Development of Sweet Almond Crisp Biscuits

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Abstract: By taking low-gluten flour and sweet almond powder as the main raw materials and adopting the method of sensory evaluation, the optimum formula of sweet almond crisp biscuits is determined through the single-factor experiment and orthogonal experiment, which is flour 55%, sweet almond 45%, butter 40%, sugar powder 50%, egg liquid 15%, and salt 0.3%. Under this process and formulation conditions, the almond biscuits produced are golden in color, crisp in taste, rich in almond flavor and the best in sensory quality.

Modern medical research has shown that sweet almonds and bitter almonds both contain a variety of active ingredients and have a variety of pharmacological effects. And sweet almonds have many functions such as eliminating free radicals in the body, reducing postprandial blood sugar, and preventing colon cancer. Therefore, the study of the nutrition and health care of almonds, the deep processing of almonds, and the development of leisure almond food, all have broad market prospects and practical significance. At present, there have been a lot of studies on adding sweet almond powder into mooncakes, and using almond protein to make beverages, but there are few studies on the application of almonds in biscuits. In this paper, sensory evaluation is taken as the test standard, and a kind of sweet almond crisp biscuit is developed through single factor experiment and orthogonal experiment, aiming to provide reference for the development and utilization of almond resources in China.

1. Materials and Methods

1.1 Materials

Here are: low-gluten flour, sugar powder, butter, eggs.

1.2 Instruments and Equipment

Here are: SCVE electric oven, 5KPM5 type mixer, DM3 electronic scale, SN8012 rolling pin, and other appliances are: scraper, wool brush, flour sieve (with 120 mesh or 60 mesh), biscuit mold, etc.

1.3 Method of Making Sweet Almond Crisp Biscuits

1.3.1 Basic Formula

It is: low-gluten flour 75%, sweet almond powder 25%, butter 30%, sugar 40%, egg 16.5%, and salt 0.3%.

1.3.2 Process

Here comes: raw material pretreatment, dough preparation, roll forming, baking, cooling, and the finished product.

1.4 Experimental Methods

1.4.1 The Single-factor Experiment of Formula Optimization

In the following experiment, the total powder dosage is calculated at 100% (Low gluten flour + Almond powder = Total powder dosage). Basic formula of crisp biscuits is: low gluten flour 75%,

sweet almond powder 25%, butter 30%, sugar powder 40%, egg 16.5%, and salt 0.3%.

On the basis of this formula, the dosage of sweet almond powder, butter, sugar powder and eggs is changed respectively, and four groups of single-factor experiments are designed. And the detail of the single-factor experiments of biscuit formulas is shown in Table 1.

Table 1. The Single-factor Experiments of Biscuit Formulas

Levels	Factors			
	Sweet almond powder/% A	Butter/% B	Sugar/% C	Egg liquid/% D
1	15	10	20	6.5
2	25	20	30	11.5
3	35	30	40	16.5
4	45	40	50	21.5
5	55	50	60	26.5

1.4.2 Orthogonal Experiment on Formula Optimization

Based on the results of single-factor experiments, the effects of adding butter, sugar powder, egg and almond powder on the sensory quality of the sweet almond crisp biscuits have been analyzed. At last, three levels of each single factor are selected to carry out the orthogonal experiment of the formula. The specific data are shown in table 2.

Table 2. Orthogonal Experiment Factor Level Table of Biscuit Formulas

Levels	Factors			
	Sweet almond Powder/% A	Butter /% B	Sugar/% C	Egg liquid/% D
1	15	30	40	10
2	30	40	50	15
3	45	50	60	20

1.5 Sensory Evaluation Methods

There are 15 sensory evaluators, all of whom have received professional sensory training. The color, shape, texture, smell and taste of the biscuits are all used as sensory evaluation indicators, and the score is calculated according to the scoring criteria we have set up before. Then the final score of the biscuit will be counted according to the total score (100 points in total).

1.6 Data Processing

The experimental results are statistically analyzed by using the SPSS 19.0 software, and the Excel 2007 is used to make the charts.

