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Р. Манзали^{1, 2},
А. Дуаик²,
М. Буксаим²,
Г. Ладзинский³,
Н. Саиди^{2*}

¹Университет Хасана Первого, факультет наук и технологий, кафедра прикладной биологии и переработки продуктов питания, Сеттат, Марокко.

²Национальный институт сельскохозяйственных исследований, Региональный центр, Рабат, Марокко, e-mail: nezsaïdi@yahoo.fr

³Главный исследователь, Агентство США по международному развитию, Проект № TAMOU 97-053, Вашингтон, США.

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ОРИГИНАЛЬНАЯ СТАТЬЯ

ОЦЕНКА ВАЖНЫХ БИОХИМИЧЕСКИХ ПАРАМЕТРОВ НОВЫХ МАРОККАНСКИХ СЕЛЕКЦИОННЫХ ЛИНИЙ ТЕТРАПЛОИДНОГО ОВСА *AVENA MAGNA*

Возделывание овса в Марокко было введено в 1920-е годы, когда страна находилась под Французским протекторатом. Овес, в основном, выращивается в районах с достаточным количеством осадков и, традиционно, используется на корм животным. Из-за его высокой питательной ценности овес все больше используется и на пищевые цели. Национальным институтом сельскохозяйственных исследований (ИНРА) была разработана программа, направленная на создание новых тетраплоидных культурных линий овса с использованием дикого вида *AAvena magna* Murph. et Terr., имеющих высокую питательную ценность для потребления человеком. Девять полученных тетраплоидных культурных линий овса с *A. magna* были изучены по большому числу биохимических признаков. Были проведены биохимические анализы, включая определение зольных элементов, белка, фракций волокон, липидов, углеводов и минеральных элементов. Линии сравнивались друг с другом и двумя дикими родительскими линиями *A. magna* с использованием статистического метода (ANOVA). Статистический анализ выявил различия в химическом составе изученных линий. Были найдены существенные различия ($P < 0,001$) по содержанию белков (11,45–13,92%), жира (3,89–10,15%), углеводов (48,99–57,86%) и золы (1,7–3,73%) в пленчатых зерновках овса. Анализ общих фракций волокон (NDF, ADF, ADL и CF) показал наличие существенных различий между полученными линиями. По содержанию белка наибольшие показатели были у линий, имеющих 13,62% и 13,92%. Кроме того, кальций, фосфор и калий были наиболее важными основными макроэлементами в зерновке овса, в то время как железо, марганец и цинк были доминирующими микроэлементами. Результаты данного исследования показывают, что марокканские культурные тетраплоидные линии овса имеют довольно высокий уровень питательных веществ с хорошей энергетической ценностью и могут служить источником полезных соединений в питании человека.

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R. Manzali^{1, 2},
A. Douaik²,
M. Bouksaim²,
G. Ladizinsky³,
N. Saidi^{2*}

¹Hassan 1st University, Faculty of Sciences and Techniques, Department of Applied Biology and Food Processing, Settat, Morocco.

²National Institute for Agricultural Research, Regional Centre of Rabat, Rabat, Morocco, e-mail: nezsaïdi@yahoo.fr

³Principal Investigator, USAID, Project No. TAMOU 97-053, Washington, U.S.A

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ORIGINAL ARTICLE

ASSESSMENT OF IMPORTANT TECHNOLOGICAL PARAMETERS OF NEW MOROCCAN DOMESTICATED TETRAPLOID OAT LINES OF *AVENA MAGNA*

Oat cultivation was introduced to Morocco during the French Protectorate in the 1920s. Oat is mainly cropped in areas with high rainfall and known to be used for animal feed. Due to its high nutritive value, there is an increased demand in oat for human consumption. A breeding programme was launched by the National Institute for Agricultural Research (INRA), aiming the development of new tetraploid oat lines of *Avena magna* Murph. et Terr., having a high nutritive value for human consumption. Nine tetraploid oat lines of *A. magna* were assessed for their technological performance. Physicochemical analyses were performed, including moisture, ash, proteins, fibre fractions, lipids, carbohydrates, and minerals. The lines were compared with each other and two wild parental lines of *A. magna* using the Analysis of Variance (ANOVA). Statistical analysis revealed noteworthy differences in the chemical composition between the cultivars. There was a very significant difference ($P < 0.001$) in the content of proteins (11.45–13.92%), fat (3.89–10.15%), carbohydrates (48.99–57.86%), and ash (1.7–3.73%) in the groat (grain with hulls). Analysis of total fibre fractions (NDF, ADF, ADL and CF) showed the presence of substantial differences between the assessed lines. The highest protein contents, 13.62% and 13.92% were found in the domesticated lines of *A. magna*. In addition, calcium, phosphorus, and potassium were the most important major minerals in oat, while iron, manganese, and zinc were the dominant minor minerals. This study's outcome suggests that Moroccan domesticated tetraploid oat lines were within a suitable range of nutrients with good computed (calculated) energy, and may serve as a source of beneficial compounds for human nutrition.

