Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Effect of serving temperature on the nutritional quality of cereal foods

To cite this article: S Warnasih *et al* 2021 *J. Phys.: Conf. Ser.* **1882** 012116

Effect of serving temperature on the nutritional quality of cereal foods

S Warnasih[1,] *, A H Mulyati[1], S Sutanto[1] and E Herlina[1]

[1] Department of Chemistry, Pakuan University, Bogor, West Java, Indonesia 16143

*E-mail: siti.warnasih@unpak.ac.id

Abstract. Cereal is one of the oat-based food products that contain high dietary fibre and nutritional value. One of the factors that affect the nutritional quality of the cereal during serving is the temperature of the water used for brewing. This study was carried out to evaluate the effect of serving temperature on the nutritional value of ready-to-eat cereal foods. The sample consisted of 4 types, i.e instant oat (A and B), and quick cook oat (A and B). Each sample was brewed using four different water temperatures, namely 40, 60, 80, and 100 °C. Then the nutritional content analyses were carried out included protein, fat, dietary fibre, and magnesium, also the organoleptic test with the panellist. The results showed that the treatment of the four serving temperatures resulted in levels of protein, fat, fibre, and magnesium which were significantly different, while the serving water temperature of 100 °C resulted in higher levels of dietary fibre. The sample that was most preferred by the panellists was the sample that was brewed with water with a temperature of 60 °C, while the sample that was least preferred was the sample that was brewed with water at 40 °C, both in the instant oat and quick cook oat samples. Therefore, water with a temperature of 60 °C was recommended for serving cereals.

Keywords: cereal, dietary fibre, nutritional quality, oat, serving temperature

1. Introduction

The American Association of Cereal Chemists (AACC) gave the following scientific and botanical definition in 1999: 'Whole grains shall consist of the intact, ground, cracked or flaked caryopsis, whose principal anatomical components – the starchy endosperm, germ and bran – are present in the same relative proportions as they exist in the intact caryopsis' [1]. The main whole-grain cereals consumed worldwide are wheat, rice and maize, followed by oats, rye, barley, triticale, millet and sorghum. The recommended consumption of whole-grain cereal products differs from one country to another, but most recommend increased whole-grain cereal product consumption [2, 3].

The beneficial effect of whole grains and cereal products has often been attributed to their fibre content [4]. Whole oat grains are good source of dietary fibre, especially soluble β-glucans ((1→3)(1→4)-β-D-glucan). β-glucan is considered to be the major active component of oats because of its cholesterol-lowering and anti-diabetic effects [5]. Oats can be made as products such as breakfast cereals, bread, cookies, and others. Breakfast cereals have currently become an important source of energy in human nutrition, since its high carbohydrate, bran, mineral and vitamins content, together with a low fat amount, makes it suitable for a healthy breakfast [6].

Based on previous research, the cooking process will affect the starch gelatinization process undercooking rice produced lower in vitro digestibility and blood glucose responses compared with fully cooked rice [7]. The process of cooking or serving breakfast cereals is very important for the

nutritional quality cereal food, therefore the aim of this study is to evaluate the effect of cooking or serving water temperature on the nutritional content of grains, especially breakfast cereals.

2. Materials and Methods

2.1. Samples preparation

Four breakfast cereals i.e instant oats brand A, instant oats brand B, quick cook oats brand A and quick cook oats brand A were obtained from Bogor, West Java, Indonesia.

In the experiment, each sample was brewed with water at four temperature 40, 60, 80, and 100 °C. Serving method use serving instruction in packaging of product, 35 gram samples were brewed with 210 mL water, let stand for 5 minutes then stirred. Control sample is non-treatment breakfast cereals. All samples were divided into 2 parts, one part for the organoleptic assay and the other for the analysis of nutritional content.

2.2. Analysis of nutritional content

Protein and fat contents were determined according to the standard method [8], dietary fibre was determined with the enzymatic method [9]. For the magnesium (Mg) content, the samples were prepared with acid-digested, using a nitric acid and perchloric acid mixtures (HNO3:HClO4, 5:1w/v). The total amounts of Mg in the digested samples were determined by atomic absorption spectrophotometry (AAS). All the assays were performed in duplicates.

2.3. *Organoleptic testing*

Oats cereals organoleptic characteristics were determined by the panellist consist of seven judges for overall acceptability using a five-point Hedonic Rating Scale (HRS) ranging from like extremely (5) to dislike extremely (1).

