

Development of Dried Taro Round Formula Based on Microwave Drying

Keywords: Taro round; Formula; Microwave drying; Texture characteristics

Abstract

The purpose of this work was to optimize the formulation process of dried taro rounds based on microwave drying. The sensory evaluation, texture characteristics, cooking time, the rehydration ratio and total drying time were used as indexes, and the comprehensive score method of membership degree was used for statistical analysis. The optimal formula of dried taro round was obtained by single factor test and orthogonal test. The results showed that the optimal formula of dried taro round was that the addition amount of cassava starch was 80%, the addition amount of modified starch was 8%, the addition amount of sugar was 16%, and the addition amount of water was 10% (taro puree 100% as the benchmark, all percentages refer to mass fraction). The experimental results showed that dried taro rounds with good quality and the highest comprehensive score of membership degree can be obtained by this formula. At the same time, adaptability to microwave drying the taro rounds obtained from this formula and taro rounds purchased from the market were compared. The results showed that the comprehensive score of membership degree of the product obtained by this formula was the highest. The study on the formula of taro rounds based on microwave drying provides a technical reference for the industrial production of taro rounds and the development of dried taro round products.

Introduction

Taro belongs to the genus Araceae [1], which grows mostly in humid tropical and subtropical areas [2]. It is a traditional famous brand product in Hezhou, which is sold well in Guangxi and Guangdong with its “taste, quality and crispy” [3]. The main food of taro is corm, which contains rich starch, protein, dietary fiber, vitamins and minerals and so on [4]. In addition, it also contains active substances such as polysaccharides, phenol and flavonoids [5], which can benefit the stomach and broaden the intestine, defecate and detoxify, tonic the liver and kidney, prevent and cure diabetes, etc. [6]. However, the processing and utilization level of taro is low, which is mainly fresh sale, and there are few kinds of deeply processed products. At present, the processed products of taro mainly include taro crisps, fresh-cut taro products, taro yogurt, taro composite beverages, etc. [7], and there is a lack of deep-processed taro products. Taro chips on the market are mainly fried. In the production process, due to high temperature and high oil, taro chips lose too many nutrients. Fresh-cut taro products are not resistant to storage, which limits their development in the market. Taro starch [8] and the taro beverage [9] have been studied deeply at home and abroad. The research on taro round is rarely reported.

At present, the market is mainly based on quick-frozen taro rounds. Low-temperature quick-freezing is used to extend the shelf life of taro rounds. Condition of cold chain is provided during transportation. The production cost is high and the storage temperature is limited. Compared with quick-frozen taro rounds, dried taro rounds have the



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advantages of room temperature storage, long storage time and no need for cold chain transportation, cost saving and soon. Microwave drying has the advantages of high efficiency, saving time and energy consumption, and ensuring product quality. Therefore, microwave-dried taro rounds can well adjust the off-peak season of the market, and are more favored by consumers and producers. At present, for the production of taro round products, different factories have different formulations or often according to their own experience. The specific production technology of taro round is lacking systematic and scientific research, which leads to uneven, unstable performance and different taste of taro rounds. Texture instrument is one of the professional instruments for objective evaluation of product texture at present. Through texture profile analysis, that is, secondary extrusion test, it can simulate the situation of human teeth chewing food [10]. The combination of texture instrument and sensory score can reduce the error of human senses and make the data more reliable.

In this study, based on microwave drying, cassava starch, modified starch, sugar and water were used as influencing factors to study the best formula of dried taro round. The addition amount of all materials was calculated according to the mass fraction, and the quality of taro puree was taken as the benchmark in this experiment. The research on the best formula of dried taro round not only provides a technical reference for its industrial production, but also effectively promotes the development of the taro industry and increases the added value of taro.

Materials and Methods

Materials

Betelnut taro was purchased from central market in Hezhou Guangxi; Cassava starch was purchased from Shanghai Fengwei Industrial Co., Ltd.; Modified starch was purchased from Zhejiang Bodan heng Food Co., Ltd.; Sugar was purchased from Taixing Supermarket in Hezhou, Guangxi; Taro round A was purchased from Fujian Zihuo Food Co., Ltd. (brand: Zhanyi); Taro round B was purchased from Guangdong Zhonghui Food Co., Ltd. (brand: Wei Xiaoyuan); Taro round C was purchased from Longhai Mark Kaduo Food Co., Ltd. (brand: Wei Xiaoyuan) Brand: Miss Baking);

Taro Round D was purchased from Dongguan DalangQuantai Food Factory (Brand: Guochao Food).

TA. XT Plus Physical Property Tester was purchased from Stable Micro System Ltd, UK;G70D20CN1P-D2 (S0) microwave oven was purchased from Guangdong Galanz Microwave Life Electric Manufacturing Co., Ltd.; HH-S2 digital display constant temperature water bath was purchased from Jiangsu Jinyi Instrument Technology Co., Ltd.; YH-M10002 Electronic balance was purchased from DongyangYingheng Intelligent Equipment Co., Ltd.; MB90 rapid moisture analyzer was purchased from Changzhou Ohaus Instrument Co., Ltd.; ZW-8 high-efficiency pill making machine was purchased from Wenzhou Dingli Medical Equipment Co., Ltd.