2. Results and Analysis

2.1 Analysis of the Single-factor Experimental Results of Formula Optimization

2.1.1 Effect of the Addition Amount of Sweet Almond Powder on Biscuit Quality

According to the previous single-factor experiment design, we select 15%, 25%, 35%, 45% and 55% of the almond powder content to conduct the single-factor experiment. And the influence of the sweet almond powder content on the biscuit quality is shown in Figure 1. When the addition amount of almond powder is 25%, the biscuit has the highest sensory score, and at this time, the biscuit is golden in color, crispy in taste and rich in almond flavor. Almond powder contains a variety of flavouring materials such as aldehydes, ketones, acids, esters, and alcohols, which are released in the baking process to the form a unique fragrance of almonds. The aroma becomes more intense as the amount of almond powder increases. Therefore, when the amount of almond powder added is too low, the flavor of almond biscuits is insufficient, then resulting in a decline in sensory

quality. And as the amount of almond powder increases, the flavor of the almond also increases. However, when the amount of almond powder added is too high, the biscuit dough will be loose and not formed. This is because the high-fat sweet almonds cannot be ground into fine powder, which may cause the almond powder to have coarser particles. And such particles have a certain dilution effect on the gluten protein in the formed dough and exert a certain negative effect on the formation of gluten network in the dough, and finally have reduced the modulus of elasticity and viscosity of the dough. As the amount of almond powder increases, the shape of the biscuit is affected to varying degrees. When the amount of almond powder reaches 55%, the biscuit dough is loosely deformed, directly affecting the sensory score. In addition, the almond powder contains β- carotene. As the amount of almond powder increases, the color of the biscuit gradually deepens. And when the color is too dark, the sensory score of the biscuit can be also affected.

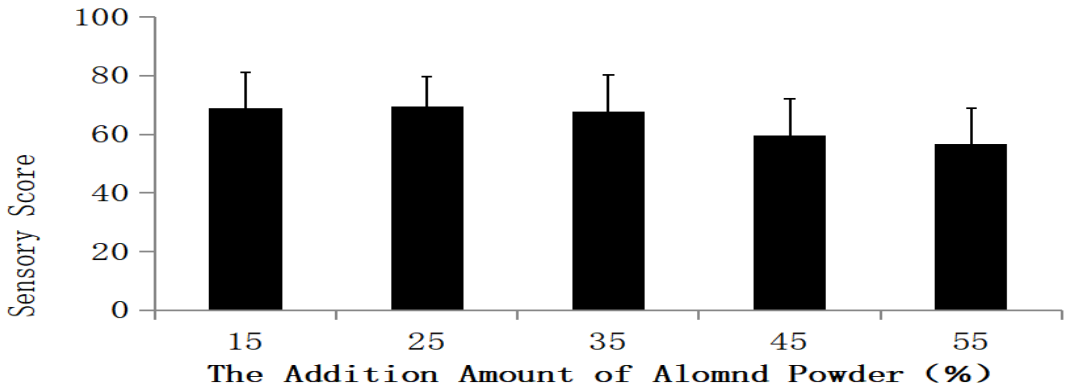

Fig. 1. The Effect of the Addition Amount of Almond Powder on Biscuit Quality

2.1.2 Effect of the Addition Amount of Butter on Biscuit Quality

According to the single-factor experiment design, the addition amount of butter is 10%, 20%, 30%, 40% and 50% respectively when the single factor experiment is carried out. And the effect of the addition amount of butter on the biscuit quality is shown in Figure 2. Along with the increase of butter addition, the sensory evaluation score of biscuits increases first and then decreases. The sensory score is highest when the addition amount of butter is 40%. As the addition amount of butter increases from 10% to 40%, the sensory scores gradually increase as well. This is because the grease in the crispy biscuit dough separates the gluten to a certain extent, which makes the gluten fragments unable to join each other, and in addition, the grease, sugar and other materials mixed together in the biscuit also form a separation effect on the gluten fragments. Then after baking, it has a soft and crispy texture. Therefore, within a certain range, the more the butter content, the better the crispness of the biscuit. However, when the butter exceeds 40%, the biscuit dough is not easy to form, and then the biscuit begins to deform or even rupture. As a result of this, the shape and structure of the biscuit are negatively affected and the sensory score begins to decrease.

