Dietary Fiber Powder Made from Purple Wheat “Jizi439” Bran: An Effective Health Food and Its Processing

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Abstract

Background: Different processing approaches could usually alter contents of different nutritional ingredients for wheat grains which benefits human health. The present study is aimed to assess the dietary fiber and other nutritional ingredients of purple wheat (Jizi439) bran via proper processing and to analyze its benefits to prevent diseases and enhance health so as to prove the dietary fiber powder made from purple wheat （Jizi439）to be an effective health food.

Methods: Approach I Pulverizing: Purple wheat bran was put into blade pulverizer to get the pulverized bran into particles with a 60-meshdiameter. Puffing: The pulverized bran was sprayed with pure water to moisten the bran, making its moisture reach 22%. The moistened bran was put into twin-screw bulking machine under a temperature of 135 ℃ , and puffed at 400 r/min, to get puffed pellets. Milling: The puffed bran pellets were put into wall mill under 32℃ and 6 – 7 MPa and at 350 r/min to get dietary fiber powder (DFP) in particles with a 130-mesh diameter. Approach II: Except for the processing parameters, the procedure of Approach II was the same as Approach I.

Results: The significant increase of nutritional elements contents in dietary fiber powder have been found when it is processed via different approaches. Different processing treatment and processing parameters bring forth different effects on the nutritional elements which are released from purple wheat bran. It is indicated that the contents of SDF produced via Approach I is greatly higher than that of the SDF produced via Approach II ($p \leq 0.01$), which suggests that Approach I is much effective for processing purple wheat bran for producing solvable dietary fiber

Conclusions: Purple wheat bran is a high-effective health food, but only it is properly processed. Different processing has different impacts on the active substances of the purple wheat bran powder related to health function. In this study, only Approach I helps to increase the health nutritional ingredients which bring forth positive effects on the enhancement of health function, while Approach II fail to improve the function on health enhancement.

Keywords: Dietary fiber powder, Purple wheat bran; Health food; Disease prevention

1 Introduction

It draws an increasing public concern to explore the new health food resource for their hygienic function to prevent some diseases[1–3], in particular hypertension, type 2 diabetes, hyperlipidemia, and coronary heart disorder[4–6], seriously afflicting human being, of which diabetes has become a major non-infectious disease threatening human health in the world next to malignant tumor, cardiovascular and cerebrovascular troubles [7–13]. Compared with the chemical medicines, such kinds of foods with medicinal function have a vantage devoid of aftereffects when they are used in the program of dietary therapy.

It is the dietary fiber in cereal grain bran that is such a kind of the above-mentioned health food resource [3, 14]. Dietary fiber is a kind of food material that is not digestible by the human small intestine and only partially digestible by the large intestine. It is beneficial in the diet because it relieves and prevents constipation, appears to reduce the risk of the cancer [14–15], plasma cholesterol levels [16] and therefore lower the risk of heart disease. The previous studies suggest an inverse relationship between fiber intake and colon cancer risk [17–18] and show that the fiber also can attenuate the type 2 diabetes [19, 20].

The bran of purple wheat (Jizi439, hereafter “the purple wheat” refers to “Jizi439” if not specified in this paper)is rich in dietary fiber that has an effect of medication [20] as well as high-nutritional value [21].

Rich in dietary fiber and other high-nutritive-value substances in its grains, purple wheat Jizi439 is a miraculous variety as a health cereal food with positive effects on longevity and disease prevention. It contains a plenty of active substances, such as anthocyanin, ferric, resistant starch and phenolic acids (including fatty acid, sinapic acid,vanillic acid, etc.) of which are devoid or short in white wheat. In particular, the content of fatty acid is considerably higher than that of white wheat.

According to the previous studies [3, 14], it is supposed that the bran of purple wheat would be a high-quality resources of dietary fiber with multiple nutritive substances. It is significant to explore the value of dietary fiber of purple wheat bran to make it possible to develop health food with both medicational effects and high nutritive value.

As we all know, wheat bran, the wheat seed coat, is the by-product of flour processing. It, however, is unsuitable for direct use as food because of palatability. Intensive processing is required for the improvement of its palatability and releasing the beneficial nutritional

ingredients.

The objective of the present study is to assess the dietary fiber and other nutritional ingredients of purple wheat (Jizi439) bran via the proper processing and to analyze its benefits to prevent diseases and enhance health so as to prove the dietary fiber powder made from purple wheat to be an effective health food resource.