Process flow

Raw material selection →Cleaning →Peeling →Slicing →Steaming →Taro puree→Preparation of dough→Preparation of raw taro rounds→Cooking, moved into cold water→Microwave intermittent drying →Determination of indexes

Operating points

Raw material pretreatment: Taro was selected according to the criteria of freshness, no pests, equal maturity, intact pericarp and uniform size. Washed and peeled the taro, then cut into thin slices. Steamed the thin slices, and then used a dough mixer to mix until the taro was puree with no obvious granularity.

Preparation of dough: First of all, all materials including taro puree, cassava starch, modified starch, sugar and water were accurately weighed. Then, the sugar was dissolved in water, and finally it was added to the kneading machine together with taro puree, cassava starch, and modified starch, and the dough with moderate hardness and non-sticky was obtained by stirring.

Preparation of raw taro rounds: The dough was put into a pill machine to make raw taro rounds with diameter of 0.8cm.

Cooking: The taro rounds were boiled in boiling water until they were fully floated, then moved into cold water for 1 minute, and drained for later use.

Microwave intermittent drying: Lightly absorbed water on the surface of the taro rounds with absorbent paper, then placed taro rounds with a certain weight in a tray and kept them free from adhesion to each other. Microwave intermittent drying was performed under the conditions of a power of 350W and an intermittent ratio of 2(heating time 1min, intermittent time 1min), and the drying was completed when the water content was 23%, and the total drying time was recorded.

Determination of indexes: After the dried taro round was cooled, the rehydration ratio, cooking time and sensory evaluation of dried taro round were measured.

Single factor experimental design

The experimental dough was composed of taro puree, cassava starch, modified starch, sugar and water, and the proportion of each component was mass ratio. Taro puree as the main raw material, with taro puree 100% as the benchmark, the effects of cassava starch, modified starch, sugar and water on the formulation process of dried taro round was studied. The specific design of the experiment was

as follows: according to the preliminary test results, the amount of cassava starch added were 60%, 70%, 80%, 90% and 100%; The amount of modified starch added were 0%,4%, 8%, 12% and 16%; The amount of white sugar added were 4%, 8%, 12%, 16% and 20%; The amount of water added were 5%,10%, 15%, 20% and 25% were tested for single factor test. Taking the sensory evaluation of taro round before drying, the sensory evaluation of dried taro round, the cooking time of dried taro round, the rehydration ratio of dried taro round and the total drying time as evaluation indexes, the effects of various factors on the sensory quality, texture characteristics and drying characteristics of taro rounds were studied, and the comprehensive score of membership degree was used for statistical analysis.

Orthogonal optimization test

On the basis of single factor test, in order to further determine the best formula of dried taro round, L9 (34) was used for orthogonal optimization test. The range of each factor level was based on the results of single factor experiments. And the orthogonal test factors and levels were shown in (Table 1).

Test method for comparison of microwave-dried taro rounds with quick-frozen taro rounds in the market

The quick-frozen taro rounds purchased from the market were thawed. The taro rounds were boiled in boiling water until they were fully floated, then moved into cold water for 1 minute, and then performed sensory evaluation before drying. Lightly absorbed water on the surface of the taro rounds with absorbent paper, then placed taro rounds with a certain weight in a tray and kept them free from adhesion to each other. Microwave intermittent drying was performed under the conditions of a power of 350W and an intermittent ratio of 2((heating time 1min, intermittent time 1min)), and the drying was completed when the water content was 23%, and the total drying time was recorded. After the sample was cooled, the ratio of sample rehydration after drying, the cooking time of sample after drying and the sensory evaluation of sample after drying were measured. The results were shown in (Figure 5).

Determination of Indicators

Determination of texture characteristics of taro round before drying: The hardness, elasticity, chewiness and cohesion of the taro rounds were measured by a physical property meter TA. XTPLUS. The parameters were set as follows: the pre-test speed was 1.0mm/s, the test speed was 0.8mm/s, the post-test speed was 0.8mm/s, the probe was P/36R, and the compression ratio was 75% [11].

Sensory evaluation of taro round before drying: The criteria for sensory evaluation were shown in (Table 2), and some modifications were made by referring to methods such as Hui-minXu [12].

Determination of water content: The initial water content of taro puree measured by MB90 moisture analyzer was 70±1.45%.

Determination of the rehydration ratio of dried taro round:

Table 1: Orthogonal test factor level.

Level	Factor			
	Cassava starch /%	Modified starch /%	White sugar /%	Water /%
1	75	6	14	7.5
2	80	8	16	10
3	85	10	18	12.5

Weighed the dried taro rounds, recorded it as m_0 , and put them in a beaker, then added 200ml of 60°C water, rehydrated in a 60°C water bath for 30 minutes, then took them out and drained them for 2 minutes. The water on the surface of the taro rounds was absorbed with absorbent paper, and then weighed and denoted as m_f [13]. Repeated the operation 3 times for each group of samples, and the results were averaged. The rehydration ratio (RR) was calculated by using the Eq. (1) [13];

$$RR = m_o / m_f (1)$$

Determination of the cooking time of dried taro round: A certain amount of dried taro rounds were placed in a pot of boiling water at 800ml and 100, cooked and stirred. When the center of the taro rounds was completely softened to no white of the center, noted the time taken and denoted by min [14].