Introduction

Oat (*Avena sativa* L.) is a cereal crop which is grown worldwide. It is a nutritious food since it contains excellent lipid, amino acid and phenolic profiles. In addition, oat is an important source of valuable nutrients, such as minerals, fibres, and vitamins (Sterna *et al.*, 2016).

Oat grains are commonly accepted by consumers and appear in a wide range of food products, including low-energy beverages, medical foods, baked goods and granolas (Carder *et al.*, 2014). In a time of increasing global food security challenges and dual health burdens of overweight and underweight, oats could be part of inexpensive and nutritious products (Rasane *et al.*, 2015).

The world's gene banks for oats hold more than 200 000 accessions of wild and cultivated *Avena* species (Diederichsen, 2008). Further breeding programmes and improvement of cultivars are critical to ensure oat diversity and its ability to be grown in changing environments, for example, in the context of climate change or water availability, and to ensure resources for crop improvement and promotion of oat properties that provide health benefits. In this respect, plant domestication, as a process of selecting characteristics that have been favoured under cultivation but are usually of low adaptive value in the wild, is an approach that may open new channels of technological investigations focusing on interesting traits (Salamini *et al.*, 2002).

This suggests that oat represents a promising cereal crop in the whole-grain market landscape due to its many unique chemical properties and potential health benefits. Although the consumption of oat products has increased because of these health-friendly traits and evidence-based impact on the risk of cardio-vascular diseases, they may also have a positive effect, if such evidence is confirmed, on gut health and some forms of cancers (Zwer *et al.*, 2010).

Considering the increased consumer awareness regarding the role of oat grain in the improvement of life quality, oat holds many qualities which are adding value to oat

cultivation (Charalampopoulos *et al.*, 2002). Thus, old and new types of oats need to be characterized on a broader scale. The current study sheds light on nine newly domesticated tetraploid oat lines of *A. magna* and aims to analyse the composition of these lines and evaluate their nutritional benefits.

Material and methods

Abbreviations: **ADF**, acid detergent fibre; **ADL**, acid detergent lignin; **CF**, crude fibre; **NDF**, neutral detergent fibre; **DM**, dry matter.

1. Plant material

Nine domesticated tetraploid oat lines of *A. magna* released by the National Institute for Agricultural Research (INRA) of Morocco, and a variety of *A. sativa* (Amlal), were used in this study.

2. Reagents and standards

All the used standards and chemical reagents were of analytical grade and obtained from Sigma-Aldrich.

3. Chemical and physicochemical analysis

3.1 Sample preparation and milling process The samples were from the harvest of 2012/2013; they were processed for pre-cleaning, drying, and storage.

In order to perform the chemical analysis, seeds were ground using a mill MF 10 basic IKA WERKE, and sieved at 1 mm. Chemical results concerning such components as ash, protein, fat, crude fibre, and micronutrients were expressed on the basis of seed dry weight. The results were presented in g/100 g, and all analyses were carried out in two or three replications.

3.2 Physicochemical characteristics

Groat flour moisture

This parameter was determined by oven-drying the samples at 80°C for 24 hrs and confirmed by near infrared spectrometry (Chopin Infraneo – NIRS). Results are

reported on a dry weight basis (Brunner et Freed, 1994).

Ash

Ash content in the treated oat samples was determined using the AACC Method No. 08-01. In a dried and pre-weighed crucible, 3 g of a sample was ignited in muffle furnace at 550°C during 6 hrs to complete the burning of all organic matter. Samples were cooled, weighted, and calculated as ash per cent (AACC, 1983).

