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Effect of oat (*Avena sativa* L.) genotype and germination time on functional properties and nutritional value of oat flour

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ABSTRACT: Germination of whole grain was improved its nutritive value and physical properties of whole grain flour. Thus, the influent of oat genotype and geminated time on physical properties and nutritive value of germinated oat flour were investigated. The experimental design was 2×3 factorials in completely randomized design (CRD). The two varieties oat seeds (AUSOAT and FAMGOA from Maehongsorn Rice Research Center, Thailand) were cleaned, washed, steeped and germination at 35 ± 2°C and 95 ± 2% relative humidity for 0, 12 and 24 h prior dried to 14 % moisture content. The dried germinated oat grain were de-hulled and milled pass through 80 mesh screen to produced germinated oat flour (GOF). The husked yield, flour yield, water absorption index, water soluble index, color value, moisture content, protein, fat, fiber, ash, carbohydrate, and dietary fiber content of the GOF were determined. The results revealed that the oat genotype was not significant affected on chemical composition and functional properties of GOF. However, the long germination time was dramatically reduced on soluble dietary fiber and carbohydrate content. In addition, the GOF produced from 12 h germination of *AUSOAT* and *FAMGOAP* genotypes had the highest in water absorption index and water soluble index same as whole wheat flour. Thus, the 12 h GOF was an appropriate for utilization as healthy food ingredients especially in various cereal breakfast and bakery products.
Keywords: color value; water absorption index; nutritive value

Introduction

Oat (*Avena sativa* L.) is the fifth largest cereal crop in the world which was cultivation as a food crop started in Europe around the Bronze Age and then spread throughout the world. Oats tolerate cold climates very well and some of the major commercial producers are the USA, Canada, Belarus, Spain, Finland, Poland, Germany, Austria and China (FAO, 2010). Thailand was imports oats at level of 36,000 US$ in 2016, down from 45,000 US$ previous year, this is a change of 20.00%. Thus, the Mae Hong Sorn Rice Research Center in Northern part of Thailand was studied on the planted of organic oat with different line genotype. The weather in Mae Hong Sorn province was cool, moist climates, with the optimum temperature for oat growth within between 20 and 21°C (68–70°F). Thus, the physicochemical properties and utilization of the oat grown in Thailand are necessary to find out.

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Nutritive value of oat grain are high percentage of protein, ash, dietary fiber, lipids (unsaturated fatty acid), minerals, vitamins and phytochemicals and some anti-nutrients (Hsueh et al., 2011). Many researchers purposed that the germination of cereal grains such as rice, wheat, barley and oat were improving its nutritive value, functional properties and reduced anti-nutritional (Binqiang et al., 2010; Othman et al., 2011and Aparicio-García et al., 2020).

During germination, whole grain proteins were degraded to increase the soluble protein content. The oat protein properties were improved without any chemical modifications. Oat seed kernel protein increased slightly, but the lysine content increased almost 30% at the end of germination. The phytic acid content declined from 0.35% to 0.11% during germination. There is a significant correlation among compositions including starch, protein, free and reducing sugars, free amino acid, and phytic acid. A close correlation also was found between the color of malt flour dried at 50 °C and the length of shoots and rootlets. The losses by removing of shoots and rootlets were the major cause of the total dry matter losses in the last 24 h of oat germination. Following the total starch enzymes activities dramatically increase (Kaukovirta et al., (2004) and Prasa et al., (2015).

The starch content decreased considerably from 60% to 20%, and the reducing and soluble sugars contents increased (Kaukovirta-Norja et al., (2004) and Singh and Belkheir, (2011). Oats are processed in order to produce oat based functional food products. Generally oat flour produced by stone milling of the de-hulled oat grain or rolled oats before pass through 60 to 80 mesh screen. Oat flour contains higher amounts of protein, lipids, minerals and β-glucan, a mixed-linkage polysaccharide, which constitutes an important part of oat dietary fiber (Ballabio et al., 2013). Thus, the objective of this study was to investigate the influent of oat genotype and germination time on physicochemical properties of the gemmated oat flour for further utilization as raw material in various healthy food products.