2.4. Statistical analysis

The data obtained were subjected to statistical analysis by following a standard method. Results were analyzed for differences between the treatments in two groups sample, instant oats and quick cook oats, by one –way ANOVA test and Duncan's Multiple Range Test/DMRT (SPSS version 16). The values of $P < 0,05$ were considered to indicate the significant levels.

3. Results and discussion

Some of the chemicals constituents of all the samples such as proteins, fats, dietary fibre, and magnesium are presented in table 1 and table 2.

Table 1 and table 2 shows that the protein, fat, and magnesium contents decreased with increasing temperature of water, whereas dietary fibre contents increased from un-brewed cereals (control) to brewed cereals (treated samples). Un-brewed cereals (UB) had 14.15% of protein contents in instant oats (sample A and B), while the protein contents in quick cook oats (sample A and B) had the protein contents between 13.52 to 13.80%. In the case of brewed cereals, the protein contents were obtained between 2.15% to 3.37% in the instant oats samples (A and B), and 2.21-2.82% in the quick cook oats sample (A and B). The fats content in the instant oats sample was higher than the quick cook oats, as well as the protein content. The fats content in the instant oats is between 10.08% and 10.60%, while the fat content in the quick cook oats is between 8.42% and 8.59%. After brewing, the fats contents were decreased from 2.23% until 0.46%. Similarly, the magnesium (Mg) contents in the instant oats with un-brewed (UB) also contain Mg from 1954.44 mg/Kg to 2097.42 mg/Kg. After brewing, the Mg content becomes 130.61 mg/Kg to 261.51 mg/Kg. While the Mg content in quick cook oats un-brewed (UB) was 1918.73 mg/Kg to 2006.26 mg/Kg decreased to 200.55 mg/Kg to 314.46 mg/Kg.

The decreasing in protein, fat, and magnesium contents of brewed cereals might be caused by the dilution process during serving. In this study, we did not determine the water contents in the samples due to during the brewing process, the water content were increased definitely. Several researchers

reported that the higher water content in the cereals sample would decrease the nutritional quality of the cereal foods. Others workers also reported that some nutrients were decreased during food processing [10, 11, 12].

Table 1. Protein and fat content of oat cereals under unbrewed (UB), brewed with 40°C (40 B), brewed with 60°C (60 B), brewed with 80°C (80 B), and brewed with 100°C (100 B)*.

	Protein (g/100g)					Fat (g/100g)				
	UB	40 B	60 B	80 B	100 B	UB	40 B	60 B	80 B	100 B
Instant oats A	$14.15^{a}\pm 0.04$	$2.70^{e}\pm 0.02$	$2.15^{g}\pm 0.02$	$2.65^{e}\pm 0.02$	$2.44^{f}\pm 0.03$	$10.08^{b}\pm 0.08$	$2.18^{c}\pm 0.03$	$1.83^{e}\pm 0.02$	$1.44^{f}\pm 0.03$	$1.01^{g}\pm 0.00$
Instant oats B	$14.15^{a}\pm 0.05$	$3.12^{d}\pm 0.05$	$3.07^{d}\pm 0.01$	$3.24^{c}\pm 0.05$	$3.37^{b}\pm 0.04$	$10.60^{a}\pm 0.04$	$2.06^{d}\pm 0.00$	$1.99^{d}\pm 0.00$	$1.79^{e}\pm 0.00$	$1.48^{f}\pm 0.00$
Sig. (P<0.05)	0.00					0.00				
Quick cook oats A	$13.52^{b}\pm 0.04$	$2.68^{d}\pm 0.04$	$2.82^{c}\pm 0.05$	$2.31^{g}\pm 0.00$	$2.80^{c}\pm 0.04$	$8.59^{a}\pm 0.02$	$1.89^{d}\pm 0.01$	$1.15^{f}\pm 0.00$	$0.76^{g}\pm 0.00$	$0.46^{h}\pm 0.00$
Quick cook oats B	$13.80^{a}\pm 0.01$	$2.51^{e}\pm 0.05$	$2.21^{h}\pm 0.01$	$2.42^{f}\pm 0.01$	$2.51^{e}\pm 0.01$	$8.42^{b}\pm 0.15$	$2.23^{c}\pm 0.02$	$1.72^{e}\pm 0.02$	$1.05^{f}\pm 0.01$	$0.82^{g}\pm 0.00$
Sig. (P<0.05)	0.00					0.00				

*Values are means ± SD of two independent determinations.
[a,b]Different letters within the same column indicate statistical differences (one-way ANOVA and Duncan test, $p < 0.05$).