Crude protein

Crude protein (CP) was determined using the conventional Kjeldahl method (VELP Scientifica, DK 20-UDK 139) according to the procedure of AOAC No. 979.09 (AOAC, 1993).

Crude fat

Total lipids (oil) from the oat samples were determined using the Soxhlet method AACC No. 30-20, when 20 g of oat flour was placed in cellulose thimbles fitted into the extractor. The crude fat was extracted with ethyl ether; the obtained mixture was subjected to concentration under vacuum by a rotary evaporator. The extracted fat was weighed and expressed in per cent (%) (AACC, 1983).

Total fibre fractions: CF, NDF, ADF, and ADL

For each sample, Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), and Crude Fibre (CF) were sequentially determined. The CF was determined according to the AOAC method No. 926.09 (AOAC, 1997). One gram of a sample was digested with 100 ml of 1.25% sulphuric acid in a beaker under reflux for 30 min. The solution was then filtered through a sintered glass crucible under vacuum. The residue was then washed with hot distilled water till being neutralised. The washed material was again transferred to a beaker and refluxed for 30 min with 100 ml of 1.25% sodium hydroxide. Digested material was again filtered and washed with hot water until being neutralised. The washed material was

dried at 130°C for 1 hr, cooled in a desiccator, and weighed. The dried residue was ignited for 6 hrs and reweighed. The NDF, ADF, and ADL were determined according to the method described by Van Soest *et al.* (1991). Afterwards, hemicellulose was calculated according to the formula (NDF – ADF), and cellulose with the formula (ADF – ADL) (Rinne *et al.*, 1997).

Mineral content determination

After incineration, mineral composition (Na⁺ and K⁺) was determined using a flame photometer. Calcium (Ca²⁺) and magnesium (Mg²⁺) were determined by complexometric titration. Oat grain phosphorus content was determined by the acidified solution reaction of ammonium molybdate containing ascorbic acid and antimony (Chapman and Pratt, 1978). The phosphate contained in the grain reacted with the solution to form the ammonium molybdiphosphate complex, which turned the solution to a blue colour because of the ascorbic acid effect. The amount of the absorbed light by the solution was measured at 825 nm with an UV-visible spectrophotometer (Jenway 6405 uv/vis spectrometer) (Chapman and Pratt, 1978).

Trace elements, including iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), and nickel (Ni), were analysed by atomic absorption spectrometry (Maurice, 1971) in a flame air-acetylene. The measured absorption was done at a specific wavelength of 248.3 nm to measure the concentration of Fe, Cu, Mn, Zn and Ni in the sample solution.

Carbohydrates

Carbohydrates (CHO) were determined on the basis of the difference of all other basic components (Duchonova *et al.*, 2013), weight (in grams) minus water, protein, fat, ash, and fibre content.

Energy value

The energy value was calculated from the approximate chemical composition data (Duchonova *et al.*, 2013). Energy value (Kcal) was calculated according to the formula:

$$E(\text{Kcal}) = CP \times 4 + CHO \times 4 + fat \times 9$$

The values were expressed in Kcal/100g.

4. Statistical analysis

Data were expressed as the mean values \pm standard deviation (SD) for each measurement. All experiments were carried out using two or three replications. The results were statistically analysed using one-way analysis of variance (ANOVA) by comparing mean values of the 9 cultivars. In case of a significant difference between lines, means were compared by the Duncan multiple range test.

Results and discussion

Chemical composition

Analysis of the newly developed tetraploid oat lines of *A. magna* showed that the mean value for groat protein content ranged from $11.45 \pm 0.44\%$ to $13.92 \pm 1.51\%$ for the lines *A. magna* 2 and *A. magna* 6, respectively, and therefore exceeds that of the tetraploid parent P1-6 ($9.67 \pm 0.64\%$) (Table 1). The results were generally in accordance with previous reports on proteins content in oat groat (Welch, 2012; Saidi *et al.*, 2013).

Regarding fat content, the samples differed substantially: the highest value was detected in the cultivar *A. magna* 4 ($10.15 \pm 0.69\%$), while the lowest value was demonstrated by the line *A. magna* 2 ($3.89 \pm 0.64\%$). This trait was prominent, since 8 lines exceeded the values recorded for the reference accessions P1-1 ($5.07 \pm 0.58\%$) and P1-6 ($5.15 \pm 0.38\%$). The lipid content in these lines was evaluated and promised some interesting applications in cosmetics and biogas production.