Materials and Methods

Materials and Experimental Design

Two genotypes of oat seeds, *AUSOAT* and *FAMGOA* were donated from Mae Hong Sorn Rice Research Center in Mae Hong Sorn province, Northern part of Thailand in 2019. After removing small and broken kernels, oat seed was collected and stored at 25°C until further processing. The germination activity of the oat seeds was tested to exceed 90%. All chemicals used in the present study were analytical grade reagents and Fiber Assay Kit (K-TDFR) were pursues from Commercial enzymatic assay kits were purchased from Megazyme (Megazyme International Ireland Ltd., Bray, Ireland. All equipment used from the Food Innovation Center, Agricultural Research Institute and Department of Argo Industry, Faculty of science and Agricultural, Rajamagala University of Technology Lanna.

Germinated oat flour (GOF) procedures

The germination of oat grain procedure was based on Binqiang et al., (2010) with some modifications. Oat grain surfaces were sterilized by soaking in 2.0% aqueous sodium hypochlorite for 15 min at room temperature, and then rinsed with tap water for at least 3 times. Before germination, the oat seeds were soaked in distilled water at 25°C in the dark for 5 h. After rinsing with distilled water, the steeped oat seeds were spread on wet sterilizes filter cotton cloth and covered with plastic lapped for control % relative humidity prior left to sprout at room temperature (25°C) for 0, 12 and 24 h, respectively. The collected oat seeds were dried to constant weight in a 60° C oven for 3 h dried to 14 % moisture content.

The germinated oat seed were removing the hull by Rubber-roll hullers (Satake, Australia). The oats fall into the center of this rotating disc and are thrown into a series of impact rings on the wall of the DE huller, which causes the groats to be separated from the hull. The geminated oat grain was made into flour by a Cyclotec sample mill (Foss, North America) and pass through an 80 mesh sieve. The GOF was packed in aluminum foil bag prior vacuum sealed and stored at 15°C for physicochemical and functional properties analyses as following detail:

Germinated oat hull and flour yield

The germinated oat (GO) hulling and germinated oat flour (GOF) yield were calculated by dividing the original mass of the rough dried GO prior to processing and percent milling yield of GOF (Francis and Peter, 2011), and were calculated thought following formula:

$$\%\text{GO hulled yield} = \frac{\text{Wt. of dehulled GO (g)}}{\text{Wt. of dried GO (g)}} \times 100$$

$$\%\ \text{GOF yield} = \frac{\text{Wt. of GOF (g)}}{\text{Wt. of dehulled GO (g)}} \times 100$$

Color value analysis

The 6 GOF samples with 3 replications were measured by a colorimeter (Hunter Lab model Color Quest XE, U.S.A) using the CIELAB system (L*, a*, b*).

Functional properties

Water absorption index and water solubility index of the GOF was determined by method outlined by Yagci and Gogus (2009) as following detail:

Water absorption index (WAI)

The water absorption index measures the volume occupied by the GOF granule after swelling in excess of water. The each GOF sample (2.5 g) was suspended in 30 ml distilled water at 30°C in a previously weighed 50 ml centrifuge tube. This mixture was stirred immediately over a 30 min period and then centrifuged (Thermo Electron, France) at 3000 g for 10 min. After pouring the supernatant into an evaporating dish, the gel was weighed and the WAI defined as the grams of gel per gram of solids was calculated as following equation:

$$\text{WAI (g/g)} = \frac{\text{wt. of water uptake in hydrated residue (g)}}{\text{wt. of germinated oat flour(g)}}$$

Water solubility index (WSI)

The water solubility index of the each GOF sample was determines the amount of polysaccharides release from the flour granule on the addition of excess of water. WSI was the weight of dried solids in the supernatant from the water absorption index test. The WSI was expressed as percentage of the original weight of the GOF sample which was calculated as following equation:

$$\text{WSI}\ (\%) = \frac{\text{Wt. of solid dissoved in supernatant (g)}}{\text{Wt. of dry sollids (g)}} \times 100$$

Chemical composition analysis

Moisture content was determined by hot air-oven drying method, protein, crude fiber, fat and ash were determined as methods described by AOAC (2002). Carbohydrate content was calculated by difference of moisture, proteins, fat, ash and crude fiber. The total dietary fiber (TDF) content was determined according to the AOAC 2011.25 (Mc Cleary et al., 2013) methods by using Fiber Assay Kit (K-TDFR) and TDF was determined as the sum of insoluble dietary fiber (IDF) and soluble dietary fiber (SDF).