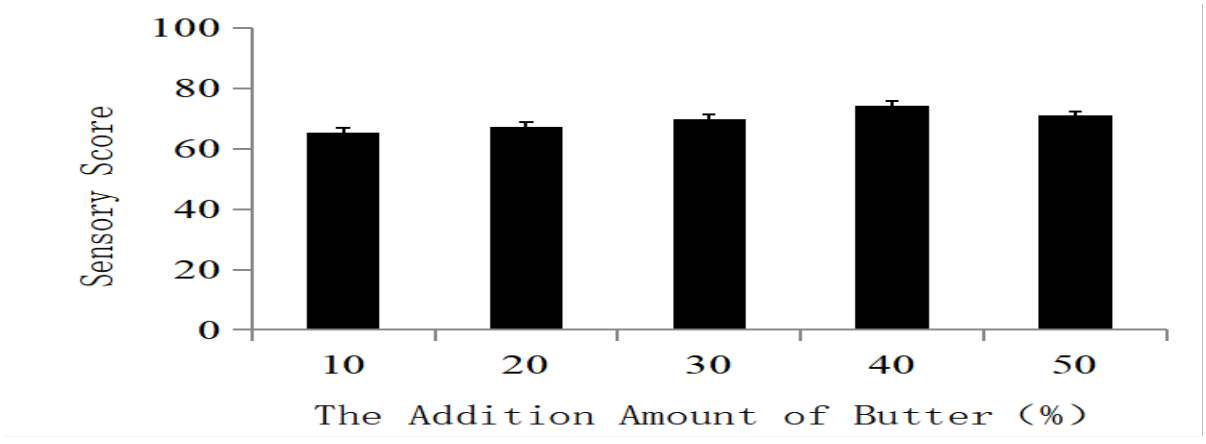

Fig. 2. The Effect of the Addition Amount of Butter on Biscuit Quality

2.1.3 Effect of the Addition Amount of Sugar Powder on Biscuit Quality

According to the single-factor experimental design, the addition amount of sugar powder is 20%, 30%, 40%, 50% and 60% respectively when the single-factor text of sugar powder is carried out. And the effect of the addition amount of sugar powder on the biscuit quality is shown in Figure 3. When the addition amount of the sugar powder is 50%, the biscuit dough is easy to form, and under that condition, the finished product is sweet, the texture is neat and intact, the taste is soft and crispy, and the sensory score is the highest. However, when the amount of sugar powder increases more, the biscuit becomes too sweet, and when it is reduced, the surface color of the biscuit will be not beautiful due to the reduced amount of Maillard reaction. Meanwhile, the taste is not crispy enough under this condition. Besides, because of the anti-hydration effect of sugar, the gluten content of the dough decreases with the increase of sugar content, and the effect of disaccharides is greater than that of monosaccharides. That is to say, within a certain range, when the amount of sugar powder increases, the gluten formation will be reduced, and the biscuit will be relatively crispier; but when the amount of sugar powder is too much, it will not only make the biscuit too sweet, but also cause the biscuit to deform in the baking process. Therefore, whether the amount of sugar powder is too small or too much, it will both affect the sensory score of the biscuit.

