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The Producing Technology of Resistant Starch (RS) from Buckwheat Using Microwave 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 microwave treatment are microwave power at 540W, treatment time is 120s, Solid-to-liquid ratio 1:3, cold storage time 24h.

Keywords

Buckwheat, resistant starch, orthogonal design

1. Introduction

RS is 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 (Escarpa et al., 1997). RS provides functional properties in controlling Glycemic Index (GI) (Hasjim et al., 2010), lowering concentration of cholesterol and triglycerides (Fukushima et al., 2005; Perez et al., 2006), inhibiting fat accumulation (Higgins et al., 2011), preventing colonic cancer (Burn et al., 2011), reducing gall stone formation (Birkett et al., 2000), maintaining intestinal tract healthy (Phillips et al., 1995; Lesmes et al., 2008) and enhancing the absorption of minerals (Yonekura et al., 2005). Resistant Starch (RS), a novel insulin receptor sensitizer, is benefited to diabetes, which can enhance insulin function and regulate blood glucose (Robertson et al., 2005). 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 (Zhang et al., 2012).

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 (Leeman et al., 2006; Yadav et al., 2009). 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 (Ring et al., 1988). 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 type less than A type, C type in the middle (Englyst et al., 1996; Biliaderis, 1991). 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 (Eerlingen et al., 1993). The effect of the chain length amylopectin on RS foramtion is unclear in detail. It reported that amylopectin starch debranched by pullulanase followed by heat-processing can increase RS content (Berry, 1986). It's due to long unbranched chains of amylopectin involve into RS formation (Mangala et al., 1999). Other components in cell' such as protein, lipid, cellulose can also effect RS content (Escarpa & Gonzalez, 1997; Torre et al., 1992). Among them, Lipids is most important effect on RS formation. Lipids can decrease RS content significantly (Mangala et al., 1999). Food additives and food processing technologies are another factors can affect RS content (Gelencser et al., 2010; Mulinacci et al., 2008). We analyzed the effects of the preparing conditions to buckwheat RS content and got the optimal preparing conditions for buckwheat RS content. Physical treatments enhanced resistant starch, such as autoclaving and retrogradation cycles was the most laborious method, typically needing 24h retrogradation time following autoclaving, and requiring typically 3 to 9 autoclaving/retrogradation cycles. So, in the future, it is very important to reduce processing times for industrial production. We try to provide a new process for improving the resistance starch content, enabling the industrialized production of resistant starch, thereby contributing to human health. The results of this work will lay the foundation of theory and application for the further study of buckwheat RS.

2. Materials and Methods

2.1 Preparation of Buckwheat Flour

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

3. Determination of RS Content

RS content was measured according to AOAC method (February, 2002) with a slight modification. 100±1 mg milled maize flour (only endosperm) were accurately weighed and placed directly into screw-cap tubes (16 x 125mm). 500μL water was added into each tube, then boiled in electric cooker for 20 min and at warm keeping status at 50ºC 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 37ºC for 1 h. Other procedures were carried out as described in the method AOAC (February, 2002) (McCleary et al., 2002).

3.1 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 microwave power, microwave treatment time, solid-to-liquid ratio (S/L), cold storage temperature) on RS content using microwave treatments. The optimum preparation conditions of buckwheat RS were further determined using orthogonal test.

4. Results and Discussion

4.1 The Effects of Microwave Power on Buckwheat RS Content

The buckwheat starch was treated using different power microwave for 1min with 1:2 solid-to-liquid ratio, then after storage at 4ºC for 24h, dried at 50ºC for 18 h. The RS content of the dried buckwheat was analyzed. The results showed that the optimum microwave power is 540W (Figure 1).

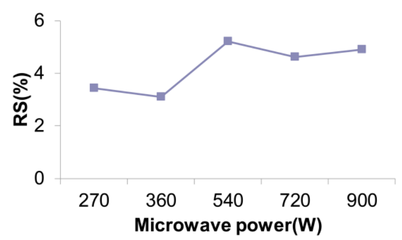

Figure 1. Effects of Microwave Power on Buckwheat RS Content

4.2 The Effects of Microwave Treatment Time on Buckwheat RS Content

The buckwheat starch was treated using 600W microwave power for different time with 1:2 solid-to -liquid ratio, then after storage at 4ºC for 24h, dried at 50ºC for 18 h. The RS content of the dried buckwheat was analyzed. The obtained results showed that the optimum microwave treatment time is 120s (Figure 2).

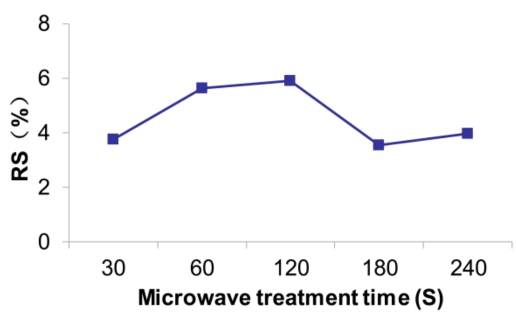

Figure 2. Effects of Microwave Treatment Time on Buckwheat RS Content

4.3 The Effects of Solid-to-Liquid Ratio Using Microwave Treatment on Buckwheat RS Content

The buckwheat starch was treated using 600W microwave power for 120 s with different solid-to -liquid ratio, then after storage at 4ºC for 24h, dried at 50ºC for 18 h. The RS content of the dried buckwheat was analyzed. The results revealed that the optimum solid-to-liquid ratio of microwave treatment is 1:3 (Figure 3).