The moisture content, the weight of 1000 seeds (TSW), and ash content are as important characters as the protein and fat contents. They can be considered as the primary quality indicators of the grain. In general, differences between the means of the three parameters

were highly significant ($P < 0.0001$), based on the used statistical method of the analysis of variance. Table 1 shows that the mean values of TSW for the developed lines varied between 22.93 ± 0.84 g and 47.52 ± 0.99 g. The TSW of the line *A. magna* 9 exceeds that of its tetraploid parents P1-6 (29.82 ± 1.20 g) and P1-1 (23.19 ± 0.83 g by 17.7 ± 0.21 g to 24133 ± 0116 g, respectively). Therefore, we noticed an improvement of the TSW for most of the assessed lines compared to their tetraploid parents. Concerning moisture content, our values range from 7.85% to 9.84% and are comparable with the reports of Nelson *et al.* (2000). However, high moisture content may affect grain quality during storage and handling of cereal products, and more when moisture is associated with high fat content (Jain and Bal, 1997).

High ash content implies high mineral content. The highest content was registered for *A. magna* 5 ($3.73 \pm 0.15\%$), and the lowest content was shown by *A. magna* 2 ($1.71 \pm 0.48\%$).

Analysis of carbohydrate content revealed that it ranges between 48.99 and 57.86%. We noticed that the contents are broadly similar to the mean levels found in the whole oat grain (Sadiq Butt *et al.*, 2008). This cereal is likely to have the highest energy content, due to its high fat content. The mean energy values of the assessed lines (Table 1) varied between 295.44 ± 3.35 Kcal and 357.36 ± 3.76 Kcal, which is close to that of the tetraploid parent lines and in accordance to a certain extent with what was obtained by Welch (1995).

Variation in energy values between samples may be partially attributable to variations in both protein and fat content, as indicated by a positive correlation with energy for protein (0.97) and fat (0.31) contents in the assessed lines.

Table 1: Chemical composition of the newly domesticated Moroccan tetraploid oat lines of *A. magna*.

Element	<i>A. magna</i> 1	<i>A. magna</i> 2	<i>A. magna</i> 3	<i>A. magna</i> 4	<i>A. magna</i> 5	<i>A. magna</i> 6	<i>A. magna</i> 7	<i>A. magna</i> 8	<i>A. magna</i> 9	P1-1	P1-6	Amlal
Moisture (%)	8.16±0.45	8.6±0.02	7.85±0.15	9.84±0.14	9.14±0.01	8.57±0.1	8.46±0.26	8.12±0.21	8.52±0	8.78±0.13	8.07±0.01	7.9±0.01
Ash (%)	2.77±0.01	1.71±0.48	3.53±0.15	3.64±0.01	3.73±0.15	3.52±0.02	3.56±0.07	3.15±0.08	2.52±0.01	3.13±0.06	3.82±0.13	4.38±0.25
Fat (%)	8.73±0.58	3.89±0.64	7.99±0.6	10.15±0.69	8.87±0.62	5.99±0.59	5.94±0.94	7.97±0.58	5.69±0.59	5.07±0.58	5.15±0.38	7.99±0.4
TSW (g)	35.52±0.58	29.86±2.4	24.01±1.59	38.72±3.16	35.49±4.06	30.94±0.68	32.1±0.68	22.93±0.84	47.52±0.99	23.19±0.83	29.82±1.2	26.49±1.34
Protein (%)	11.78±0.065	11.45±0.44	12.17±0.01	11.8±0.25	11.74±0.19	13.92±1.51	13.11±0.19	12.01±0.07	13.62±1.89	16.5±0.07	9.67±0.64	10.46±0.012
Carbohydrate (%)	50.95±1.42	53.67±1.78	51±1.69	55.35±2.68	54.54±1.53	57.86±2.44	53.38±2.17	48.99±2.83	51.37±3.92	54.37±1.04	56.59±2.32	52.96±3.75
Energy (Kcal/100 g)	329±1.5	295.44±3.35	323.52±1.31	357.36±3.76	344±1.74	338.72±4.17	314.64±2.11	313.06±2.93	307.37±3.2	301.32±5.23	309.08±4.77	320.89±1.37

Micronutrient composition

The mineral composition of oat cultivars is presented in Table 2. All the selected essential elements (K, Ca, Na, P, Mg, Mn, Zn, Cu, Fe, and Ni) were detected in all samples. However, their concentrations were found to be variable among the studied collection but slightly higher than the registered values for P₁₋₁ and P₁₋₆.