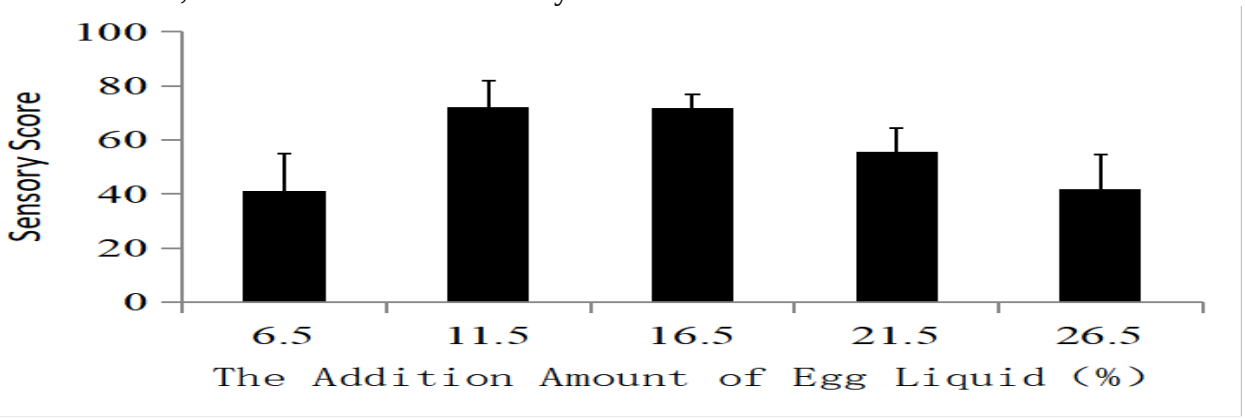

Fig. 3. The Effect of the Addition Amount of Sugar Powder on Biscuit Quality

2.1.4 Effect of the Addition Amount of Egg Liquid on Biscuit Quality

According to the single-factor experimental design, the addition amount of egg liquid is 6.5%, 11.5%, 16.5%, 21.5%, and 26.5% respectively when the single-factor experiment of egg liquid is carried out. And the effect of the addition amount of egg liquid on the biscuit quality is shown in Figure 4. Raw eggs have a light fishy taste and when heated, they can give off an enticing aroma. During the heating process, phospholipids, proteins and sugars in the egg liquid can oxidize to release volatile flavor substances. And Millard reaction occurs between amino acids, small peptides and reducing sugars. After the interaction of products, Strecker degradation reaction occurs and the flavor substances are finally released, thus forming an unique flavor of eggs. The process of Millard reaction is very complicated. In addition to the final products like black pigment that may affect the color of biscuits, there are also many intermediate products, such as reductone and volatile heterocyclic compounds, which can also affect the flavor of biscuits. When the addition amount of eggs exceeds 16.5%, these intermediates will also increase. And there may be some unpleasant flavors in these intermediates that have exceeded the threshold, finally affecting the smell and taste of the biscuits.

The eggs added to the biscuit dough are all liquid materials with a moisture content of up to 75%, so the amount of egg liquid has a significant effect on the biscuit dough. When the addition amount of the egg liquid is too small, the biscuit dough becomes too hard and the viscosity is greatly reduced, which is not favorable for the roll forming of the biscuit dough. However, when the amount of the egg liquid is too large, the biscuit dough becomes too soft and the fluidity is greatly increased, so that the biscuit is easily flow-deformed during the process of baking.

Combined with the above factors, when the addition amount of egg liquid is between 11.5% and

16.5%, the biscuits will become golden in color, soft in texture, good in taste and have the highest sensory score.

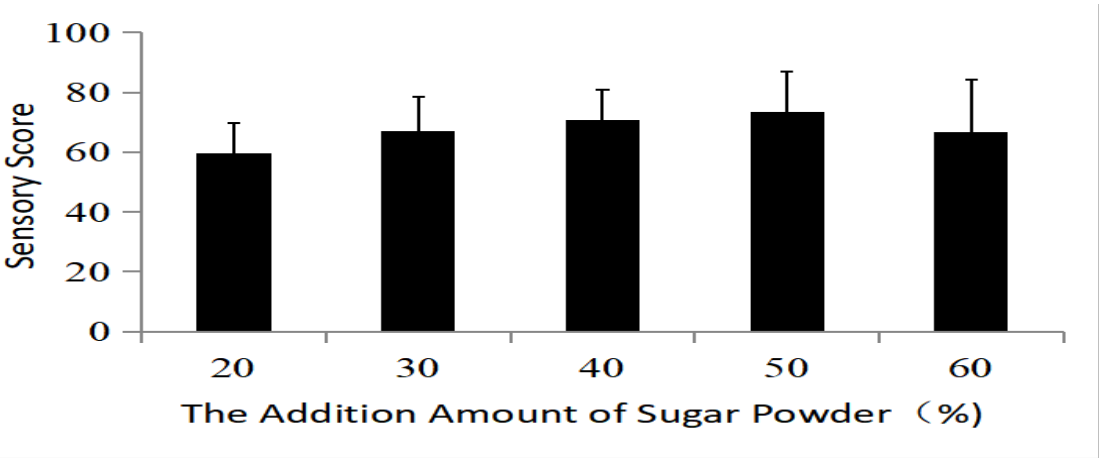

Fig. 4. The Effect of Addition Amount of Egg Liquid on Biscuits Quality

2.2 Analysis of Orthogonal Experimental Results of Formula Optimization

After the single-factor experimental results are analyzed, different levels of almond powder (15%, 30%, 45%), butter (30%, 40%, 50%), powdered sugar (40%, 50%, 60%), and eggs (10%, 20%, 20%) are selected for carrying out the L9(34) orthogonal experiment. And the experimental results are shown in Table 3.