2 Materials And Methods

2.1 Materials

2.1.1 Raw materials

The purple grain bran made by removal of 95% wheat flour of Jizi439[21], a purple wheat variety, developed by Professor Li Xingpu et al, Institute of Cereal and Oil Crops, Hebei Academy of Agricultural and Forestry Sciences, was used to be processed into dietary fiber powder (DFP).

2.1.2 Bran powder sample for nutrient chemical analysis

The processed bran powder, acquired by Approach I and Approach II (see the next two sections), was used for nutrient chemical analysis.

2.2 Dietary fiber powder processing

2.2.1 Approach I

With Approach I, DFP of purple wheat grain is processed as follows:

Pulverizing

Purple wheat grain bran was put into blade pulverizer to get the pulverized bran into particles with a 60-mesh diameter.

Puffing

The pulverized bran was sprayed with pure water to moisten the bran, making its moisture reach 22%. The moistened bran was put into twin-screw bulking machine under a temperature of 135℃, and puffed at 400 r/min, to get puffed pellets.

Left: The purple wheat bran with a 60-mesh diameter.

Right: The dietary fiber powder with a 130-mesh diameter

Milling

The puffed bran pellets were put into wall mill under 32℃ and 6–7 MPa, at 350 r/min to get dietary fiber powder (DFP) in particles with a 130-mesh diameter.

2.2.2 Approach II

With Approach II, DFP of purple wheat grain bran was processed as follows:

Pulverizing

Purple wheat bran was put into blade pulverizer to get the pulverized bran into particles with a 45-mesh diameter.

Puffing

The pulverized bran was sprayed with pure water to moisten the bran, making its moisture reach 15%. The moistened bran was put into twin-screw bulking machine under a temperature of 150℃, and puffed a 450 r/min, to get puffed pellets.

Milling

The puffed bran pellets were put into wall mill under 32–37°C and 6–7 MPa, at 350 r/min to get DFP in particles with a 130-mesh diameter. .

2.3 Chemical analysis

The processed dietary fiber powder of purple wheat and the unprocessed purple grain bran were tested by ICAS Testing Technology Services (Shanghai) Co., Ltd. Protein was determined by Kjeldahl analysis descripted as GB 5009.5–2016)[22]. Starch was determined by the method of GB 5009.9–2016 [23]. Solvable dietary fiber (SDF), insolvable dietary fiber (IDF) and Total fiber were tested by the method of GB/T 5009.88–2014[24]. Magnesium, Ferric, Zinc, Manganese, Cuprum, Chromium and Selenium were tested by the method of GB 5009.268–2016 [25] in products was determined by atomic absorbent spectrophotometry (atomic fluorescence spectrometer, AFS-2201, China).

2.4 Statistical analysis

The data were analyzed with a general linear model (ANOVA) followed by Tukey's multiple comparison test. Values of $p \leq 0.05$ were considered statistical significance. All the statistical analyses were performed by use of the SPSS software v19 (SPSS Inc, USA).

3 Results

3.1 The altercation of nutritional ingredients in bran fiber powder via Approach I

The results show that the altercations of nutritional ingredients in purple wheat bran can be found after the bran is processed via Approach I (Table 1 and Table 2).

As shown in Table 1, a significant increase of SDF($p \leq 0.05$) and, a decrease of IDF ($p \leq 0.05$), without significant change of total fiber by Approach I, are found among the organic nutritional ingredients (ONI), compared with those of the unprocessed bran. It is indicated that IDF could turn to SDF by Approach I. The content of SDF by Approach I has been increased by as high as about 1.4 times compared with that of the unprocessed samples ($p \leq 0.05$). It is of significance for such a result because solvable dietary fiber is proved to be an effective health nutritional substance, which can reduce the risk of some cancers [14–15], plasma cholesterol levels [16] and therefore the risk of cardiovascular disorder.

Table 1
The altercation of ONI in purple wheat (Jizi 439) bran via of Approach I

	Protein (%)	Starch (%)	SDF (%)	IDF (%)	Total fiber (%)
Unprocessed bran	16.90	38.00	1.81	43.10	44.91
Bran fiber powder	16.10	40.12	4.29**	40.26*	44.55

Similarly, it is also found that the contents of sundry micronutritional elements have altered after the bran is processed via Approach I (Table 2).