Calculation of intermittent ratio: The intermittent ratio (R) was calculated by using the Eq. (2) [15];

$$R = (T_A + T_T) / T_A (2)$$

In the formula: R is the intermittent ratio [15]; T_A is the heating time (min); T_T is the intermittent time (min).

Sensory evaluation of dried taro rounds: The sensory evaluation group consists of 10 members of food profession, and the score is 100 points. The criteria for sensory evaluation were shown in (Table 3).

Comprehensive score calculation: The sensory evaluation, rehydration ratio, cooking time and total drying time were used as evaluation indicators, and statistical analysis was carried out using the comprehensive scoring method of membership degree.

The larger the sensory score and the rehydration ratio, the better,

Table 2: Criteria for sensory evaluation of taro rounds before drying.

Project	Evaluation criteria	Sensory score / point
Color(15points)	Bright color, slightly purple with fragrant taro	11-15
	Darker color	6-10
	Have other abnormal colors and Browning occurs	<5
Apparent(15points)	The surface is smooth and exquisite, insoluble, and the particles are distinct	11-15
	The surface is slightly rotten and rough	6-10
	The surface is rough, bumpy, sticking together	<5
Taste(40points)	Moderate hardness and chewiness, sufficient toughness, good elasticity, refreshing, delicate and non-sticky teeth	32-40
	Harder or softer, general viscoelasticity, slightly smooth	24-31
	Too hard or too soft, poor elasticity, sticky teeth, rough, difficult to chew	<24
Turbidity(10points)	Clear, no precipitation	7-10
	Slightly clear, the precipitation is not obvious	4-6
	Turbidity, with obvious sediment	0-3
Smell and taste (20points)	A strong flavor of taro, no peculiar smell, moderate sweetness	16-20
	Taro taste is not obvious, no peculiar smell, moderate sweetness	11-15
	No taro flavor, have an abnormal taste, sweeter or lighter	<11

Table 3: Criteria for sensory evaluation of dried taro round.

Project	Total score/point	Evaluation criteria	Sensory score / point
Color (After drying)	10 points	The color is uniform and bright, with lavender	7-10
		The surface color is slightly uniform, and the brightness is slightly worse	4-6
		Uneven surface color, caramel or dark yellow or other abnormal colors	0-3
Apparent(After drying)	15 points	Smooth surface, no blistering deformation, no cracks	11-15
		The surface is slightly rough, with a little bubbling and whitish	6-10
		The surface is rough and porous, blistering or swelling and deforming, severe cracking	0-5
Color (Cooked again)	10 points	The color is uniform and bright, with lavender	7-10
		The surface color is slightly uniform, and the brightness is slightly worse	4-6
		Uneven surface color, caramel or dark yellow or other abnormal colors	0-3
Apparent(Cooked again)	15 points	The surface structure is fine, smooth and insoluble	11-15
		Slightly concave or dissolved	6-10
		Rugged or badly damaged	0-5
Taste(Cooked again)	20 points	The taste is soft and waxy, chewy, viscoelastic and delicate	14-20
		Slippery, insufficient viscoelasticity, harder or softer	7-13
		Poor viscoelasticity, too hard or too soft, difficult to chew	0-6
Smell and taste (Cooked again)	20 points	A strong flavor of taro, no peculiar smell, moderate sweetness	14-20
		Taro taste is not obvious, no peculiar smell, moderate sweetness	7-13
		No taro flavor, have an abnormal taste, sweeter or lighter	0-6
Turbidity(Cooked again)	10 points	Clear, no precipitation	7-10
		Slightly clear, the precipitation is not obvious	4-6
		Turbidity, with obvious sediment	0-3

they were calculated according to formula (3):

$$Z = (G_i - G_{\min}) / (G_{\max} - G_{\min}) \quad (3)$$

The smaller the cooking time and the total drying time, the better, they were calculated according to formula (4):

$$Z = (G_{\max} - G_i) / (G_{\max} - G_{\min}) \quad (4)$$

In the formula, Z is the membership degree; G_i is the index value; G_{\min} is the minimum value of the index; G_{\max} is the maximum value of the index [16].

According to formula (5), the comprehensive score of the drying process was obtained by weighting:

$$G = aZ_1 + bZ_2 + cZ_3 + dZ_4 + eZ_5 \quad (5)$$

In the formula, G is the comprehensive score of membership degree; Z_1 is the membership degree of sensory score before drying; Z_2 is the membership degree of sensory score after drying; Z_3 is the membership degree of rehydration ratio; Z_4 is the membership degree of cooking time; Z_5 is the membership degree of total drying time [17]; a, b, c, d and e are the weights of each index, all of which are 0.2.

Statistical Analysis

SPSS 24 and Origin 8.5 were used for statistical analysis the data and mapping. Values in Tables 4-7 are expressed as mean ± standard deviation. Common lowercase letters in the same column indicates no significant difference at $p > 0.05$; Different lowercase letters in the same column indicates significant differences at $p < 0.05$.

