Research on the application of microwave expanded fine-cut heavily rolled stems

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Abstract: In order to improve the adaptability of slim cigarettes blended with cut stems. In this study, we have developed the microwave expanded fine-cut heavily rolled stems. By setting the different proportions of cut stems, compared with the traditional pneumatically dried cut stems, we analyzed the application characteristics of the microwave expanded fine-cut heavily rolled stems into the slim cigarette from the aspects of blending uniformity, physical characteristics of cigarette, mainstream smoke, sensory quality. The results showed that: the microwave expanded fine-cut heavily rolled stems is conducive to the Blending Uniformity, the draw resistance stability is better than that of the traditional pneumatically dried cut stems, the adaptability in slim tobacco is better than that of the traditional pneumatically dried cut stems, the stability of tar and CO release is improved, and the overall sensory quality of the microwave expanded fine-cut heavily rolled stems is better in sensory evaluation. This study supports the application of the microwave expanded fine-cut heavily rolled stems in the slim cigarettes.

1. Introduction

Compared with traditional cigarettes, slim cigarettes are more accepted by the market because of their small circumference, low tar content, and long cigarettes. As an essential component of the slim cigarette formula, the stem properties directly affect the filling value and production-consumption of the stem and affect the sensory quality by affecting the combustion state, which is an essential factor affecting the quality stability of the slim cigarette. At present, the research on the influence of processing method, process parameter adjustment, physical characteristics change and blending proportion change of cut stem on the filling uniformity, moistening performance, volatile chemical components, and aroma components, mainstream smoke components, and sensory quality of cigarette are relatively comprehensive[1-5]. However, most of the above studies mainly focus on improving the cut stem of traditional cigarettes and few on the influence of the physical properties and chemical components of the cut stem of slim cigarettes. Also, it is mentioned in literature [6] that the innovation of the cut stem and the research of the unique cut stem of slim cigarettes are the main direction of cut stem research in the future. Therefore, in order to improve the adaptability of the slim cigarettes blended with cut stems, this research independently developed the microwave expanded fine-cut heavily rolled stems and carried out the comparison between the microwave expanded fine-cut heavily rolled stems and the traditional pneumatically dried cut stem from the aspects of the physical characteristics, smoke characteristics and sensory characteristics of the cigarette, and studied the influence and control technology of the
microwave expanded fine-cut heavily rolled stems on the quality of the slim cigarette. It supports the application of cut stem in slim cigarettes and the stabilization of the quality of slim cigarettes.

2. Materials and Methods

2.1. Preparation of the microwave expanded fine-cut heavily rolled stems

The process flow of the microwave expanded fine-cut heavily rolled stems is consistent with that of the traditional pneumatically dried cut stem process. In the process of pressing stem and cutting stem, smaller processing parameters of pressing stem roller gap and cutting stem width are adopted. Thus, the shape of the cut stems and dried cut stems are closer to that of cut tobacco. In this study, the samples were prepared with 0.7mm of pressing stem roller gap, 0.12mm of cutting stem width, 550Kg / h of SIROX steam flow, and 162 °C of Air temperature in the drying process.

2.2. Experiment materials

The prepared the microwave expanded fine-cut heavily rolled stems, 2013 Brand-B K326 C3FS4 pure cut tobacco(cutting tobacco width 0.7mm), Cigarette accessories of product A.

KNF240-constant temperature and humidity box (Germany binder company); RM200A-rotary smoking machine (Germany borgwaldt KC company); XP404S- electronic analytical balance (sensitivity: 0.0001g, Switzerland METTLER TOLEDO company); UT12-oven (Germany Heraeus company); YQ-2-tobacco vibrating screen (Zhengzhou Tobacco Research Institute); RH-YC152-tobacco filling tester (Guangzhou Humid Lake Instrument Co., Ltd.); SBL-AV6519-cigarette moisture and density distribution tester, AV5170-cigarette weight sorter (the 41st Research Institute of China Electronic Technology Corporation); SODIM110MAX600-cigarette comprehensive test bench (SODIM company of France); KTC80E-Tobacco Cutter, PROTOS2C-Cigarette machine (Germany Hauni company); Automatic cigarette planer (self-made).