Table 2
The altercation of microelements in purple wheat (Jizi 439)bran via of Approach I

	Magnesium (mg/kg)	Ferric (mg/kg)	Zinc(mg/kg)	Manganese(mg/kg)	Cuprum(mg/kg)	Chromium (mg/kg)	Selenium (ug/kg)
Unprocessed bran	4644.64	128.86	92.06	175.82	17..46	0.22	150.0
Bran fiber powder	4454.72**	157.13**	99.92**	141.28**	19..20*	0.60**	191.0**

A significant increase of several mincronutrients by Approach I, such as Ferric, Zinc, Chromium and Selenium ($p \leq 0.01$) and Cuprum ($p \leq 0.05$), compared with that of unprocessed bran, which are beneficial to prevent sundry diseases (Table 1). For example, Chromium

can reduce the risk of suffering from diabetes [26]; and Selenium can reduce the risk of cancer [27–28].

3.2 The altercation of nutritional ingredients in bran fiber powder of purple wheat via Approach II

When processed via Approach II, the different organic nutritional ingredient variables in purple wheat bran have also changed, but in a reverse tendency, except for the starch, with the change that are brought forth by Approach II(Table 3).

Table 3
The altercation of ONI in purple wheat (Jizi 439)bran via of Approach II

	Protein (%)	Starch (%)	SDF (%)	IDF (%)	Total fiber (%)
Unprocessed bran	16.31	38.20	1.60	42.02	43.62
Bran fiber powder	14.11*	43.52**	1.51	38.08*	39.59**

Table 3 shows that all the organic nutritional ingredients except starch are decreased, compared with that of unprocessed bran, after the purple wheat bran is processed via Approach II.

It is also found that the contents of organic Chromium and Selenium, two important micronutritional elements just slightly alter ($p > 0.05$)after the bran is processed via Approach II (Table 4). So, it is inferred that the bran fiber powder processed via Approach II would bring less beneficial to the health enhancement compared DFP processed via Approach I.

Table 4
The altercation of microelements in purple wheat (Jizi 439)bran via of Approach II

	Magnesium (mg/kg)	Ferric (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Cuprum (mg/kg)	Chromium (mg/kg)	Selenium (ug/kg)
Unprocessed bran	4548.04	125.86	91.055	170.825	17..00	0.256	148.30
Bran fiber powder	4554.72	160.13**	92.92	163.28*	19..30**	0.278	151.25

3.3 The comparison for the effects of the different processing approaches on the dietary fiber of purple wheat bran powder

The different altercations of nutritional ingredients in purple wheat bran powder have been found when the powder is processed via different processing approaches. In other words, different processing approaches and processing parameters can bring forth different effects on the nutritional ingredients. Table 5 shows the direct comparison of the effects of Approach I and Approach II on the nutrients. It indicates that the contents of SDF produced via Approach I is greatly higher than that of the SDF produced via Approach II ($p \leq 0.01$), which suggests that Approach I is much effective for processing purple wheat bran for producing solvable dietary fiber, the effective ingredient for the health of human body as many previous studies reported[4–6, 9, 12, 26].

Table 5
Comparison of dietary fiber of purple wheat bran via Approach I and Approach II

	SDF (%)	IDF (%)	Total fiber (%)
Approach I	4.29**	40.26*	44.55*
Approach II	1.51	38.08	39.59

4 Discussion

Many studies have proved that dietary fiber is an efficient health food which can lower the risk of some diseases and has a host of benefits for the health of human being. Wheat grain bran, especially the purple wheat bran, is rich in dietary fiber (see Table 1). Like herbal drug, the purple wheat bran has effects both on tonification and on enhancing the immunity of human body. According to the previous studies, we can conclude that dietary fiber functions on the prevention of at least three kinds of diseases. First is to ward off heart troubles because it can help to reduce cholesterol in human body and lower blood pressure, so it may lower the risk of heart disease and apoplexy [4, 5, 9, 12]. Second is to prevent diabetes, especially type 2 diabetes [6, 19, 27]. Feeding dietary fiber can help to slow the evolution of diabetes because fiber can improve insulin sensitivity and regulate blood sugar levels [31, 34]. Third is to keep the gastrointestinal health because dietary fiber helps to stave off gastrointestinal disorders, such as diverticulitis, constipation, hemorrhoids, etc. [3, 13]. Furthermore, fiber-enriched foods can help to keep one feel full on fewer calories and eating a high-fiber food can help one lose more weight than a low-fiber foods while lower weight is conducive to relieving hypertension[35–36].