Results and Analysis

Effects of different amounts of cassava starch on the quality and drying characteristics of taro round

The effects of different additions of cassava starch on the texture

characteristics of taro round before drying and sensory evaluation of taro round before drying were shown in (Table 4). It can be seen from (Table 4) that the hardness, cohesion and chewiness of taro round increased with the increased of the amount of cassava starch. It may be due to the water absorption and swelling of starch in the process of heating, resulting in the formation of starch gel system [18]. Heating not only enhanced the gelatinization degree and water absorption swelling of starch, but also increased the degree of random binding between starch molecules, which strengthened the relationship between the inter-molecular and intra-molecular, and made the network structure of the gel more tight [19]. It led to the increase of cohesion and hardness of taro round. Chewiness represents the work done by chewing a solid sample into a steady state when swallowing. (Table 4) reflected a positive correlation between chewiness and hardness, and similar result was also reported by other researcher as well [20]. It showed that the harder the taro rounds were, the more work they needed to do when chewing the taro rounds. Due to the requirements of taste of taro round, hardness and chewiness should be appropriate of intermediate value. When the cassava starch addition increased from 60% to 90%, the taro round elasticity increased; when the cassava starch addition was 100%, the taro round elasticity decreased, but it was not significant. This may be due to the gelatinization of starch to form elastic colloid, which can increase the elasticity of taro round to a certain extent, but with the increase of the amount of starch, the free water of the system was relatively reduced, and the gel showed the phenomenon of too hard and tough [21], and then the elasticity decreased slightly. When the addition of cassava starch was 60% and 70%, the taste of taro round was softer, chewiness and elasticity were poor, and the sensory score of taro round before drying was lower. When the addition of cassava starch was 90% and 100%, the hardness and chewiness of taro rounds were larger, and the taste of taro disappeared, which reduced people's acceptance and sensory score. When the addition of cassava starch was 80%, the taro

Table 4: Effect of cassava starch addition on the taro round before drying.

Additive amount (%)	Hardness/g	Elasticity	Cohesion	Chewiness	Sensory score/point
60	756.83±6.21 ^d	0.83±0.054 ^b	0.60±0.01 ^c	378.95±31.45 ^c	47.17±1.40 ^d
70	800.09±12.94 ^{cd}	0.86±0.08 ^{ab}	0.63±0.03 ^b	432.65±49.50 ^c	60.13±1.97 ^c
80	837.92±16.23 ^c	0.90±0.05 ^{ab}	0.67±0.01 ^a	500.41±24.85 ^b	74.60±2.05 ^a
90	987.93±10.8 ^b	0.93±0.01 ^a	0.67±0.01 ^a	608.15±14.43 ^a	66.73±1.45 ^b
100	1120.25±68.03 ^a	0.84±0.02 ^{ab}	0.68±0.01 ^a	637.61±32.96 ^a	59.23±1.96 ^c

Table 5: Effect of the amount of modified starch on the taro round before drying.

Additive amount (%)	Hardness/g	Elasticity	Cohesion	Chewiness	Sensory score/point
0	769.92±72.78 ^c	0.85±0.01 ^b	0.65±0.01 ^b	424.33±36.17 ^c	58.00±1.21 ^e
4	851.96±27.03 ^b	0.86±0.02 ^{ab}	0.68±0.02 ^{ab}	515.02±53.67 ^{bc}	67.20±1.90 ^c
8	879.91±33.29 ^b	0.89±0.03 ^a	0.69±0.01 ^a	534.41±8.46 ^{ab}	76.90±1.83 ^a
12	1021.22±135.15 ^a	0.88±0.01 ^{ab}	0.68±0.03 ^{ab}	631.29±98.38 ^a	73.23±1.78 ^b
16	1075.89±56.12 ^a	0.86±0.01 ^b	0.68±0.01 ^{ab}	634.67±23.67 ^a	63.03±1.29 ^d

Table 6: Effect of white sugar addition on the taro round before drying.

Additive amount (%)	Hardness/g	Elasticity	Cohesion	Chewiness	Sensory score/point
4	720.38±24.22 ^b	0.85±0.0 ^a	0.65±0.01 ^a	398.88±13.58 ^b	68.60±0.89 ^d
8	746.15±46.51 ^b	0.87±0.03 ^a	0.66±0.02 ^a	431.15±49.05 ^b	72.17±0.35 ^c
12	822.33±16.82 ^a	0.88±0.02 ^a	0.67±0.01 ^a	485.04±17.96 ^a	74.47±0.95 ^b
16	833.36±26.48 ^a	0.89±0.03 ^a	0.67±0.01 ^a	496.27±31.37 ^a	78.58±0.65 ^a
20	852.89±9.40 ^a	0.87±0.02 ^a	0.66±0.01 ^a	490.13±21.46 ^a	72.70±0.40 ^c

Table 7: Effect of water addition on taro round before drying.

Additive amount (%)	Hardness/g	Elasticity	Cohesion	Chewiness	Sensory score/point
5	1015.28±27.68 ^a	0.85±0.07 ^a	0.65±0.02 ^a	563.74±34.58 ^a	72.87±0.70 ^c
10	896.96±20.33 ^b	0.88±0.01 ^a	0.66±0.02 ^a	522.56±9.62 ^b	78.53±0.71 ^a
15	833.14±23.08 ^c	0.88±0.03 ^a	0.65±0.02 ^{ab}	471.50±27.56 ^c	74.47±0.75 ^b
20	734.93±5.41 ^d	0.87±0.01 ^a	0.62±0.02 ^{bc}	398.50±10.19 ^d	70.77±1.01 ^d
25	709.13±11.26 ^d	0.86±0.02 ^a	0.61±0.01 ^c	374.75±14.30 ^d	66.47±0.70 ^e

Table 8: Results of orthogonal test on the formula of dried taroround.