Data assessment

Statistical analysis was performed in 3 replications for each sample. A 2x3 factorial in completely randomized design (CRD) was applied in this study. The collected data were subjected to the analysis of variance and differences among means were determined by Duncan’s multiple range tests procedure by using Minitab program version 18 State College, Pennsylvania, USA.

Results and Discussion

Physical properties of GO and GOF

Oat seed size and appearance of 0, 12 and 24 h germination time of GO hulled and GOF milled which combination of the two oat varieties (*AUSAT* and *FAMGOAP*) shown in **Figure 1.** The *AUSAT* GO seed was thin and longer grain than the *FAMGOAP* GO seed that was shorter and bigger grain. The longer germination time (24 h) produced the larger grain than the 12 h germination and control oat grain. This due to the water absorption into the oat endosperm that contain of carbohydrate in the form of starch granule that composed of difference of amylose and amylopectin in oat grain cultivar. Many researchers purpose that amylose content in oat starch was between 25 to 33.6% which was depending on oat variety and location planted (Tester and Karkarlas, 1996; Wang and White, 1994). Thus, the amylose content in the oat grain might be influence the WAI of the geminated oat flour. In addition, the 0, 12 and 24 h GOF from *FAMGOAP* genotype were softer texture than the *AUSAT* GOF within the same germination time. This might be influent by the oat genotype.

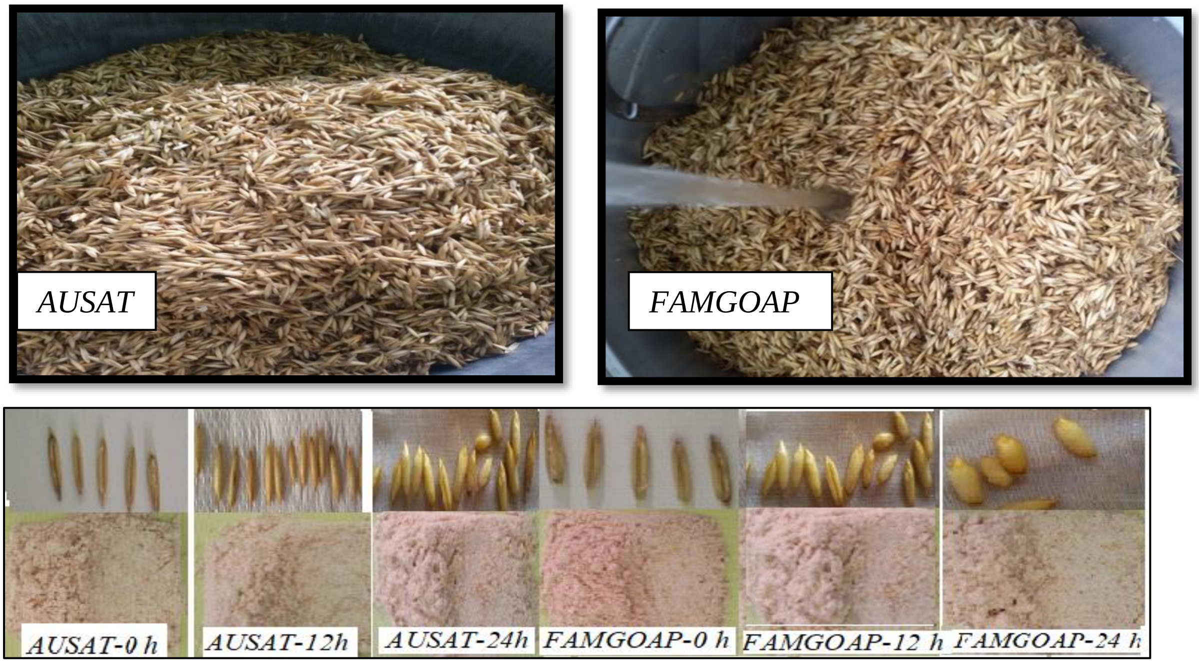

Figure 1 An appearance of *AUSAT* and *FAMGOAP* oat genotype and 0, 12 and 24 h germinated oat seed (GOS) and germinated oat flour (GOF)

Oat hulling yield (%)

Oat hulling of 0, 12 and 24 h germination time and combination with two oat varieties (*AUSAT* and *FAMGOAP*) shown in **Table 1**. The result revealed that the *FAMGOAP* oat genotype was significantly ($p<0.05$) higher hulling yield (80.44%) than the *AUSAT* genotype (76.66%). While, in case of germination time found that the longer germinated time reduced GO hulling yield from 74.36-81.08 %. The GO hulling yield are influences by groats percent, grain weight, thins and contaminant (physical, biological and chemical) levels. Groats percent (proportion of groats to total grain weight including the hull) is one of the most important quality characters for millers. Groats percent values greater than 72% are acceptable, but 75% or higher are optimum (Girardet and Webster, 2011). Moreover, groats percentage is important also for breeding programs as has been reported to be good predictor of milling yield (%).