Oat protein is unique among temperate cereals because it is high in globulin. The addition of isolated oat protein into chick diets at levels of 4.5% and 6% significantly reduced the total plasma cholesterol. Oat oil, high in polyunsaturated fatty acids, has the potential to reduce the plasma cholesterol compared with the fats rich in saturated fatty acids [13]. Intracellular magnesium concentration has been shown to be effective in increasing insulin secretion and the rate at which glucose is cleared from the blood [14].

Table 2 shown that instant oats and quick cook oats increase in dietary fibre content due to the brewing process. This is inversely proportional to the content of other nutrients. The content of dietary fibre in the instant oats during un-brewed (UB) is from 0.12% to 0.17%, while, the dietary fibre contents during brewing process were increased with increasing the water temperature of brewing process. Similarly, with the instant oats samples, the dietary fibre contents in the quick cook oats samples were also increase during brewing process from 40 °C to 100 °C.

Oats are good source of dietary fibre, it can be classified as either soluble or insoluble fibre based on water solubility. The main constituent of soluble fibre is β-glucan. The health effects of oats are primarily related to the dietary fibre, or dietary fibre complex (dietary fibre and its bioactive co-passengers) in oat products. There are many proposed benefits. High-fibre diets promote laxation, thus preventing or curing constipation. Incorporation of ~90 g oat bran into diets per day increased the frequency of bowel movements and fecal bulk. Consumption of oat products (high in dietary fibre) may also prevent the onset of colorectal cancer by: 1) increasing the fecal bulk, which dilutes carcinogens in the colon, 2) speeding up the transit rate through the colon, which decreases the available time for interaction between carcinogens and colon tissue, and 3) reducing carcinogen generation by the bacterial flora. In addition, fermentation of oat soluble fibres, such as β-glucan in the colon may be beneficial in preventing colorectal cancer [13].

Table 2. Dietray fibre and magnesium content of oat cereals under unbrewed (UB), brewed with 40°C (40 B), brewed with 60°C (60 B), brewed with 80°C (80 B), and brewed with 100°C (100 B)*.

	Dietary Fibre (g/100g)					Mg (mg/Kg)				
	UB	40 B	60 B	80 B	100 B	UB	40 B	60 B	80 B	100 B
Instant oats A	0.12^{g}± 0.01	0.24^{e}± 0.00	0.46^{d}± 0.01	0.65^{c}± 0.01	1.10^{b}± 0.01	1954.44^{b}± 0.629	261.51^{c}± 0.042	224.12^{e}± 0.262	246.99^{d}± 1.075	130.61^{h}± 0.255
Instant oats B	0.17^{f}± 0.01	0.26^{e}± 0.00	0.46^{d}± 0.01	0.62^{c}± 0.01	1.27^{a}± 0.02	2097.42^{a}± 7.453	246.48^{d}± 0.544	223.12^{e}± 0.799	198.64^{f}± 0.799	191.88^{g}± 0.205
Sig. (P<0.05)	0.00					0.00				
Quick cook oats A	0.15^{i}± 0.01	0.21^{h}± 0.00	0.49^{e}± 0.01	0.72^{c}± 0.03	1.23^{b}± 0.01	1918.73^{b}± 7.382	205.44^{g}± 0.141	222.46^{f}± 2.567	293.66^{d}± 0.064	293.10^{d}± 1.662
Quick cook oats B	$0.18^{h,i}$± 0.01	0.26^{g}± 0.01	0.37^{f}± 0.03	0.61^{d}± 0.03	1.44^{a}± 0.01	2006.26^{a}± 2.602	314.46^{c}± 0.368	217.20^{f}± 1.096	284.30^{e}± 2.871	200.55^{g}± 0.679
Sig. (P<0.05)	0.00					0.00				

*Values are means ± SD of two independent determinations.
[a,b]Different letters within the same column indicate statistical differences (one-way ANOVA and Duncan test, $p < 0.05$).

The acceptability of the brewed samples were significantly different with ANOVA test ($p<0.05$), both for instant oats and quick cook oats. The organoleptic characteristics of all the sample is presented in Table 3. The Table 3 showed that, the Instant oats A has an overall acceptability's score of 1.00, 4.71, 4.00, 1.86; instant oats B has score of 1.00, 4.71, 4.00, 2.29, quick cook oats A has score 1.00, 4.71, 4.57, 2.00, and quick coot oat B has score 1.00, 5.00, 4.00, 2.00 at serving temperatures of 40°C, 60°C, 80°C, and 100°C, respectively. It is therefore, concluded that overall acceptability scores of brewed cereals in the category of like extremely to dislike extremely. The most preferred sample was brewed with water at serving temperature of 60 °C.

