Study on computer assisted green millet noodles electrical equipment design

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Abstract. In order to enrich the nutrition of noodles and improve its health function, at the same time expand new ways to utilize millet resources and increase the added value of millet processing. In this paper, millet noodles and wheat flour are used as the test objects, and the methods of single factor, response surface and sensory evaluation are used to study the production process of millet noodles. The results can show that the best process parameters are: 25% water addition, 152°C for the first stage extrusion temperature, and 78°C for the second stage extrusion temperature. The primary and secondary order of factors affecting the sensory scoring of millet noodles is the amount of water added, the second-stage extrusion temperature, and the first-stage extrusion temperature in descending order. This article aims to provide technical and theoretical references for the further development, scientific research and utilization of millet noodles.

1. Introduction

Millet, commonly known as "millet", has a wide variety of varieties and colors, among which yellow millet has the best quality [1,2]. It is rich in proteins, fats, carbohydrates, vitamins and minerals and other nutrients necessary for the human body [3]. Because millet does not need to be refined during processing, it reduces the loss of many vitamins and inorganic salts. It also has the effects of preventing indigestion, anti-neuritis and preventing beriberi; it also has the effects of nourishing yin and blood, reducing wrinkles, spots, The effect of pigmentation [4]. The digestibility of millet can reach more than 90%, which is the basis of high-quality nutrient sources [5]. China is the main producing area of millet, and its output accounts for about 80% of the world's total output. However, the traditional way of eating millet products is usually porridge, with a single method and lack of other related product development [6]. However, millet itself does not contain gluten protein and cannot form dough, which limits its development in modern industry [7], and the extrusion process can reduce the level of anti-nutritional factors in grains and improve the availability of nutrients [8]. The increasingly severe global drought situation and the diverse needs of the national dietary structure make the millet industry a rare opportunity for development [9]. In addition, the use of grains and grains to develop new noodle products has always been a topic explored by related companies and developers, and various grains of noodle products have also appeared on the market [10]. Noodles are produced in many forms, including fresh, dried, boiled, and steamed. In this experiment, on the basis of the traditional noodle making process, millet flour is added to the noodles to further improve the nutritional value, providing people
with a healthier noodle making method and also conducive to the scientific use of millet deep-processed products. Millet deep processing has opened up a new path. All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

2. Materials and Methods

2.1. Raw materials and reagents.
Wheat flour, Shanxi Huanglong Flour Industry Co., Ltd.; Millet flour, Xinghua Pincan Food Co., Ltd.

2.2. Instruments and equipment.
ATZ-48 spring dial scale, Yongkang Huatong Weighing Apparatus Manufacturing Factory; 25-type noodle mixer, Xingtai Zhiyi Machinery Manufacturing Co., Ltd.; JC-60IT general extruder, Changchun Shengda Food Industry Research Institute Machinery Factory.

2.3. Millet noodle production process.
Put the millet and wheat mixed flour into the noodle mixing machine, add proper amount of water and stir, and then feed the material into the extruder. After extruding the noodles, they are cooled and dried to shape.

3. One-factor experiment of millet noodles

3.1. The effect of water addition on the sensory score of millet noodles.
The first-stage extrusion temperature is 140°C and the second-stage extrusion temperature is 80°C as fixed conditions, and the water addition amount is 21%, 23%, 25%, 27%, and 29% as the variable factors, and the single factor experiment is carried out under this condition. Using the sensory score of the noodles as an indicator, the finished product obtained under the following conditions was used to analyze the influence of the amount of water added on the sensory score of millet noodles.

3.2. The effect of one-stage extrusion temperature on the sensory score of millet noodles.
The water content is 25%, the second-stage extrusion temperature is 80°C as the fixed conditions, and the first-stage extrusion temperature is 130°C, 140°C, 150°C, 160°C, and 170°C as the variable factors, and the single factor experiment is carried out under this condition. Using the noodle sensory score as an indicator, the finished product obtained below analyzes the influence of a period of extrusion temperature on the sensory score of millet noodles.

3.3. The effect of two-stage extrusion temperature on the sensory score of millet noodles.
The water content is 25%, the first-stage extrusion temperature is 140°C as the fixed conditions, and the second-stage extrusion temperature is 60°C, 70°C, 80°C, 90°C, and 100°C as the variable factors, and the single factor experiment is carried out under this condition. Using the sensory score of the noodles as an indicator, the finished product obtained below is used to analyze the influence of the second-stage extrusion temperature on the sensory score of millet noodles.