Milling yield of germinated oat (%)

Results on GOF milling yield revealed that both of oat genotype and germination times were not significant difference ($p>0.05$) between treatments. However, the data in Table 1 shown that the combination were significantly difference between mean. GOF milling yield from the *FAMGOAP* oat genotype was significantly ($p<0.05$) higher hulling yield (94.41%) than the other treatments. However, the 24 h germinated of oat flour was significant ($p<0.05$) lower milling yield which was 92.17%. This due to the oat starch molecule reduced upon longer germination times. This results are similar trend with Binqian et al., (2010) reported that oat starch content decreased significantly from 60% to nearly 20%. A decrease in the starch content was observed after 24 h germinated oat seed.

Table 1 Hulling yield and thousand-kernel weight (g) of fractionated of dried seed samples

Treatments	Germinated oat seed size class (g) <16% Moisture content			Hulling yield (%)	Milling yield (%)
	Large	Medium	Small		
<u>Oat genotype</u>					
AUSAT (A_1)	40.13±0.23 ^{ns}	30.23±0.81^{ns}	22.03± 0.50 ^{ns}	76.66 ±3.64^{a}	91.41±0.36^{ns}
FAMGOAP (A_2)	41.40 ± 0.23	32.10 ± 0.28	23.01 ± 0.54	80.44 ± 2.26 ^{b}	92.17 ±0.26
<u>Germination time</u>					
0 h (B_1)	40.92 ±0.09^{ns}	32.22 ± 0.20^{ns}	21.63 ± 0.21^{ns}	80.08 ± 1.29^{ns}	91.65±0.69^{ns}
12 h (B_2)	41.82± 0.09	32.44 ± 0.21	21.72 ± 0.80	76.89 ± 3.28	92.07±0.45
24 h (B_3)	42.96 ± 0.28	32.22 ± 0.19	21.70 ± 0.64	75.74 ± 1.56	91.64±1.58
<u>Combination factor</u>					
(A_1 B_1)	41.12 ± 1.21 ^{ns}	32.14±1.22 ^{ns}	21.07± 0.41^{ns}	81.08 ±0.93 ^{a}	88.50±0.61^{c}
(A_1 B_2)	41.53 ± 1.02	32.46 ± 1.20	21.14 ± 0.40	79.07 ±0.89 ^{b}	93.74±0.63^{ab}
(A_1 B_3)	41.22 ± 1.24	32.64 ± 1.26	21.41 ± 0.49	74.36 ±0.93^{b}	92.92±0.56^{b}
(A_2 B_1)	40.32 ± 1.23	33.18 ± 2.18	21.35 ± 0.49	79.31±0.96^{a}	92.73±0.63^{b}
(A_2 B_2)	41.43 ± 1.04	33.03 ± 1.20	22.12 ± 0.43	74.50 ± 0.91^{b}	94.410±0.6^{a}
(A_2 B_3)	42.23 ± 1.32	33.06 ± 1.21	21.24 ± 1.49	76.93 ±0.95 ^{b}	92.17±0.62 ^{b}
C.V %	2.10	2.85	2.12	2.22	0.87

$^{a, b,..}$ Values are mean ± standard deviation. Different superscripts in columns differ significantly ($p < 0.05$), ^{ns} Values are mean ± standard deviation in columns not significantly ($p > 0.05$)

Functional properties of GOF

The effect of oats varieties (*AUSAT* and *FAMGOAP*) and germination time on the functional properties on the color value, water absorption index (WAI) and water solubility index (WSI) of the germinated oat flour are show in **Table 2** and following detail.