2.3. Experiment method

YC/T31-1996 standard [7] was used to measure the moisture content of the microwave expanded fine-cut heavily rolled stems, traditional pneumatically dried cut stem and pure cut tobacco(slim cigarette), and the weight of mixed materials under the standard moisture content (12.0%) was converted. According to the design proportion, the cut stem is mixed and then sent to the PROTOS 2C machine for rolling. See table 1 for sample information. The slim cigarette samples were placed in a constant temperature and humidity box at t = 22 °C and Rh = 60% for 48 hours, and were sorted according to (545 ± 5) mg/cigarette.

| Type of cut stem | Cut stem blending proportion | Cigarette formula No. | Rolling sample No. |
|------------------|------------------------------|-----------------------|-------------------|
| the microwave expanded fine-cut heavily rolled stems | 8 | BY1 | BJ1 |
|                  | 13 | BY2 | BJ2 |
|                  | 23 | BY3 | BJ3 |
| traditional pneumatically dried cut stem | 8 | CT1 | CJ1 |
|                  | 13 | CT2 | CJ2 |
|                  | 23 | CT3 | CJ3 |

Table 1 Sample number and mixing proportion

Analysis of blending uniformity: take five samples of 8%, 13%, and 23% cut stem blending proportion of slim cigarettes, 200 cigarettes of each sample were decomposed by an automatic cigarette planer to obtain the mixed samples. According to YC/T426-2012 standard [8], the total sugar, Nicotine, and potassium content were measured, and the blending uniformity H was calculated according to the following formula:
Eigenvalue: \[ PV = \frac{TS}{TA} \times K \]

Where:
- \( PV \) -- Eigenvalue of sample, %
- \( TS \) -- Total Sugar of sample, %
- \( TA \) -- Nicotine of sample, %
- \( K \) -- Potassium content of sample, %

\[
H = (1 - \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 / \bar{x}) \times 100\%
\]

Where:
- \( H \) -- Blending uniformity, %
- \( n \) -- Number of samples
- \( x_i \) -- Eigenvalue of the \( i \)th sample, %
- \( \bar{x} \) -- Mean of \( n \) sample eigenvalues, %

Determination of the loss of tobacco from the ends and the dust content: take 650 balanced slim cigarette samples, divide them into 11 groups, and then measure the loss of tobacco from the ends according to YC/T151.2-2001 standard [9].

Determination of the draw resistance and relative standard deviation (RSD): take 550 cigarettes from the prepared slim cigarette samples at random, divide them into 11 groups, and then measure the draw resistance according to the standard of GB/T 22838.2-2009 [10] and calculate the relative standard deviation.

Determination of the cigarette density and standard deviation: take 540 balanced slim cigarette samples, divide them into 11 groups, then the cigarette density was measured in turn, and the mean value of the standard deviation of cigarette density distribution was calculated. Accurately: Scan from the fire end of the cigarette to the front end of the tipping paper, the scanning interval is 1mm. According to the density values of different positions, the standard deviation of the density of a single cigarette is obtained, and then the mean value of the density deviation within the group is calculated. Variance analysis was used to analyze the standard deviation of cigarette density distribution.

Determination of the mainstream smoke components and relative standard deviation (RSD): take 11 groups of balanced slim cigarette samples, and determine the release of total particles, tar, CO, Nicotine, and water in mainstream smoke according to GB/T19609-2004, GB/23356-2009, GB/T23355-2009 and YC/T157-2001[11-14], and calculate the relative standard deviation according to the parallel measurement results of mainstream smoke.

Sensory quality: according to the sensory technical requirements of cigarettes, sensory evaluation is carried out.