Test number	Factor				G ₁ /point	G ₂ /point	G ₃	G ₄ /min	G ₅ /min	G/point
	A	B	C	D						
1	1(75%)	1(6%)	1(14%)	1(7.5%)	80.20	74.10	1.59	10.50	88	1.38
2	1	2(8%)	2(16%)	2(10%)	84.70	80.50	1.62	8.50	96	2.73
3	1	3(10%)	3(18%)	3(12.5%)	82.40	78.60	1.61	9.00	98	1.80
4	2(80%)	1	2	3	88.60	84.80	1.63	8.50	94	3.82
5	2	2	3	1	90.30	88.20	1.61	8.00	96	3.84
6	2	3	1	2	89.80	87.80	1.60	9.00	92	3.68
7	3(85%)	1	3	2	82.50	79.70	1.60	9.00	90	2.51
8	3	2	1	3	84.80	80.20	1.58	8.50	92	2.47
9	3	3	2	1	85.40	82.50	1.57	11.00	90	1.91
k ₁	5.92	7.72	7.53	7.13						
k ₂	11.34	9.04	8.47	8.92						
k ₃	6.89	7.39	8.15	8.09						
R	5.42	1.64	0.32	1.79						
Optimal combination	A ₂ B ₂ C ₂ D ₂									

Table 9: Verification test results.

Group	G ₁ /point	G ₂ /point	G ₃	G ₄ /min	G ₅ /min	G/point
1	88.90	85.80	1.60	8.50	92	3.60
2	90.60	88.70	1.59	8.50	92	3.94
3	91.60	90.80	1.62	8.00	94	4.51
Mean ± standard deviation	90.37±1.37	88.43±2.51	1.61±0.01	8.33±0.29	92.67±1.16	4.02±0.46

rounds were lilac, with suitable hardness and chewy taro flavor, so the sensory score of taro round before drying was the highest.

The effects of different amounts of cassava starch on the quality of dried taro round and drying characteristics of taro round were shown in (Figure 1). It can be seen from (Figure 1) that under the same condition of drying, the rehydration ratio of dried taro round decreased and the cooking time of dried taro round increased with the increase of cassava starch content. The reason may be that the higher the cassava starch content, the stronger the starch network structure, which not only made its rehydration worse, but also increased the taro round hardness, resulting in longer cooking time. It has been reported that there is a negative correlation between starch content and rehydration [22]. When the cassava starch content increased from 60% to 80%, the sensory score of dried taro round and the total drying time showed an upward trend. The reason was that the starch content was less, the taro round structure was not tight, easy to lose water, the surface melts, resulting in difficult processing and poor appearance of the finished products. When the cassava starch content increased from 80% to 100%, the sensory score of dried taro round and the total drying time decreased. The reason was that the starch content was too high, the surface viscosity of taro round increased [22], the drying process was easy to stick to the bottom, the loss rate increased, and the palatability of taro round was poor. In the preparation of dough,

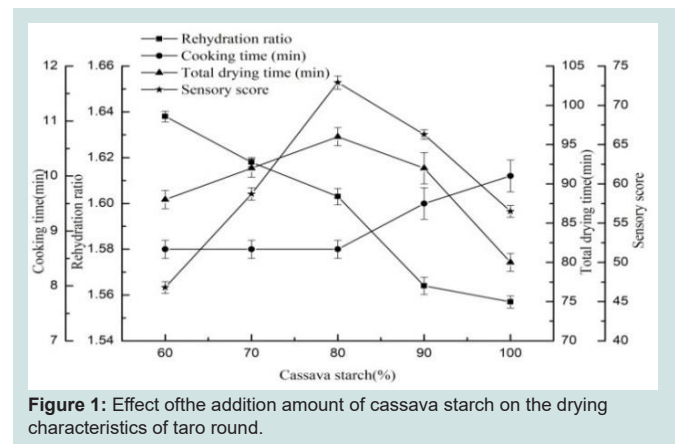


Figure 1: Effect of the addition amount of cassava starch on the drying characteristics of taro round.

due to the small amount of starch, the dough was soft and easy to adhere to deformation, while too much starch led to hard dough and was not easy to form.

To sum up, this experiment considered that the addition amount of cassava starch was 75%, 80% and 85% for orthogonal experiment.