Color value

The color value of the six germinated oat flour were not significant (p> 0.05) difference between the oat genotype, germination time and interaction factor, which was L*(79.75-80.23) a* (2.06-2.33) and b* (11.26-12.13) value. An appearances color of the GOF from *AUSAT* was yellowish than the *FAMGOA P* genotype. In addition, appearances of the six GOF treatments were light pink color and soft texture as shown in Table 2 and Figure 1.

Water absorption index

Results on water absorption index (WAI) of the six germinated oat flour were significant (p< 0.05) difference between treatments as show in Table 2. The WAI of AUSAT GOF (5.38%) was higher than the germinated *FAMGOAP* oat flour (4.72%). The longer germination time was trend to decrease WAI from 4.89 to 4.14%. This might be the change of carbohydrates composition of the germinated oat flour. Thus, is not easy to hydrate in cold water. However, the germinated oat flour can absorb water reversibly at room temperature and swell around 20% of their own size, and return to their original size upon drying, but they imbibe significantly more water at higher temperatures and this process is irreversible. This due to the de-hulled oat grains consisted of 40-60% starch and the amylose and amylopectin content in oat starch is about 25% and 75%, respectively (Yong et al., 2017). The oat starch granules are pretty compact and insoluble and therefore they are not so easy to hydrate in cold water.

Water soluble index

The water soluble index (WSI) of the six GOF were not significant difference (p>0.05) between the oat genotype, germination time and combination treatments. However the oat genotype and germination time were slightly increased in WSI upon longer germinations time. The GOF from AUSAT and *FAMGOAP* genotype were not significant between oat variety that was 5.14 and 5.23, respectively. In addition, the 0, 12 and 24 h GOF from *FAMGOAP* genotype were softer texture than the AUSAT GOF within the same germination time. This might due to the oat starch granules are pretty compact and insoluble. In contrast, water soluble index (WSI) increased as the germination time increases, which confirmed the action of enzymes during germination and thus the release of water soluble compounds. Previously study found that the germinating grains affected on amylases hydrolysis of starch to simple sugars such as glucose, maltose and moto-triose (Liu and White, 2011; Chen et al., 2018 and Shen et al., 2016).

Table 2 Color value, % water absorption index (WAI) and % water soluble index (WSI) of GOF made from *AUSAT* and *FAMGOAP* genotype with germinate for 0, 12 and 24 h

Treatments	Color value			WAI	WSI
	*L**	*a**	b*	(%)	(%)
<u>Oat genotype</u>					
AUSAT (A_1)	80.23 ± 0.86 [ns]	2.23 ± 0.81[ns]	12.03±0.52 [ns]	5.38 ± 0.67[a]	5.14 ± 0.20[ns]
FAMGOAP (A_2)	80.10 ± 0.46	2.10 ± 0.78	12.01±0.59	4.72 ± 0.71 [b]	5.23 ± 0.21
<u>Germination time</u>					
0 h (B_1)	80.92 ± 0.09[ns]	2.22 ± 0.00[ns]	11.63± 0.51[ns]	4.89 ± 0.71[a]	4.58 ± 1.65[ns]
12 h (B_2)	80.82 m	2.14 ± 0.12	11.72 ± 0.80	4.23 ± 0.78[b]	4.76 ± 0.39
24 h (B_3)	81.96 ± 0.28	2.23 ± 0.19	11.70 ± 0.64	4.14 ± 0.38 [b]	4.82 ± 0.67
<u>Combination factor</u>					
(A_1 B_1)	81.22 ± 1.41 [ns]	2.22 ±0.12 [ns]	12.07±0.41 [ns]	5.28 ±1.12 [a]	4.38 ± 0.32[ns]
(A_1 B_2)	79.93 ± 1.45	2.06 ± 1.21	11.19 ± 0.40	5.49 ± 1.23 [a]	4.16 ± 0.34
(A_1 B_3)	80.32 ± 1.49	2.14 ± 1.22	11.91 ± 0.49	5.18 ± 1.14[b]	4.90 ± 0.36
(A_2 B_1)	80.65 ± 1.46	2.18 ± 1.14	11.65 ± 0.49	4.89 ± 1.16[b]	4.62 ± 0.36
(A_2 B_2)	80.96 ± 1.49	2.33 ± 1.12	12.13 ± 0.43	4.28 ± 1.16[b]	4.74 ± 0.32
(A_2 B_3)	79.75 ± 1.75	2.06 ± 1.12	11.26 ± 1.49	4.29 ± 1.11 [b]	4.79 ± 0.33
C.V (%)	5.51	2.12	3.45	5.40	1.09

