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The Producing Technology of Resistant Starch from Buckwheat Using Ultrasonic Treatment

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Abstract

Resistant Starch (RS) has various functions in controlling the Glycemic Index (GI), lowering concentration of cholesterol and triglycerides, inhibiting fat accumulation, preventing colonic cancer, reducing gall stone formation, maintaining intestinal tract healthy and enhancing the absorption of minerals. Elevated RS in food is an important and effective approach for public health. RS is also an important material for industries. In this paper, the producing technologies of resistant starch from buckwheat were investigated. The results showed that the optimum parameters for producing technology of resistant starch from buckwheat using ultrasonic treatment are ultrasonic treatment time is 20 min, ultrasonic power is 300 W, and ultrasonic frequency is 63 KHz, Solid-to-liquid ratio 1:8.

Keywords: Buckwheat; Resistant Starch (RS); Orthogonal design

Introduction

Resistant Starch (RS) is also called enzyme resistant starch, definited as the starch and starch degradation products which cannot be digested and absorbed in the healthy small intestine of human [1]. RS provides functional properties in controlling GI [2], lowering concentration of cholesterol and triglycerides [3,4], inhibiting fat accumulation [5], preventing colonic cancer [6], reducing gall stone formation [7], maintaining intestinal tract healthy [8,9] and enhancing the absorption of minerals [10]. RS a novel insulin receptor sensitizer is benefited to diabetes, which can enhance insulin function and regulate blood glucose [11]. Elevated RS in food is an important and effective approach for public health. RS is also an important material for industries. Buckwheat (*Fagopyrum esculentum*) belonging to plants of the genus Polygonaceae Buckwheat, is edible biologic medicine with relative high starch content, with various values of nutritional therapy health care [12].

The mechanism of RS formation is largely unknown. There are several factors affect the RS formation. It's reported that RS content is positive related to AC [13,14]. Starch granule size and structure are related the RS content. Starch granule in potato is larger than that in cereals, the potato starch digested more slowly than that of cereals [15]. Starch Crystalline structure can be classified into A type, B type and C type, according X-ray scattering pattern. The digestibility of the starch with B types less than A type, C type in the middle [16]. The chain length of amylose and amylopectin is another major factor affect the RS formation. RS increase according Degree of Polymerization (DP) of amylose (from 10 DP to 610 DP) by hydrothermal treatment with retention [17]. The effect of the chain length amylopectin on RS formation is unclear in detail. It reported that amylopectin starch debranched by Pullulanase followed by heat-processing can increase RS content [18]. It's due to long unbranched chains of amylopectin involve into RS formation [19]. Other components in cell, such as protein, lipid, cellulose can also effect RS content [20,21]. Among them, Lipids is most important effect on RS formation. Lipids can decrease RS content significantly [19]. Food additives and food processing technologies are another factors can affect RS content [22,23]. We analyzed the effects of the preparing conditions to buckwheat RS content and got the optimal preparing conditions for buckwheat RS content. The results of this work will lay the foundation of theory and application for the further study of buckwheat RS.

Materials and Methods

Preparation of Buckwheat flour

Buckwheat was purchased from Jilin City. Buckwheat was grinded into flour using flour mill, then filtered using 200 mesh sieve.

Determination of RS content

RS content was measured according to AOAC method (2002.02) with a slight modification [24]. 100 ± 1 mg milled maize flour (only endosperm) were accurately weighed and placed directly into screw-cap tubes (16 × 125 mm). 500 µL water was added into each tube, then boiled in electric cooker for 20 min and at warm keeping status at 50°C for 10 min. Tubes were taken out and cooled to room temperature. KCl-HCl buffer (pH=1.5) containing 6 IU/mg pepsin was added into each tube and the rice floury was ground and dispersed by a stirring rod, mimicking the chewing in mouth and warmed at 37°C for 1 h. Other procedures were carried out as described in the method AOAC (2002.02) [24].

