cohesiveness	Gumminess	Chewiness
0	32856.52 ± 1234.91c	1.95 ± 0.06a	0.74 ± 0.03b	0.43 ± 0.02bc	13313.15 ± 2136.97c	10754.77 ± 1085.33b
5	46515.50 ± 2014.86abc	0.95 ± 0.00cd	1.27 ± 0.64ab	0.41 ± 0.02bc	19260.49 ± 1355.32bc	24871.43 ± 1255.43ab
10	39817.30 ± 2508.26bc	0.90 ± 0.01cde	1.79 ± 0.63a	0.29 ± 0.26c	16123.25 ± 1346.62bc	42529.31 ± 1515.33a
15	58301.86 ± 1344.75ab	0.87 ± 0.01de	1.62 ± 0.96ab	0.42 ± 0.02bc	24990.28 ± 1018.77ab	41491.91 ± 2548.73a
20	66312.51 ± 1929.68a	0.82 ± 0.01e	0.67 ± 0.03b	0.52 ± 0.10b	34139.77 ± 1506.44a	22913.92 ± 1965.31ab
25	39927.26 ± 2701.52bc	1.03 ± 0.08b	0.69 ± 0.05b	0.76 ± 0.06a	31140.02 ± 1678.62a	21703.17 ± 1056.55ab
30	40218.93 ± 1250.43bc	0.96 ± 0.05bc	0.67 ± 0.02b	0.84 ± 0.02a	33499.06 ± 1334.59a	22499.74 ± 1701.86ab

The values were mean ± standard error (n = 3). Different letters in the same column indicate significant difference (P < 0.05).

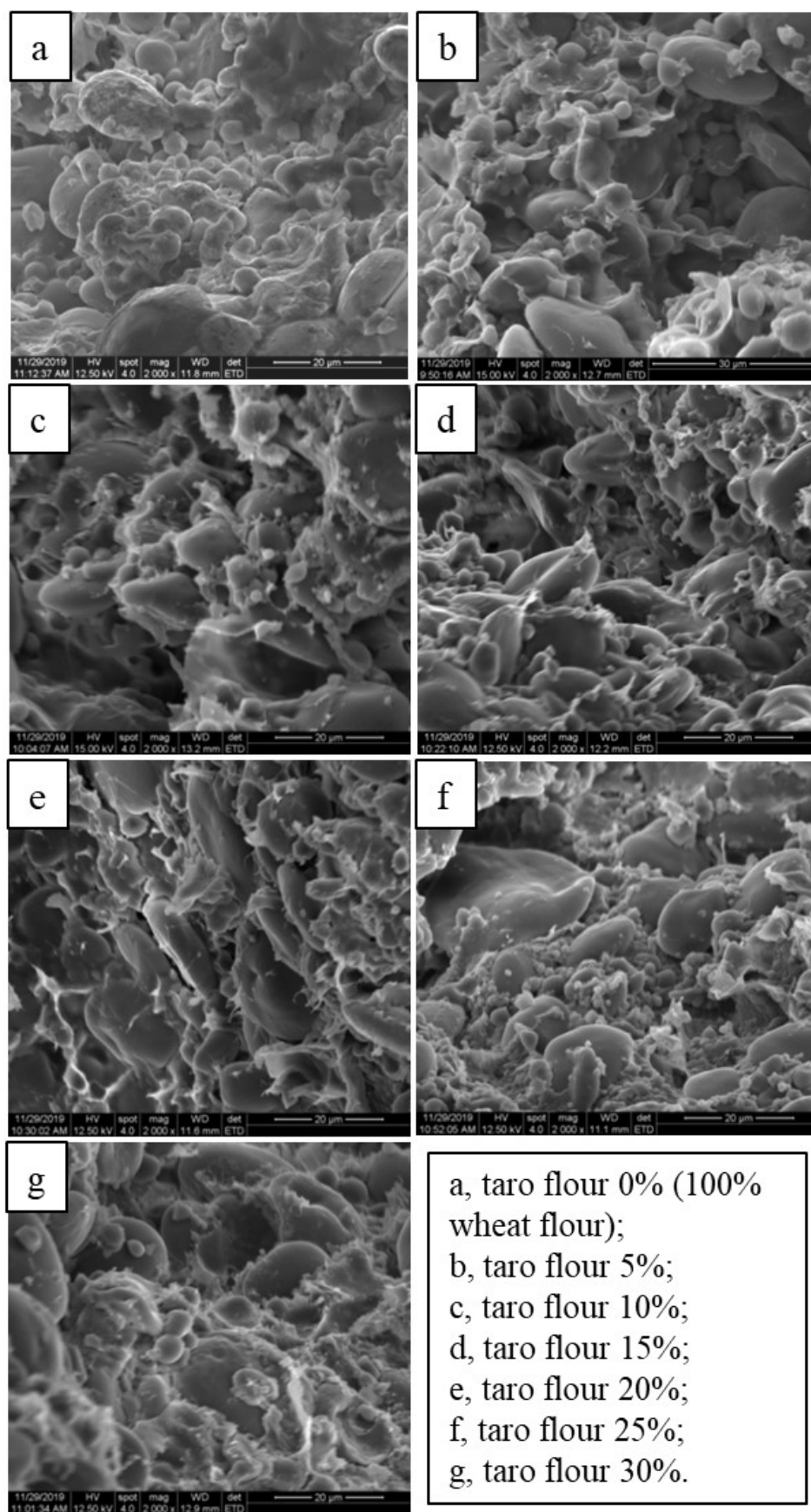


Figure 2. Microstructure of dough prepared with wheat flour-KGM blends (2000 ×). a, taro flour 0% (100% wheat flour); b, taro flour 5%; c, taro flour 10%; d, taro flour 15%; e, taro flour 20%; f, taro flour 25%; g, taro flour 30%.

taro powder is added, resulting in loose deformation of the network structure (Kim et al., 2009).

4 Conclusions

With the increase in the amount of taro powder, the starch content of the mixed flour gradually increased, and the color gradually became darker. The water absorption of the mixed flour showed an upward trend, but the formation time of the dough and the weakening degree of the protein showed a downward trend. The properties of mixed roux and the thermal stability of starch paste tended to increase first and then decrease, and the stability of cold gelatinization of starch gradually decreased. The peak viscosity, peak time, grain viscosity, final viscosity and regaining value of the mixed powder increased gradually, while the damage value decreased gradually. Taro powder has a clear effect on the texture of dough. The addition of taro powder increases the firmness of the dough, but after a certain amount, the firmness decreases slightly. The cohesiveness of the dough increases with increasing taro powder. According to the transverse relaxation diagram, each sample curve has two peaks. The addition of taro powder causes both peaks of the dough to move to the left, reducing the moisture flow in the dough. The addition of taro powder may make the dough less resistant to mechanical blending and slightly less viscoelastic, but the gluten structure is smoother. Considering its nutritive factors and silty properties, it is suitable to make noodles when the proportion of taro flour in wheat flour is 25%.

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