[a, b,..] Values are mean ± standard deviation. Different superscripts in columns differ significantly (p< 0.05), [ns] Values are mean ± standard deviation in columns not significantly (p > 0.05)

Chemical composition of GOF

Analysis result on chemical composition of GOF from different oat genotype and germinated times revealed in **Table 3**. Results demonstrate that the moisture content and crude fiber was not significant (p>0.05) between the oat genotypes, which was higher in *FAMGOAP* then *AUSAT*. The results revealed that the geminated time induces changes content of moisture, protein, fat, ash, and carbohydrate which was dramatically decrease with longer germination time. The interaction mean of moisture, protein, fat, ash, crude fiber and carbohydrate content ranged from 7.00 -7.68%, 8.74- 8.91%, 4.72 - 7.74, 3.22 - 3.79% and 75.35-76.53%, respectively. In addition, the germination times and oat genotype did not significantly (p>0.05) effect on moisture content, protein, and fat contents in the GOF samples. However, Ash and carbohydrate content were significantly (p<0.05) decreased during germination time. The amount of carbohydrate in germinated oat flour were between 68.49 - 70.81% which was higher in *AUSAT* then *FAMGOAP* genotype. Germinated oats flour from 24h germinated *FAMGOAP* genotype had the highest amount of protein (11.91%). Previous research found that the protein content in oat grain ranges from 7.4 to 14.4% that depend on the oat genotype, planted area and fertilizer (Capouchova et al., 2018; Boukid et al., 2017). Lipid level in germinated oat flour is non-significant between treatment ranges from 4.42-4.74%. The germinated *FAMGOAP* oats flour had higher levels of ash than *AUSAT* (4.60-4.72%). Ash in oat is high in magnesium, potassium, iron and phosphorus, but a lower copper and calcium. Furthermore, oat grains fiber is high amount of water-soluble fiber and is known as beta glucan that was numerous health benefits reduced risk of various chronic diseases such as diabetic and colon cancer. Previous researcher reports recommend on safety of oats to be included in the gluten free diet in children suffering from celiac disease (Hübner et al., 2010 and Francis et al., 2011). Thus, gluten free products such as pasta, biscuit snacks have been developed for celiac patients from oats (Ballabio et al., 2011).

Table 3 Chemical composition of GOF produced from *AUSAT* and *FAMGOAP* genotype and germinated for 0, 12 and 24 h

Treatments	Chemical composition (g/100 g wet basic)					
	Moisture	Protein	Lipid	Ash	Crud fiber	Carbohydrate
Oat genotype						
AUSAT(A_1)	7.62±0.54^{ns}	10.75±0.2^{ns}	4.72 ±0.2^{ns}	3.6 ± 0.64^{a}	4.52±0.5^{b}	67.81±0.5^{a}
FAMGOAP(A_2)	7.73±0.60	10.74±0.1	4.74±0.1	4.0 ± 0.55^{b}	4.63±0.6^{a}	66.29±0.6^{b}
Germination times						
0 (B_1)	6.62±0.4 ^{ns}	10.78±0.3^{ns}	4.72 ± 0.2^{ns}	3.86±0.23^{ns}	4.62±0.4 ^{ns}	67.42±0.6 ^{a}
12(B_2)	7.63±0.6	10.74±0.4	4.64 ± 0.4	3.83±0.24 ^{b}	4.63±0.2	66.86±0.2^{b}
24 (B_3)	7.64±0.6	10.72±0.2	4.52 ± 0.4	3.80±0.23^{b}	4.82±0.6	66.62±0.2^{b}
Combination factor						
(A_1 B_1)	7.00±0.4^{ns}	10.74±0.1^{ns}	4.72±0.2^{ns}	3.41 ± 0.1^{a}	4.00±0.4^{ns}	67.13±0.31^{a}
(A_1 B_2)	7.77±0.2	10.78±0.5	4.62 ± 0.2	3.30 ± 0.2^{b}	4.77±0.22	66.51±0.12^{b}
(A_1 B_3)	7.38±0.6	10.87±0.1	4.60 ± 0.2	3.27 ± 0.3^{b}	4.88±0.12	67.96±0.20^{a}
(A_2 B_1)	7.40±0.4	11.76±0.5	4.73 ± 0.1	3.79 ± 0.3^{a}	4.70±0.4	65.35±0.22^{c}
(A_2 B_2)	7.48±0.6	11.74±0.3	4.72 ± 0.1	3.31 ± 0.3^{b}	4.48±0.6	65.73±0.24^{c}
(A_2 B_3)	7.68±0.2	11.91±0.2	4.70 ± 0.2	3.22 ± 0.2^{b}	4.68±0.2	65.49±0.24^{c}
C.V (%)	2.23	2.06	0.75	1.20	2.23	4.63