3. Results and Analysis

3.1. Analysis of Eigenvalue and Blending uniformity

Table 2 shows the statistical results of the blending uniformity of the formula in each slim cigarette sample. It can be seen from the table that the standard deviation of the Eigenvalue of the sample blended with the microwave expanded fine-cut heavily rolled stem is smaller than that of the sample blended with the traditional pneumatically dried cut stem at the blending proportion of 8.0%, 13.0%, and 23.0%. The blending uniformity of the sample blended with the microwave expanded fine-cut heavily rolled stems is more significant than that of the sample blended with the traditional pneumatically dried cut stem, increasing by 2.159%. The main reason is that the size of the microwave expanded fine-cut heavily rolled stem is smaller than that of the traditional pneumatically dried cut stem, and the shape similarity of the cut tobacco is higher, which is conducive to the uniformity of the blending.
Table 2 Statistical results of sample blending uniformity (n = 5)

| Sample No. | Mean of Eigenvalue | The standard deviation of Eigenvalue | blending uniformity |
|------------|--------------------|-------------------------------------|---------------------|
| BJ1        | 15.972             | 0.428                               | 97.320              |
| BJ2        | 16.280             | 0.484                               | 97.025              |
| BJ3        | 18.908             | 0.630                               | 96.669              |
| Mean       | 17.053             | 0.514                               | 97.005              |
| CJ1        | 15.368             | 0.867                               | 94.356              |
| CJ2        | 16.726             | 0.844                               | 94.955              |
| CJ3        | 18.905             | 0.902                               | 95.227              |
| Mean       | 16.999             | 0.871                               | 94.846              |

3.2. Analysis of the loss of tobacco from the ends

Table 3 shows the mean value of the measurement results of the loss of tobacco from the ends of the slim cigarette sample. It can be seen from the table that there is no significant difference under the blending proportion of 8.0%, 13.0%, and 23.0%.

Table 3 Test results of the loss of tobacco from the ends of slim cigarettes (n = 11)

| Sample | blending proportion (%) | the loss of tobacco from the ends (mg/cigarette) |
|--------|--------------------------|-----------------------------------------------|
| BJ1    | 8                        | 3.81                                          |
| CJ1    | 8                        | 3.66                                          |
| BJ2    | 13                       | 2.54                                          |
| CJ2    | 13                       | 2.22                                          |
| BJ3    | 23                       | 3.52                                          |
| CJ3    | 23                       | 3.30                                          |

3.3. Analysis of the draw resistance and relative standard deviation

The fluctuation of draw resistance is one of the essential physical characteristics to reflect the quality stability of the slim cigarette. The relative standard deviation is often used to characterize the uniformity of the sample. Table 4 shows the mean values of draw resistance and relative standard deviation of slim cigarette samples. It can be seen from the table that under the same blending proportion, the relative standard deviation of draw resistance of the samples with the microwave expanded fine-cut heavily rolled stem is smaller than that of the samples with the traditional pneumatically dried cut stem.

Table 4 statistical table of draw resistance and relative standard deviation of slim cigarette (n=11)

| Sample | blending proportion (%) | Mean of draw resistance (Pa/cigarette) | RSD     |
|--------|--------------------------|---------------------------------------|---------|
| BJ1    | 8                        | 1714.8                                | 0.0466  |
| CJ1    | 8                        | 1704.7                                | 0.0499  |
| BJ2    | 13                       | 1783.1                                | 0.0412  |
| CJ2    | 13                       | 1748.7                                | 0.0474  |
3.4. Analysis of the cigarette density and standard deviation

Table 5 shows the mean of the standard deviation of the cigarette density with different blending proportions of two kinds of the cut stem. Variance analysis was carried out on the standard deviation of the cigarette density distribution of slim cigarette samples with the same stem and different blending proportion. The results showed that the p-value of the standard deviation of the cigarette density was less than 0.05 under the same cut stem and different blending proportion (8%, 13%, 23%), which indicated that there was a significant difference in the standard deviation of the cigarette density among the samples with different blending proportion.

The mean of the standard deviation of the cigarette density distribution of the samples rolled with the microwave expanded fine-cut heavily rolled stem at different blending proportions (8%, 13%, 23%) is smaller than that of the traditional pneumatically dried cut stem.