Table 3. Orthogonal Experimental Results and Range Analysis

NO.	Levels				Sensory Evaluation
	A	B	C	D	
1	1	1	1	1	33.25
2	1	2	2	2	72.33
3	1	3	3	3	58.75
4	2	1	2	3	64.25
5	2	2	3	1	58.33
6	2	3	1	2	59.42
7	3	1	3	2	61.25
8	3	2	1	3	64.08
9	3	3	2	1	57.29
K_1	164.33	158.75	156.75	148.87	
K_2	182.00	194.74	193.87	193.00	
K_3	182.62	175.46	178.33	187.08	
k_1	54.777	52.917	52.250	49.623	
k_2	60.667	64.913	64.623	64.336	
k_3	60.873	58.487	59.443	62.360	
R	6.096	11.996	12.373	14.710	

When the addition amount of almond powder is 15%, 30% and 45%, the total score of sensory evaluation is 164.33, 182.00 and 182.62 respectively. Since 182.62>182.00>164.33, so it has the best effect when the addition amount of almond powder is 45%. Similarly, when the amount of butter, sugar powder and egg liquid is 40%, 50% and 15% respectively, the sensory score of the sweet almond crisp biscuits is the highest. And the optimal combination of sensory experiments is A3B2C2D2. In addition, according to the analysis of range R value (14.71>12.737>11.996>6.096), the addition of egg liquid has the greatest influence on the biscuit quality, followed by sugar powder and butter, while the addition of almond powder has the weakest influence.

Table 4. Variance Analysis of Orthogonal Experiments

Factors	Sum of Squares	Variance	Mean Square	F	P
Calibration Model	2628.231[a]	8	328.529	20.710	**
Intercept	92394.900	1	92394.900	5824.368	**
A	236.677	2	118.388	7.460	*
B	619.753	2	309.877	19.534	**
C	661.159	2	330.579	20.839	**
D	1110.642	2	555.321	35.006	**
Error	285.543	18	15.864		
Total	95308.675	27			
Corrected Total	2913.775	26			
R^2=0.902		Adjusted R^2=0.858			

Note: * indicates a significant level of P=0.05, and ** indicates a significant level of P=0.01.

As can be seen from Table 4, almond powder has a significant effect on the quality of biscuits while butter, sugar powder and egg liquid have an extremely significant influence on the quality of biscuits. From the perspective of the sum of squares of the contribution dispersion, the order of the influencing factors is: egg liquid>sugar powder>butter>almond powder, which is consistent with the orthogonal experimental results. Thus the formula combination A3B2C2D2 is optimal without considering the interaction, but the formula has not been included in the 9 groups of experiments, so further verification tests are needed. And verification test results are shown in Table 5.

Table 5. Verification Test Results

Test NO.	Test Combination	1	2	3	Mean Value of Sensory Scores
1	$A_3B_2C_2D_2$	81.6	79.3	81.9	80.93
2	$A_1B_2C_2D_2$	74.3	73.1	75.6	74.33

According to results of the verification test, the best formula combination of sweet almond crisp biscuits is A3B2C2D2. Compared with A1B2C2D2, the biscuits produced by this formula are superior in terms of color, shape, texture, taste and smell.

3. Conclusion

Based on the basic formula of crisp biscuits, this study has determined that the optimum formula of sweet almond crisp biscuits is flour 55%, sweet almond 45%, butter 40%, sugar powder 50%, egg liquid 15% and salt 0.3% through the single-factor experiments and orthogonal experiment of formula optimization. Under this formula, the almond biscuits are golden in color, crispy in taste, rich in almond flavor and the best in sensory quality. Besides, the addition of sweet almond powder has also increased the flavor and nutritional and health value of biscuits. Furthermore, the results of this study will not only provide new varieties of biscuit products in Chinese markets, but also will provide a reference for the in-depth development of huge almond resources in China.

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