However, the purple wheat bran should be properly processed to make the active ingredient released as well as improve its palatability. The present study proves that Approach I is the adequate method for processing purple wheat bran to improve its health function. When the bran is processed via Approach I, the content of solvable dietary fiber reaches as high as 4.29%, much higher than that of the unprocessed bran powder ($p < 0.05$). On the contrary, the content of solvable dietary fiber just slightly lower than that of the unprocessed bran powder ($p > 0.05$) when the bran is processed via Approach II. Therefore, Approach II is unsuitable for processing the purple wheat bran because it cannot make the active substances release.

The experiments indicate that the content of total dietary fiber decreases while the solvable dietary fiber increases after the bran is subjected to superfine grinding. Therefore, the processing can improve the efficiency of dietary fiber utilization because the solvable dietary fiber can be effectively assimilated by human body. The more solvable dietary fiber releases after processing, the more effective the processing method. In the present research, it is proved that Approach I to be the better choice for processing procedure.

Apart from the high content of dietary fiber, the purple wheat bran also contains a high level of the organic Chromium as one of the essential microelements for human body and it plays a substantial role in maintaining and regulating proper levels of carbohydrate, lipid metabolism and in enhancing insulin signaling [20, 21, 29–31]. Most researches have proved that the supplement of Chromium is beneficial to the type 2 diabetes patients [26, 31–33], though a few studies reach a contrary conclusion [34].

The bran powder of Jizi439, a commendable purple wheat variety, is rich in solvable dietary fiber and organic Chromium. As a result, its bran powder can afford a medicational effect to help lower the risk of heart troubles, diabetes and even cancers as well as nutritional value as long as it is properly processed. The dietary fiber powder of purple wheat bran is a kind of health food and it will be found that its prospective application to the prevention of different diseases which afflict human being.

5 Conclusions

From the above analysis, the following conclusions can be reached:

5.1 Purple wheat bran is a high-effective health food, but only it is properly processed (via Approach I) to make the nutritional ingredients release from the bran (see Table 1 and Table 2) as well as make it more palatable, while inadequate processing cannot improve such a health enhancement function.

5.2 Different processing approaches have different impacts on the active substances of the purple wheat bran powder related to health function. In this study, only Approach I helps significantly to increase the health nutritional ingredients (see Table 1 and Table 2) which bring forth positive effects on the enhancement of health function, while Approach II fail to improve the function on health enhancement because organic nutritional ingredients as active substances remains unchanged, compared with the unprocessed bran (see Table 3 and Table 4).In other words, Approach I is more effective than Approach II for processing wheat grain bran to produce solvable dietary fiber.

In summary, the purple wheat bran powder has been proved to be an effective health food because its high content of health ingredients, such as dietary fiber, chromium and selenium, which is beneficial to reduce the risk of cardiovascular disorder, diabetes and some cancers [5, 14, 18, 28].

Abbreviations

DFP dietary fiber powder

IDF Insolvable dietary fiber

ONI Organic nutritional ingredients

SDF Solvable dietary fiber

Declarations

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Authors' contributions

L X-P, the corresponding author, contributed to the conception and design of this study, led the implementation of the project, and to the modifying of the manuscript. Z Y-L the corresponding author, contributed to the conception and design of this study, analysis and modification of the manuscript. M Y-N conducted majority of the data collection and analysis and contributed to the writing of the manuscript. S-Q L conducted some of the data collection and analysis and contributed to the writing of the manuscript. M Y-N and L S-Q contributed to the study equally. L Y-P, N Z-H and G G-Y contributed to participate in the formulation of processing technology of the study.

All authors have read and approved the final manuscript.

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Availability of data and materials

The data can be made available on reasonable request to the corresponding

author.

Ethics approval and consent to participate

Not applicable.

Consent for publication

All authors have given consent for the paper to be published by the

corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

The purple wheat bran and dietary fiber powder. Left: The purple wheat bran with a 60-mesh diameter. Right: The dietary fiber powder with a 130-mesh diameter