The optimization of the preparation process of buckwheat RS

To optimize the preparation process of buckwheat RS, the major factors and their levels were determined according the effects of various factors (such as ultrasonic power, ultrasonic frequency, ultrasonic treatment time, heating temperature after ultrasonic treatment, Solid-to-Liquid ratio (S/L) using ultrasonic treatment) on RS content using ultrasonic treatments. The optimum preparation conditions of buckwheat RS were further determined using orthogonal test.

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Results and Discussion

The effects of ultrasonic frequency on buckwheat RS content

The buckwheat starch was heated at 100℃ for 20 min after using different ultrasonic frequency for 30 s with 1:2 solid-to-liquid ratio, then after storage at 4℃ for 24 h, dried at 50℃ for 18 h. The RS content of the dried buckwheat was analyzed. The optimum ultrasonic frequency is 40 KHz (Figure 1).

The effects of ultrasonic power on buckwheat RS content

The buckwheat starch was heated at 100℃ after using different ultrasonic power for 30 s with 1:2 solid-to-liquid ratio, then after storage at 4℃ for 24 h, dried at 50℃ for 18 h. The RS content of the dried buckwheat was analyzed. The optimum ultrasonic power is 300 W (Figure 2).

The effects of ultrasonic treatment time on buckwheat RS content

The buckwheat starch was heated at 100℃ after using 28 KHz ultrasonic power for different time with 1:2 solid-to-liquid ratios, then after storage at 4℃ for 24 h, dried at 50℃ for 18 h. The RS content of the dried buckwheat was analyzed. The optimum ultrasonic treatment time is 20 min (Figure 3).

Effects of heating temperature after ultrasonic treatment on buckwheat RS

The buckwheat starch was heated at different temperature after using 28 KHz ultrasonic power for 30s with 1:2 solid-to-liquid ratio, and then heated at different temperature after storage at 4℃ for 24 h, dried at 50℃ for 18 h. The RS content of the dried buckwheat was analyzed. The optimum heating temperature after ultrasonic treatment is 120℃ (Figure 4).

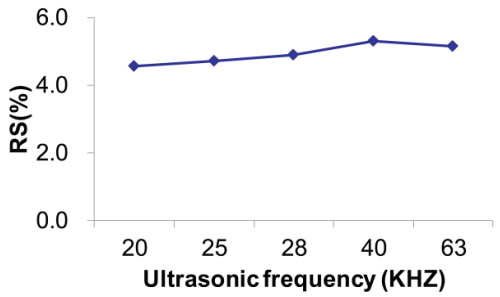

Figure 1: Effects of ultrasonic frequency on buckwheat RS.

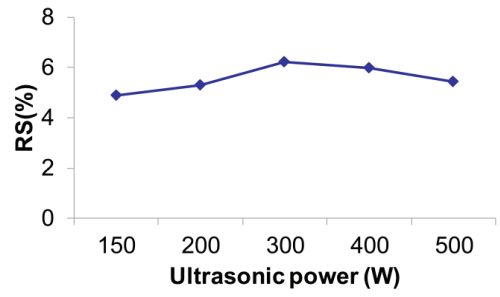

Figure 2: Effects of ultrasonic power on buckwheat RS.

The effects of solid-to-liquid ratio using ultrasonic treatment on buckwheat RS content

The buckwheat starch was heated at 100℃ after using 28 KHz ultrasonic power for 30s with different solid-to-liquid ratio, then after storage at 4℃ for 24 h, dried at 50℃ for 18 h. The RS content of the dried buckwheat was analyzed. The optimum solid-to-liquid ratio using ultrasonic treatment is 1:6 (Figure 5).

RS processing orthogonal experiment

According the effects of individual factors on the RS contents, orthogonal experiments were conducted using microwave power, treatment time using microwave power, solid-to-liquid ratio and annealing time after microwave treatment as factors and RS content as index (Tables 1 and 2).