3.4. Research on the technology of millet noodles.
Combining the results of the single factor experiment, taking the amount of water added (A), the first-stage extrusion temperature (B), and the second-stage extrusion temperature (C) as three factors, and the sensory score (Y) of millet noodles as the response value, design three The response surface test of factor three levels (Table 1), using Design-Expert 8.0.6 software and Box-Behnken design principle, to determine the best millet noodle process parameters.
Table 1. Process parameters of response surface experiment

| Level | A Water addition (%) | B One-stage extrusion temperature (°C) | C Two-stage extrusion temperature (°C) |
|-------|----------------------|----------------------------------------|----------------------------------------|
| -1    | 23                   | 140                                    | 70                                     |
| 0     | 25                   | 150                                    | 80                                     |
| 1     | 27                   | 160                                    | 90                                     |

3.5. Sensory evaluation of millet noodles.
The sensory evaluation criteria of millet noodles are shown in Table 2.

Table 2. Sensory evaluation criteria of millet noodles

| Evaluation index | Evaluation standard                          | Score |
|------------------|---------------------------------------------|-------|
| Color            | The color is positive and bright             | 10-8.5|
|                  | General                                     | 8.4-6 |
|                  | The color is dark or different               | 1-6   |
| Apparent state   | Smooth, compact structure                    | 10-8.5|
|                  | General                                     | 8.4-6 |
| Palatability     | Rough and severely deformed                 | 1-6   |
|                  | Moderately bite the noodles                 | 20-17 |
|                  | Slightly hard or soft                       | 17-12 |
|                  | Too hard or too Soft                        | 1-12  |
|                  | Chews chewy and elastic                     | 25-21 |
|                  | General                                     | 21-15 |
| Toughness        | Poor chewing, low elasticity                | 15-1  |
|                  | Chews refreshing, not sticky to teeth       | 25-21 |
| Stickiness       | More refreshing, slightly sticky            | 21-15 |
|                  | Unpleasant, sticky teeth                    | 15-10 |
|                  | Smooth                                      | 5-4.3 |
| Smoothness       | general                                     | 4-3-3 |
|                  | Poor                                        | 1-3   |
|                  | Has a clear fragrance                       | 5-4.3 |
| Taste            | Basically no odor                           | 4.3-3 |
|                  | Smell                                       | 1-3   |

4. Result analysis

4.1. Single factor experiment results and analysis of millet noodles.

4.1.1. The effect of water addition on the sensory score of millet noodles. The effect of water addition on the sensory score of millet noodles is shown in Figure 1.
Fig 1. Influence of moisture content on sensory score of millet noodles

It can be seen from Figure 1 that when the amount of water added is 23%, the sensory score value is lower, and as the amount of addition gradually increases, the sensory score value gradually increases. When the amount of water added is 25%, the sensory score reaches the highest value. As the amount of water added increased again, the sensory score gradually decreased. This may be because the amount of water added is too small, and some raw materials will be burnt, which affects the taste, so the score is low; too much water added, causing the temperature of the extruder to change and slipping. Therefore, 23%, 25%, and 27% of water addition are selected as the response surface test research level.

4.2. The effect of one-stage extrusion temperature on the sensory score of millet noodles.

The effect of a period of extrusion temperature on the sensory score of millet noodles is shown in Figure 2.

Fig 2. Influence of extrusion temperature on sensory score of millet noodles

It can be seen from Figure 2 that when the extrusion temperature of one stage is 130°C, the sensory score value is lower, and as the temperature gradually increases, the sensory score value gradually
increases. When the extrusion temperature for a period of time is 150°C, the sensory score reaches its peak, and then the temperature rises again, and the sensory score gradually decreases. This may be because the extrusion temperature in one stage is too low and the flour cannot be fully gelatinized, which has a greater impact on the gloss and cooking resistance of the product, so the score is relatively low; the extrusion temperature in the first stage is too high, causing machine blockage and partial coking of noodles. The noodles taste, so the score is low. Therefore, a section of extrusion temperature of 140°C, 150°C, and 160°C was selected as the response surface test research level.

4.3. The effect of two-stage extrusion temperature on the sensory score of millet noodles.
The effect of the second-stage extrusion temperature on the sensory score of millet noodles is shown in Figure 3.

![Fig 3. Influence of extrusion temperature of the second section on sensory score of millet noodles](image)

It can be seen from Figure 3 that when the second-stage extrusion temperature is 60°C, the sensory score value is lower, and as the temperature gradually increases, the sensory score value gradually increases. When the second-stage extrusion temperature is 80°C, the sensory score reaches its peak, and as its temperature rises again, the sensory score gradually decreases. This may be because the second-stage extrusion temperature is too low and the noodles cannot be formed, so the score is relatively low; the second-stage extrusion temperature is too high, and the noodles are partially coked, which affects its taste. Therefore, the two-stage extrusion temperature of 70°C, 80°C, and 90°C is selected as the response surface test research level.