As can be noted from Table 2, phosphorus and potassium were predominant among the macro elements (K, Ca, Na, Mg, and P). Phosphorus content varied from 0.26 to 0.36 mg/100 g for the lines *A. magna* 7 and *A. magna* 9, respectively. Potassium ranged from 0.32% to 0.54±0.01% for *A. magna* 1 and *A. magna* 5, respectively, and therefore, potassium content of these later exceeded that of the tetraploid parents P1-1 (0.36±0%) and P1-6 (0.42±0%) by 0.18±0.01% and 0.12±0.01%, respectively. Magnesium content was variable: the highest value was observed in *A. magna* 4 (0.31±0.09%), exceeding that of P1-6 by 0.07±0.02%, and the lowest value was registered in *A. magna* 1 and *A. magna* 3 (0.17±0.02%). All samples had relatively lower amounts of calcium and sodium compared to the other measured minerals (P, K, and Mg).

As for the levels of trace elements, we noticed that minor elements (manganese, zinc, and iron) were present in good amounts in all assessed lines (Table 2). Zn content in the analysed lines ranged from 2.55±0.05% to 5.65±0.05%, exceeding that of the tetraploid parent P1-1 by 1.45±0.35% to 2.55±0.05%, as recorded for *A. magna* 2 and *A. magna* 6 respectively. A narrow range of Mn content was recorded, ranging from 3.85±0.05% to 5.7±0.1%, which slightly exceeded that of P1-1 by 0.4±0.1% for the line *A. magna* 5. In general, according to the obtained results, we can rank the contents of mineral elements in the assessed lines in descending order as follows: Fe > Mn > Zn > Cu > Ni > K > P > Ca > Mg > Na

Major and minor elements might be of nutritional importance, especially in those parts of the world where malnutrition and mineral deficiency are relatively rampant.

Thus, the existence of sufficient quantities of essential minerals in cereal grain in general, and in the studied oat lines in particular, may prove an asset in supplying these elements through their inclusion into daily diets, reasonably enabling consumers to easily meet their daily requirements in such minerals.

Fibre fractions composition

The analysis of the examined components (NDF, ADF, ADL and CF) has shown a considerable variability between the tested lines. The mean ADF values for all lines ranged from 9.82±0.72% in *A. magna* 8 to 35.63±1.14% in *A. magna* 5, and this later exceeded that of both tetraploid parents P1-1 (27.7±0.77%) and P1-6 (12.65±0.93%) by 7.93±0.37% and 22.98±0.21%, respectively (Table 3).

The mean NDF values of the nine samples ranged between 32.9±0.96% in *A. magna* 2 and 44.61±0.07% in *A. magna* 3, which exceeded that of P1-6 (35.61±0.91%) and P1-1 (40.71±0.81%) by 9±0.84% and 3.9±0.74%, respectively (Table 3). The reported values of NDF, ADL, and ADF in the analysed tetraploid oat lines are broadly similar to the reported values of oat hexaploid cultivars and lines (Welch, 1995; Manzali *et al.*, 2014). In accordance with our results, Thompson *et al.* (2000) reported higher contents for previously cited fibre fractions, in particular NDF. Several researchers have reported inverse correlation between lignin content and digestibility (Crosbie *et al.*, 1984; Garleb *et al.*, 1991), and thus the obtained values for ADL suggest that the new domesticated tetraploid lines may show good digestibility.

The means and ranges of values for the studied parameters that further describe the nutrient and fibre composition of different lines, summarised in Tables 1 to 3, have revealed a great potential of the newly developed domesticated tetraploid lines of *A. magna*. These lines were characterised by high protein and fat content, well balanced profile of minerals, and an appropriate fibre composition

Table 2: Mineral composition of the newly domesticated Moroccan tetraploid oat lines of *A. magna*.