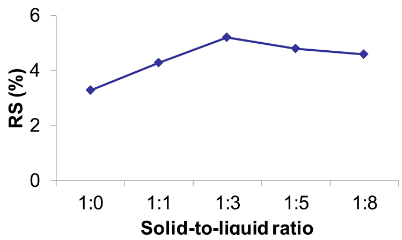

Figure 3. Effects of Solid-to-Liquid Ratio Using Microwave Treatment on Buckwheat RS Content

4.4 The Effects of Cold Storage Temperature Using Microwave Treatment on Buckwheat RS Content

The buckwheat starch was treated using 600W microwave power for 120 s with 1:2 solid-to-liquid ratio, then after storage at different temperatures for 24h, dried at 50ºC for 18 h. The RS content of the dried buckwheat was analyzed. The optimum cold storage temperature of microwave treatment is 24 h (Figure 4).

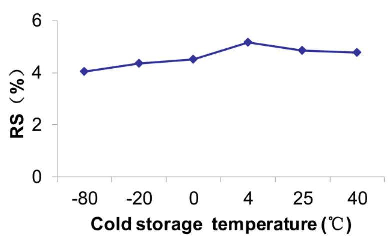

Figure 4. Effects of Cold Storage Temperature Using Microwave Treatment on Buckwheat RS Content

4.5 The Effects of Cold Storage Time Using Microwave Treatment on Buckwheat RS Content

The buckwheat starch was treated using 600W microwave power for 120 s with 1:2 solid-to-liquid ratio, then after storage at 4ºC for different times, dried at 50ºC for 18 h. The RS content of the dried buckwheat was analyzed. The optimum cold storage time of microwave treatment is 24 h (Figure 5).

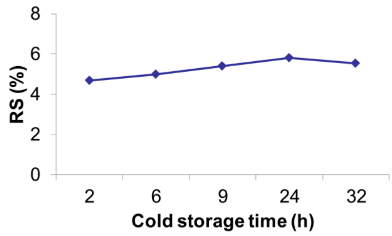

Figure 5. Effects of Cold Storage Time Using Microwave Treatment on Buckwheat RS Content

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 cold storage time after microwave treatment as factors and RS content as index (Tables 1 and 2).

Table 1. Factor Level Table

Level	A power/W	B treatment time /S	C solid-liquid ratio	D cold storage time /h
1	360	60	1:1	9
2	540	120	1:3	24
3	720	180	1:5	32

Table 2. $L_9(3^4)$ RS Processing Orthogonal Experiment Design and Results

No.	Apower/W	B treatment time /S	C solid-liquid ratio	D cold storage time /h	RS (%)
1	1(360)	1(60)	1(1:1)	1(9)	5.83
2	1(360)	2(120)	2(1:3)	2(24)	6.98
3	1(360)	3(180)	3(1:5)	3(32)	5.64
4	2(540)	1(60)	2(1:3)	3(32)	7.37
5	2(540)	2(120)	3(1:5)	1(9)	7.57
6	2(540)	3(180)	1(1:1)	2(24)	7.08
7	3(720)	1(60)	3(1:5)	2(24)	6.15
8	3(720)	2(120)	1(1:1)	3(32)	6.39
9	3(720)	3(180)	2(1:3)	1(9)	6.26
K1	18.45	19.35	19.3	19.66	
K2	22.02	20.38	20.61	20.21	
K3	18.8	18.98	19.36	19.4	
R	3.57	1.40	1.31	0.81	

As the results shown in the Table 2, microwave power had the largest effect on RS content. Treatment time had the second largest effect on RS content. Solid-to-liquid ratio had the third largest effect on RS content. Cold storage time had the fourth largest effect on RS content. The optimum parameters for producing technology of resistant starch from buckwheat using microwave treatment are $A_2B_2C_2D_2$, that is microwave power at 540W, treatment time is 120s, Solid-to-liquid ratio 1:3, cold storage time 24h, The sequence of effects on RS content: A>B>C>D.

The research for increasing Resistant Starch content by physical treatments is mainly focused on Hydrothermal Treatments (HTTs), Autoclaving and retrogradation cycles, High hydrostatic pressure, Extrusion. And among these physical methods, autoclaving and retrogradation cycles, and high-pressure processing, were successful in increasing the RS starch content of various types of starches. Autoclaving in particular was the most laborious method, typically needing 24h retrogradation time following autoclaving, and requiring typically 3 to 9 autoclaving/retrogradation cycles. In the future. It is very important to optimize the autoclaving process in order to increase RS while decreasing its processing times (Dupuis et al., 2014). We try to use microwave treatment to increase the RS content. This method has the advantages of easy operation, cheap equipment, time saving, energy saving. In the future, it is necessary to study the positive effects and mechanisms of microwave pulse processing to increase RS content, such as the effects of microwave treatment to starch structure and starch digestion characteristics. Microwave treatment combined with other methods to increase the RS content of resistant starch to improve the positive effect of resistant starch content. Another important research area is the positive effects of microwave treatment combined with other methods to increase RS content.

6. Conclusions

The major factors on RS content using microwave treatment are microwave power, Treatment time, Solid-to-liquid ratio, Cold storage time microwave treatment. The optimum parameters for producing technology of resistant starch from buckwheat using microwave treatment are microwave power at 540W, treatment time is 120s, Solid-to-liquid ratio 1:3, cold storage time 24h.

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