| No. | 8% blending proportion | 13% blending proportion | 23% blending proportion |
|-----|------------------------|--------------------------|-------------------------|
|     | BJ1        | CJ1         | BJ2        | CJ2         | BJ3        | CJ3         |
| 1   | 21.5       | 22.49       | 20.99      | 18.75       | 19.41      | 21.76       |
| 2   | 24.42      | 27.38       | 17.25      | 20.86       | 18.69      | 21.87       |
| 3   | 18.81      | 21.94       | 19.78      | 20.93       | 22.59      | 22.97       |
| 4   | 18.60      | 19.59       | 24.13      | 20.43       | 19.27      | 24.26       |
| 5   | 22.48      | 20.05       | 23.80      | 21.84       | 18.46      | 22.14       |
| 6   | 19.25      | 20.57       | 18.19      | 22.50       | 20.61      | 18.38       |
| 7   | 20.59      | 24.58       | 24.27      | 23.67       | 23.35      | 23.75       |
| 8   | 23.87      | 18.85       | 19.92      | 21.57       | 18.91      | 25.93       |
| 9   | 20.91      | 21.69       | 22.59      | 24.93       | 22.03      | 22.12       |
| 10  | 18.63      | 25.24       | 17.57      | 23.81       | 25.79      | 18.47       |
| 11  | 20.03      | 22.94       | 21.31      | 23.70       | 20.38      | 19.69       |
| Mean| 20.83      | 22.30       | 20.89      | 21.75       | 20.86      | 21.94       |

3.5. Study on the influence of the microwave expanded fine-cut heavily rolled stem on mainstream smoke components

See table 6 for mainstream smoke components and relative standard deviation data of samples. It can be seen from the table that there is no significant difference in the puff number and the stability of Nicotine between the two samples. The stability of Tar and CO in the samples blended with the microwave expanded fine-cut heavily rolled stem was improved compared with that of the traditional pneumatically dried cut stem.

| Sample | Puff number (numbers /cig) | Puff number RSD | Corrected Tar(mg/cig) | Corrected Tar RSD | Nicotine (mg/cig) | Nicotine RSD | Corrected CO(mg/cig) | Corrected CO RSD |
|--------|----------------------------|----------------|-----------------------|-------------------|------------------|--------------|---------------------|------------------|
|        |                            |                |                       |                   |                  |              |                     |                  |

5
3.6. Study on the influence of the microwave expanded fine-cut heavily rolled stem on Sensory quality

Table 7 shows the sensory evaluation results of the sample. Compared with the traditional pneumatically dried cut stem, the samples with microwave expanded fine-cut heavily rolled stem have better overall sensory quality, the delicate texture of smoke, clear smoke, functional richness, less offensive odor.

| Sample No. | luster 5 | aroma 32 | harmony 6 | impurity 12 | irritation 20 | aftertaste 25 | Total 100 |
|------------|---------|----------|-----------|-------------|--------------|---------------|------------|
| BJ1        | 5.00    | 30.06    | 5.00      | 11.00       | 17.50        | 21.94         | 90.50      |
| BJ2        | 5.00    | 29.38    | 5.00      | 10.81       | 17.38        | 21.81         | 89.38      |
| BJ3        | 5.00    | 28.63    | 4.84      | 10.44       | 17.19        | 21.25         | 87.34      |
| CJ1        | 5.00    | 29.50    | 5.00      | 11.00       | 17.50        | 22.00         | 90.00      |
| CJ2        | 5.00    | 28.94    | 5.00      | 10.44       | 17.25        | 21.44         | 88.06      |
| CJ3        | 5.00    | 28.19    | 4.75      | 10.06       | 17.00        | 21.25         | 86.25      |

4. Conclusion and Discussion

In this study, by comparing the characteristics of each indicator of the traditional pneumatically dried cut stem in slim cigarette samples, it is found that the microwave expanded fine-cut heavily rolled stem are beneficial to improve the Blending Uniformity, the stability of draw resistance, the adaptability in a slim cigarette. Besides, the overall sensory quality of smoke performance, the stability of tar and carbon monoxide release from smoke are also improved.

Based on the work carried out under the special topic of "stem processing technology" in the research section of "traditional stem preparation technology" under the systematic research route of "slim cigarette" blending formula, a set of processing technology of "the microwave expanded fine-cut heavily rolled stem" was established, which effectively improved the approximation between stem and cut tobacco. On the premise of maintaining the quality level and stability of cigarettes, the proportion of stem in product A reached 10%, which broke through the technical bottleneck of traditional stem preparation technology applied to slim cigarettes.
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