Effects of different amounts of modified starch on the quality and drying characteristics of taro round

The effects of different additions of modified starch on the texture characteristics of taro round before drying and sensory evaluation of taro round before drying were shown in (Table 5). Modified starch is an ideal thickener, gelling agent, stabilizer, emulsifier and excipient in food processing [23]. An appropriate amount of modified starch can improve the taste and appearance of taro rounds, make them soft and hard, and give them better viscoelasticity and formability, thus making the surface structure of taro round delicate and smooth [24]. It can be

seen from (Table 5) that the hardness and chewiness of taro round increased slowly with the increased of modified starch. The reason may be that with the increase of modified starch, the cross-linking between starch molecules enhanced the degree of connection between starch molecules [25], resulting in a gradual increased in hardness and chewiness of taro round. With the increase of modified starch content, the elasticity of taro round increased gradually and then decreased slightly. The reason may be that the addition of modified starch was too high, and its steric hindrance reduced the aggregation between starch molecules [26], which reduced the viscoelasticity of the gel. The results shown that addition of the appropriate amount of modified starch can make the product more flexible, which was consistent with the effect of modified starch on the quality of frozen dough bread studied by Xiaoyan Wang et al. [27]. It can be seen from the (Table 5) that the addition of 8% modified starch can help to improve the texture quality of taro round. The sensory score of taro round before drying increased at first and then decreased with the increase of the amount of modified starch. The reason was that the content of modified starch was too much, which led to the hardness of taro round, the decrease of elasticity and the decrease of surface fineness [13], so the sensory score of taro round before drying was lower. When the amount of modified starch was 8%, the chewiness of taro round was moderate, the elasticity of taro round was good, the color of taro round was bright, the surface of taro round was smooth and the sensory score of taro round was highest.

The effects of different amounts of modified starch on the quality of dried taro round and drying characteristics of taro round were shown in (Figure 2). It can be seen from (Figure 2) that the rehydration of dried taro round and drying time of taro round decreased slowly with the increase of modified starch. When the addition of modified starch was 8%, the cooking time of dried taro round was the shortest. When the amount of modified starch increased from 0% to 8%, the sensory score of dried taro round increased significantly, and then decreased slowly after exceeding 8%. The reason for these phenomena may be due to the addition of too much modified starch, the gel strength was enhanced, resulting in the increase of hardness and the decrease of rehydration ratio. On the other hand, the hardness increased and the elasticity decreased, so that the taste of taro round was poor. At the same time, the addition of too much modified starch made the surface of taro round rough and sticky increased [12], which was not only not conducive to drying, but also decreased the appearance quality of taro round.

To sum up, it was considered that the addition amount of modified starch was 6%, 8% and 10% for orthogonal test.

Effects of different amounts of sugar on the quality and drying characteristics of taro round

The effects of different additions of sugar on the texture characteristics of taro round before drying and sensory evaluation of taro round before drying were shown in (Table 6). The addition of sugar can not only improve the flavor and taste of the food, but also improve the texture characteristics of the food [19]. It can be seen from (Table 6) that the hardness and chewiness of taro round increased slowly with the increased of sugar content. This may be due to the interaction of sugar and starch, which strengthened the

network structure of starch glue [28], making the structure of taro round more stable. When the amount of sugar was from 12% to 20%, the changes of hardness and chewiness were not significant. With the increase of sugar addition, the elasticity and cohesion of taro round increased slowly, and the change was not significant. When the sugar addition increased from 4% to 16%, the sensory score of taro round before drying showed an upward trend. Adding the right amount of sugar can improve the flavor of the product. When the amount of sugar was small, the sweetness was not enough; when the sugar was added more, the product was too sweet. (Table 6) showed that the sugar addition was 16%, and the sensory score was the highest.

The effects of different amounts of white sugar on the quality of dried taro round and drying characteristics of taro round were shown in (Figure 3). It can be seen from (Figure 3) that the rehydration ratio of dried taro round and sensory score of dried taro round increased with the increase of sugar addition, but beyond a certain limit, the rehydration ratio of dried taro round and sensory score of dried taro round decreased significantly. When the sugar addition was 12% and 16%, the cooking time of dried taro round was the least. The total drying time increased with the increase of sugar content. The reason for these phenomena may be that the addition of white sugar can form a delicate and dense micro-network gel structure, which increased elasticity, gave the product better taste and rehydration [29], and increased the sensory score. Too high sugar content enhanced the gel strength, resulted in poor rehydration [30], and made the product too sweet. When the addition of sugar was 16%, the sensory score of dried taro round was the highest, the cooking time of dried taro round was the shortest, the rehydration was higher, and the total drying time was shorter.

To sum up, it was considered that the addition amount of white sugar was 7.5%, 10% and 12.5% for orthogonal test.

Effects of different amounts of water on the quality and drying characteristics of taro round

The effects of different additions of water on the texture characteristics of taro round before drying and sensory evaluation of taro round before drying were shown in (Table 7). It can be seen from (Table 7) that when the amount of water added increased from 5% to 20%, the hardness and chewiness of taro rounds changed significantly ($P > 0.05$), and with the increase of water addition, the hardness and chewiness of taro round tend to decrease gradually. On the other hand, when the amount of water added was 10%, the cohesion was the highest. It shows that the hardness, cohesion and chewiness of taro round were closely related to water content. With the addition of too little water, the intermolecular interaction of starch was enhanced and the hardness was increased. At the same time, it will also affect the bonding of the dough, resulting in loose structure and low cohesion of the dough. The addition of too much water the network structure formed by starch was diluted, which made the structure of taro round soft and easy to deform, and the elasticity and chewiness of taro round were poor. The cohesion of taro round refers to its internal adhesion. The quality of taro round was positively correlated with its elasticity and cohesion. The larger the value of the index was, the more elastic and non-sticky taro round was. It can be seen from the (Table 7) that when the amount of water was 10%, the starch combined fully