Table 3. Organoleptic characteristics of oat cereals, brewed with 40°C (40 B), brewed with 60°C (60 B), brewed with 80°C (80 B), and brewed with 100°C (100 B)*.

	Overall acceptability			
	40 B	60 B	80 B	100 B
Instant oats A	1.00^{d}±0.00	4.71^{a}±0.49	4.00^{b}±0.58	1.86^{c}±0.38
Instant oats B	1.00^{d}±0.00	4.71^{a}±0.49	4.00^{b}±0.58	2.29^{c}±0.76
Sig. (P<0.05)		0.00		
Quick cook oats A	1.00^{e}±0.00	4.71^{b}±0.49	4.57^{b}±0.53	2.00^{d}±0.00
Quick cook oats B	1.00^{e}±0.00	5.00^{a}±0.00	4.00^{c}±0.00	2.00^{d}±0.00
Sig. (P<0.05)		0.00		

*Values are means SD of seven panellists.
[a,b]Different letters within the same column indicate statistical differences (one-way ANOVA and Duncan test, $p < 0.05$).

4. Conclusion

The protein, fat, and magnesium contents decreased with increasing temperature of water, whereas dietary fibre contents increased. The brewing temperature of 100 °C tends to produce the lowest levels of protein, fat, and magnesium, while the highest levels of dietary fibre. Based on the results of the organoleptic test, the panellists liked the sample that was brewed at 60 °C, both for instant oats and quick cook oats. Therefore it may be inferred from the present study that the brewing temperature of

60 °C is the best temperature based on the acceptability of the panellists, and also the nutritional content is not too reduced.

Acknowledgments
We would like to thank Muhammad Fikri Akbar for helping this research.

References

[1] The American Association of Cereal Chemists (AACC) International 1999 Definition of whole grain. http://www.aaccnet.org/definitions/wholegrain.asp (accessed October 2020)
[2] European Food Information Council (EUFIC) 2009 Whole grain fact sheet. http://www.eufic.org/article/en/ page/BARCHIVE/expid/Whole-grain-Fact-Sheet/ (accessed October 2020)
[3] Lang R and Jebb S A 2003 Who consumes whole grains, and how much? *Proc Nutr Soc* **62** 123–127
[4] Jacobs D R, Pereira M A, Meyer K A and Kushi L H 2000 Fibre from whole grains, but not refined grains, is inversely associated with all-cause mortality in older women: the Iowa women's health study *J. American College of Nutrition* **19** 326S–330S
[5] Singh R, De S and Belkheir A 2013 Avena sativa (Oat), a potential neutraceutical and therapeutic agent: an overview *Crit Rev Food Sci Nutr* **53** 126-144
[6] Bertais S, Luque M L P, Preziosi P, Fieux B, Torra de Flot M, Galan P et al. 2000 Contribution of ready-to-eat cereals to nutrition intakes in French adults and relations with corpulence *Annals in Nutrition and Metabolism* **44** 249–255
[7] Panlasigui L N, Thompson L U, Juliano B O, Perez C M, Yiu S H and Greenberg G R 1991 Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans *Am. J. Clin. Nutr.* **54** 871–7
[8] Badan Standarisasi Nasional 1992 Standar Nasional Indonesia (SNI) 01-2891-1992 Cara uji makanan dan minuman (Jakarta)
[9] Association of Anlytical Chemists (AOAC) 1999 AOAC International. Official Method 985.29; 993.19; 991.42
[10] Saikia P, Sarkar C R and Borua I 1999 Chemical composition, antinutritional factors and effect of cooking on nutritional quality of rice bean [*Vigna umbellata* (Thunb; Ohwi and Ohashi)] *Food Chemistry* **67** 347-352
[11] Seenaa S, Sridhara K R, Arun A B and Chiu-Chung Y 2006 Effect of roasting and pressure-cooking on nutritional and protein quality of seeds of mangrove legume Canavalia cathartica from southwest coast of India *J of Food Composition and Analysis* **19** 284–293
[12] Tyagi S B, Kharkwal M and Saxena 2015 Impact of cooking on nutritional content of food *J. of Undergraduate Research and Innovation* **1** 3 180-186
[13] Liu Y 2010 Beta-glucan effects on pasting properties and potential health benefits of flours from different oat lines *Thesis Food Science and Technology* (Iowa: Iowa State University)
[14] Rebello C J, Greenway F L and Finley J W 2014 Whole Grains and Pulses: A Comparison of the Nutritional and Health Benefits Candida *J. Agric. Food Chem.* dx.doi.org/10.1021/jf500932z/