5. Research on the technology of millet noodles

5.1. Establishment of Mathematical Model and Significance Test.
Combining the analysis of single factor results, according to the principle of response surface experiments, choose the three factors of water addition (A), first-stage base temperature (B), and second-stage extrusion temperature (C), and select sensory score (Y) as the evaluation index. The experimental design and results are shown in Table 3.
Table 3. BOX-BEHNKEN center combination test design and results

| Test number | Water addition/% | One-stage extrusion temperature /℃ | Two-stage extrusion temperature /℃ | Sensory score |
|-------------|------------------|------------------------------------|------------------------------------|--------------|
| 1           | -1               | -1                                 | 0                                  | 88.01        |
| 2           | 1                | -1                                 | 0                                  | 90.36        |
| 3           | -1               | 1                                 | 0                                  | 89.45        |
| 4           | 1                | 1                                 | 0                                  | 91.01        |
| 5           | -1               | 0                                 | -1                                 | 91.13        |
| 6           | 1                | 0                                 | -1                                 | 90.98        |
| 7           | -1               | 0                                 | 1                                  | 86.89        |
| 8           | 1                | 0                                 | 1                                  | 91.47        |
| 9           | 0                | -1                                 | -1                                 | 93.18        |
| 10          | 0                | 1                                 | -1                                 | 93.65        |
| 11          | 0                | -1                                 | 1                                  | 90.20        |
| 12          | 0                | 1                                 | 1                                  | 93.87        |
| 13          | 0                | 0                                 | 0                                  | 95.31        |
| 14          | 0                | 0                                 | 0                                  | 95.65        |
| 15          | 0                | 0                                 | 0                                  | 95.42        |
| 16          | 0                | 0                                 | 0                                  | 95.77        |
| 17          | 0                | 0                                 | 0                                  | 95.74        |

Using response surface software to perform multiple regression fitting, analysis of variance and significance test on the table, the functional relationship between the response value and each factor can be obtained. The regression equation is as follows: Sensory score = 95.58 + 1.04A + 0.78B - 0.81C - 0.20AB + 1.18AC + 0.80BC - 4.24A² - 1.63B² - 1.22C²

According to Table 4 and Table 5, the response model p < 0.0001, which means that the response surface is extremely significant, and the relative error between the theoretical value and the actual value is extremely small. Therefore, the test results can be analyzed using this equation, R² = 99.34%. According to the results of the analysis of variance, the first-order terms A, B, and C, the interaction terms AC, BC, and the quadratic terms A², B², and C² all have a significant impact on the results. The biggest influence on millet noodles is the amount of water added, followed by the second-stage extrusion temperature and the first-stage extrusion temperature.
Table 4. Regression equation and variance analysis table

| Source | Squares | df | Square | Value | Prob > F | Significance |
|--------|---------|----|--------|-------|----------|--------------|
| Model  | 127.48  | 9  | 14.16  | 117.10| < 0.0001 | **           |
| A      | 8.69    | 1  | 8.69   | 71.88 | < 0.0001 | **           |
| B      | 4.85    | 1  | 4.85   | 40.11 | 0.0004   | **           |
| C      | 5.30    | 1  | 5.30   | 43.80 | 0.0003   | **           |
| AB     | 0.16    | 1  | 0.16   | 1.29  | 0.2934   |              |
| AC     | 5.59    | 1  | 5.59   | 46.24 | 0.0003   | **           |
| BC     | 2.56    | 1  | 2.56   | 21.16 | 0.0025   | **           |
| A²     | 75.66   | 1  | 75.66  | 625.50| < 0.0001 | **           |
| B²     | 11.21   | 1  | 11.21  | 92.66 | < 0.0001 | **           |
| C²     | 6.28    | 1  | 6.28   | 51.94 | 0.0002   | **           |
| Residual | 0.85  | 7  | 0.12   |       |          |              |
| Lack of Fit | 0.68  | 3  | 0.23   | 5.51  | 0.0665   |              |
| Pure Error | 0.17  | 4  | 0.041  |       |          |              |
| Cor Total | 128.33 | 16 |        |       |          |              |

Table 5. Reliability analysis of regression model

| Project | Mean | R-Squared/% | Adj R-Squared/% | C.V. % |
|---------|------|-------------|-----------------|--------|
| Result  | 92.24| 99.34       | 98.49           | 0.38   |

5.2. Process parameters of millet noodles.

According to the analysis of response surface software, the best process parameters are: water addition amount 25.14%, first-stage extrusion temperature 152.45℃, second-stage extrusion temperature 77.77℃. In order to facilitate the operation, the parameters were modified to 25% water addition, one-stage extrusion temperature of 152℃, and second-stage extrusion temperature of 78℃. The sensory score of millet noodles prepared from this ratio was 95.78 points.

6. Conclusion

The optimal process parameters of millet noodles are: 25% water addition, 152℃ for one stage, and 78℃ for two stage. Under these conditions, the sensory score of millet noodles is 95.78 points. The order of primary and secondary factors affecting the sensory score of millet noodles is from largest to smallest as follows: water addition>second-stage extrusion temperature>first-stage extrusion temperature. According to the test results and data analysis, the millet noodles prepared with the best technological parameters have good taste and good mouthfeel.

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