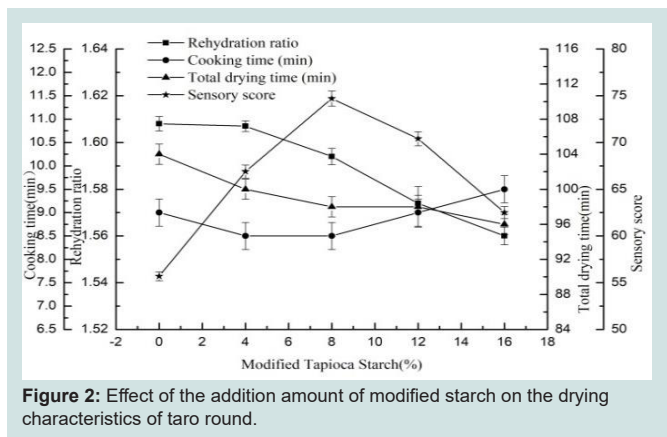


Figure 2: Effect of the addition amount of modified starch on the drying characteristics of taro round.

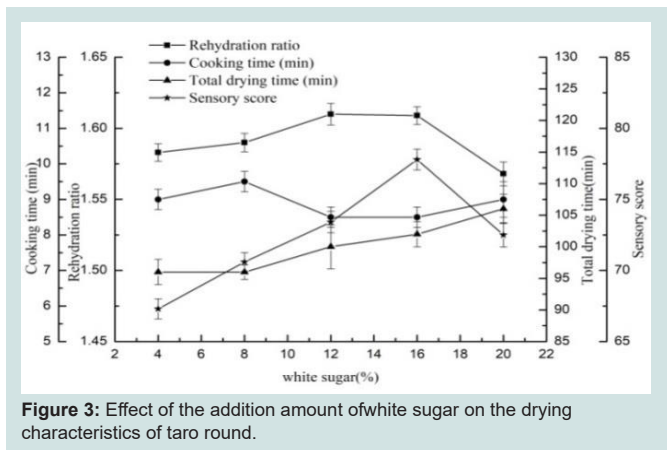


Figure 3: Effect of the addition amount of white sugar on the drying characteristics of taro round.

with water, gave taro round proper chewing strength and hardness, as well as greater elasticity and cohesion, so that the quality of taro round was better. Water content will affect the appearance and taste of products to some extent. When the amount of water was small, the combination of starch and water was not sufficient, it was not easy to form and the taste of taro round was hard. The addition of a large amount of water made the taro round lack of elasticity and chewiness, sweetness was not obvious and the surface dissolves after cooking, so the sensory score of taro round before drying was lower. When the amount of water added was 10%, the sensory score of taro round before drying was the highest, which was significantly better than that of other groups in terms of luster, color, toughness and taste.

The effects of different amounts of water on the quality of dried taro round and drying characteristics of taro round were shown in (Figure 4). It can be seen from (Figure 4) that the rehydration ratio of dried taro round and sensory score of dried taro round increased with the increase of water addition, but beyond a certain limit, the rehydration ratio of dried taro round and sensory score of dried taro round decreased, and the change trend of the cooking time of dried taro round was opposite. The reason was that in the drying process, microspores were produced due to the evaporation of water, and with the increase of water content, the number of microspores increased, thus increased the water-holding capacity of the product [31], so the re-water ratio increased, and it resulted in less the cooking time of dried taro round. The water content was too high, when the drying temperature was much higher than the glass conversion of

temperature, the product shrank obviously, and the structure of the final product was dense [32], so the rehydration was reduced, resulting in an increase in the cooking time of dried taro round. On the other hand, due to the excessive addition of water, taro round collapsed and wrinkled and stuck to the bottom in the drying process, which greatly affected the apparent quality of taro round. When the amount of water added was 15%, the drying time was the longest. Because, when the combination of water and starch was sufficient, the structure of taro round was compact and not easy to lose water. (Figure 4) shown that when the addition of water was 10%, the sensory score of dried taro round was the highest, the rehydration was larger, the cooking time and total drying time were shorter.

To sum up, it was considered that the addition amount of water was 7.5%, 10% and 12.5% for orthogonal test.

Orthogonal optimization test results of dried taro round

The investigated levels of each factor were selected depending on the above experiment results of the single-factor. In the present study, all selected factors were examined using an orthogonal L_9 3^4 test design. The results were statistically analyzed by the comprehensive scoring method of membership degree. And the results were shown in (Table 8).

Note: In the Table 8, A was the additive amount of cassava starch (%); B was the additive amount of modified starch (%); C was the additive amount of white sugar (%); D was the additive amount of water (%). G_1 was the sensory evaluation of taro round before drying; G_2 was the sensory evaluation of dried taro round; G_3 was the rehydration ratio of dried taro round; G_4 was the cooking time of dried taro round; G_5 was the total drying time; G was the comprehensive score of membership degree.

It can be seen from (Table 8) that the factors influence the comprehensive membership score of dried taro rounds were listed in a decreasing order as follows: A(additive amount of cassava starch)>D(additive amount of water)>B(additive amount of modified starch)>C(additive amount of sugar) according to the R value. According to the range analysis of k value, the best combination was $A_2B_2C_2D_2$, that is, the addition amount of cassava starch was 80%, the addition amount of modified starch was 8%, the addition amount of sugar was 16%, and the addition amount of water was 10%.