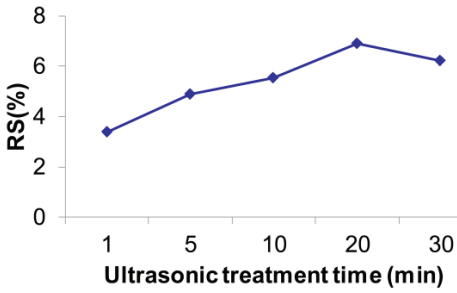

Figure 3: Effects of ultrasonic treatment time on buckwheat RS.

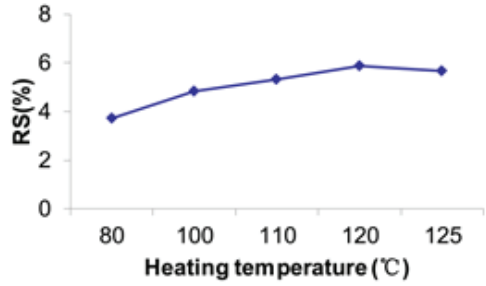

Figure 4: Effects of heating temperature after ultrasonic treatment on buckwheat RS.

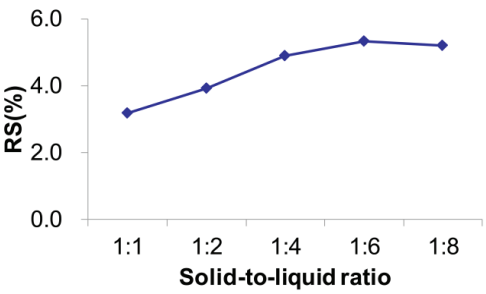

Figure 5: Effects of solid-to-liquid ratio using ultrasonic treatment on buckwheat RS content.

Level	A	B	C	D
	Power (W)	Ultrasonic frequency (KHz)	Solid-liquid ratio	Treatment time (min)
1	200	28	01:04	10
2	300	40	01:06	20
3	400	63	01:08	30

Table 1: Factor level table.

S. No.	A	B	C	D	RS
	Power (W)	Ultrasonic frequency (KHz)	Solid-liquid ratio	Treatment time (min)	(%)
1	1 (200)	1 (28)	1 (1:4)	1 (10)	5.93
2	1 (200)	2 (40)	2 (1:6)	2 (20)	6.95
3	1 (200)	3 (63)	3 (1:8)	3 (30)	6.84
4	2 (300)	1 (28)	2 (1:6)	3 (30)	7.14
5	2 (300)	2 (40)	3 (1:8)	1 (10)	7.07
6	2 (300)	3 (63)	1 (1:4)	2 (20)	7.73
7	3 (400)	1 (28)	3 (1:8)	2 (20)	7.32
8	3 (400)	2 (40)	1 (1:4)	3 (30)	6.89
9	3 (400)	3 (63)	2 (1:6)	1 (10)	6.67
K1	19.72	20.39	20.55	19.67	-
K2	21.94	20.91	20.76	22	-
K3	20.88	21.24	21.23	20.87	-
R	2.22	0.85	0.68	2.33	-

Table 2: L_9 (3^4) RS processing orthogonal experiment design and results.

As the results shown in the Table 2, ultrasonic treatment time had the largest effect on RS content. Ultrasonic Power had the second largest effect on RS content. Ultrasonic frequency had the third largest effect on RS content. Solid-liquid ratio had the fourth largest effect on RS content. The optimum parameters for producing technology of resistant starch from buckwheat using ultrasonic treatment are D2A2B3C3, that is ultrasonic treatment time is 20 min, ultrasonic Power is 300 W, ultrasonic frequency is 63 KHz, Solid-to-liquid ratio 1:8. The sequence of effects on RS content: D>A>B>C.

Conclusion

The major factors on RS content using ultrasonic treatment are ultrasonic treatment time, microwave power, ultrasonic frequency, and solid-to-liquid ratio. The optimum parameters for producing technology of resistant starch from buckwheat using ultrasonic treatment are ultrasonic treatment time is 20 min, ultrasonic Power is 300 W, and ultrasonic frequency is 63 KHz, Solid-to-liquid ratio 1:8.

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