[a, b,..] Values are mean ± standard deviation. Different superscripts in columns differ significantly ($p < 0.05$) [ns] Values are mean ± standard deviation. Superscripts in columns not significantly ($p > 0.05$)

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Dietary fiber components

Analysis results on dietary fiber components of GOF from *AUSAT* and *FAMGOAP* variety germinated for 0, 12 and 24 h are present in Table 4. Results revealed that the oat genotype and geminated time induces changes of insoluble fiber that was dramatically increased with longer germination time. While the soluble dietary fiber decline upon long germination time this due to the soluble fiber such as β-glucan soluble during germination steps. Results revealed that the *AUSAT* was higher total dietary fiber then *FAMGOAP* variety. Among the interaction treatment found that In general, the impact of germination process conditions on solubilization of dietary fiber depends on the cereal cultivar, since differences in hydration rate affect enzyme synthesis and activity (Cáceres et al., 2014, Liu. and White. 2011; Zhang et al. 2011 and Teixeira et al., 2016). Pervious study on oat fiber fractions was associated with reduced risk of heart diseases and anti-cancerous activity. In vitro studies imply butyrate exerts multiple effects to modulate gene expression and regulatory effect of apoptosis and cell cycle within countering colon cancer (Hsueh et al. 2011 and Hübner et al., 2010).

Table 4 Dietary fiber component of GOF produced from *AUSAT* and *FAMGOAP* variety and germinated at room temperature for 0, 12 and 24 h

Treatments	Dietary fiber component (g/100 g dry basic of crude fiber)		
	Insoluble fiber	Soluble fiber	Total dietary fiber
<u>Oat variety</u>			
AUSAT (A_1)	20.42±2.2^a	4.64 ± 1.64^a	25.06 ±1.64^a
FAMGOAP (A_2)	19.26± 2.8^b	4.45 ± 0.55^b	24.71 ±1.25^b
<u>Germination times</u>			
0 (B_1)	18.56±2.3^b	4.86 ± 0.23^a	23.42±1.23^b
12 (B_2)	19.38±2.4^b	4.53 ± 0.24^b	23.91 ±1.24^b
24 (B_3)	19.42±2.2^a	4.28 ±0.23^b	4.20 ±1.02^a
<u>Combination factor</u>			
(A_1 B_1)	20.74±1.43^b	4.41 ± 0.31^a	24.89 ± 1.28^a
(A_1 B_2)	20.44±2.54^b	4.30 ± 0.32^b	24.74 ± 1.12^b
(A_1 B_3)	19.36±2.16^a	3.27 ± 0.33^b	23.63 ± 1.22^c
(A_2 B_1)	19.28±2.34^b	4.79 ±0.30^a	23.07 ± 1.32^b
(A_2 B_2)	19.82±2.16^b	4.31 ± 0.38^b	23.13 ± 1.23^a
(A_2 B_3)	19.64 ±2.2^b	4.11± 0.30^b	23.75 ± 2.21^b
C.V (%)	5.36	2.20	4.63

$^{a, b,..}$ Values are mean ± standard deviation. Different superscripts in columns differ significantly ($p < 0.05$), ^{ns} Values are mean ± standard deviation.

Superscripts in columns not significantly ($p > 0.05$)

Conclusion

The oat genotype and germination time were not affected on color value of the germinated oat flour but trend to reduce the water absorption index and water soluble index after germinating. While, protein, ash and crud fiber of the germinated oat flour produces from *FAMGOAP* genotype was higher than *AUSAT* genotype. Germinating oat grain resulted increase of total fiber and insoluble fiber in the two oat genotypes. Presently, the consumer demands for healthier cereal based foods, the geminated oat flour might be a source of innovation for healthy food product development and consumer acceptability of foods formulated with them will be further studied on bread product.

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