Verification Test Results

The optimal formula $A_2B_2C_2D_2$ obtained by orthogonal test analysis was verified, and the test results were shown in (Table 9).

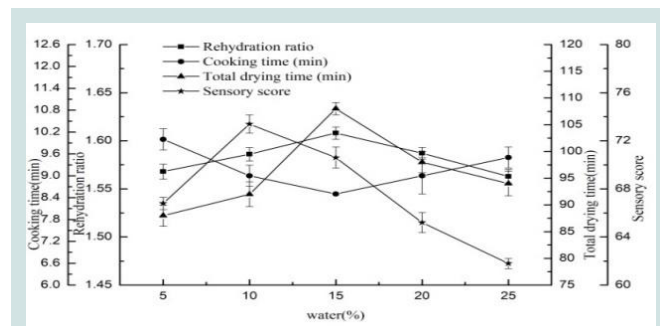


Figure 4: Effect of the addition amount of water on drying characteristics of taro round.

The results showed that under the best formula (A₂B₂C₂D₂), the comprehensive membership score of dried taro round was 4.02 ±0.46, which was higher than that of the highest score combination (A₂B₂C₃D₁) in the orthogonal test group. It showed that the combination of formula obtained by orthogonal test was more reliable, so the final formula of dried taro round was as follows: the addition amount of cassava starch was 80%, the addition amount of modified starch was 8%, the addition amount of sugar was 16%, and the addition amount of water was 10%.

Comparative test of the suitability of microwave drying

In order to investigate the adaptability of microwave drying among the product of this formula and similar products on the market, the taro round obtained from this formula (self-made taro round) and four different brands of taro rounds in the market (A, B, C and D) were compared. The results were shown in (Figure 5).

Before drying, the taro round A had bright color and soft waxy taste, but its elasticity was slightly worse. Because the surface was sticky and slightly melted, it was sticky in the drying process and was easy to destroy the apparent of taro round. After drying, the surface of taro round A shrank seriously, there were many lines, and it was rough. Therefore, the comprehensive score of membership degree of taro round A was low. Before drying, taro round B was grayish white, the taste was too soft, and no skeleton of the taro rounds, at the same time, accompanied by the sand texture, resulting in the taste was poor. On the other hand, because the surface was sticky and soft, it was not easy to operate during drying and easy to collapse, resulting in a poor appearance of taro round. After cooking, the appearance of taro rounds was not full and smooth enough. Before drying, taro round C was dark in color, poor chewiness and slightly sticky teeth in taste, sticky and melting in appearance, which not only made it difficult to operate but also increased the loss rate of taro round in the drying process. Before drying, taro round D was grayish black with soft taste and poor elasticity. In addition, the flavor of spice masked the taste of taro, and there was no sweetness. In terms of structure, the structure of taro round was loose, and the apparent melting was serious after cooking, which was not only not conducive to drying processing, but also the sensory quality of dried

taro round was not good, and the taste was not ideal. Therefore, the comprehensive score of membership degree was low. The taro round prepared in this experiment had uniform and bright color, good elasticity and good flavor before drying. In addition, because the taro round had a smooth and delicate appearance and compact structure, it was not only conducive to drying, but also had a better quality of appearance after drying. After cooking, the taste of taro round was better, and the appearance was more plump and smooth. Therefore, the comprehensive score of membership degree was higher.

Conclusion

In this experiment, the formula technology of dried taro round was studied by single factor test and orthogonal test, and a kind of dried taro round product with good quality, easy to carry and could be stored at room temperature was developed. The results showed that the optimal formula of dried taro round was as follows: the addition amount of cassava starch was 80%, the addition amount of modified starch was 8%, the addition amount of sugar was 16%, and the addition amount of water was 10%(taro puree 100% as the benchmark, all percentages refer to mass fraction).In addition, the microwave drying adaptability of taro rounds of this formula was compared with that of taro rounds of different formulations purchased from the market. The results showed that the product obtained by this formula was the most suitable for microwave drying, which provided a new idea for the development of dried taro products.

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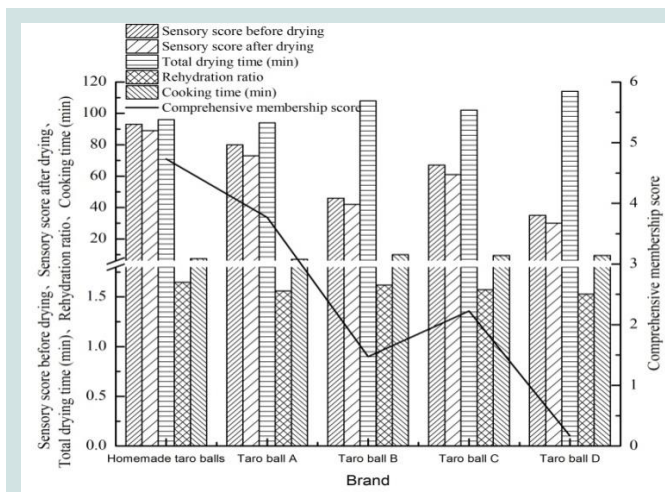


Figure 5: Contrast test results.

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