Element (mg/100g D.W)	<i>A. magna</i> 1	<i>A. magna</i> 2	<i>A. magna</i> 3	<i>A. magna</i> 4	<i>A. magna</i> 5	<i>A. magna</i> 6	<i>A. magna</i> 7	<i>A. magna</i> 8	<i>A. magna</i> 9	P ₁₋₁	P ₁₋₆	Amlal
P	0.3±0.01	0.34±0.04	0.29±0	0.33±0.01	0.36±0.01	0.34±0.02	0.26±0.05	0.28±0.03	0.36±0.03	0.34±0.01	0.31±0.01	0.34±0
Na	0.09±0	0.07±0	0.09±0	0.09±0	0.11±0	0.13±0	0.08±0	0.1±0	0.19±0.01	0.07±0	0.09±0	0.07±0
K	0.32±0	0.33±0.01	0.37±0	0.46±0.01	0.54±0.01	0.45±0.02	0.34±0.01	0.45±0	0.45±0	0.36±0	0.42±0	0.32±0
Ca	0.22±0	0.22±0.02	0.18±0.02	0.18±0.02	0.22±0.02	0.18±0.02	0.22±0.06	0.14±0.02	0.22±0.06	0.16±0	0.28±0.04	0.32±0.04
Mg	0.17±0.02	0.24±0.05	0.17±0.02	0.31±0.09	0.2±0.01	0.23±0.01	0.22±0.03	0.24±0.02	0.28±0.06	0.24	0.19±0.02	0.24±0.02
Fe	7.15±0.05	9.35±0.15	6.3±0	9.05±0.05	8.45±0.25	6.65±0.05	6.2±0.1	7±0.1	7.75±0.05	7.1±0	8.55±0.15	6.4±0.2
Zn	2.65±0.05	4.55±0.35	2.95±0.05	3.05±0.05	3.35±0.15	5.65±0.05	2.6±0.1	2.55±0.05	2.7±0.1	3.1±0	2.85±0.05	3.1±0.2
Cu	1.25±0.15	1.6±0	1±0.1	0.8±0	0.85±0.05	0.8±0	0.85±0.05	0.9±0	1.05±0.05	0.7±0	0.7±0	0.55±0.05
Mn	3.85±0.05	3.95±0.05	4.3±0.1	4.55±0.15	5.7±0.1	4.15±0.05	5.5±0.3	4.4±0	4.5±0.1	5.3±0	4.45±0.15	4.6±0.1
Ni	0.7±0	0.6±0	0.65±0.05	0.9±0	0.75±0.05	0.6±0	0.9±0	0.9±0	0.6±0	0.6±0	0.8±0	0.55±0.05

Table 3: Content of fibre fractions in the newly domesticated Moroccan tetraploid oat lines of *A. magna*.

Element (%)	<i>A. magna</i> 1	<i>A. magna</i> 2	<i>A. magna</i> 3	<i>A. magna</i> 4	<i>A. magna</i> 5	<i>A. magna</i> 6	<i>A. magna</i> 7	<i>A. magna</i> 8	<i>A. magna</i> 9	P ₁₋₁	P ₁₋₆	Amlal
DM	91.83±0.44	91.4±0.02	92.14±0.15	90.16±0.14	90.86±0.01	91.43±0.1	91.54±0.26	91.88±0.21	91.47±0.03	91.21±0.13	91.93±0.01	92.1±0.01
CF	18.2±0.09	20.74±0.48	18.23±0.08	10.07±0.92	12.85±0.36	10.98±0.82	16.69±0.15	20.49±0.95	18.77±0.87	20.2±2.29	17.68±0.7	17.51±1.11
NDF	39.92±0.67	32.9±0.96	44.61±0.07	40.64±1.63	39.73±0.37	34.98±2.26	36.95±0.09	36.92±2.47	35.37±1.14	40.71±0.81	35.61±0.91	41.78±0.42
ADF	11.23±0.2	19.83±0.73	11.66±1.16	20.74±0.03	35.63±1.14	17.51±1.96	14.82±0.86	9.82±0.72	15.07±0.06	27.7±0.77	12.65±0.93	20±0.85
ADL	7.07±0.63	9.12±1.09	3.48±0.14	11.82±1.85	9.87±1.05	15.77±3.51	3.34±0.5	1.58±0.01	12.52±1.12	7.27±0.44	6.81±0.1	4.14±0.21
Cellulose	32.85±0.03	23.77±2.05	41.13±0.06	28.81±0.23	25.75±2.19	19.21±1.25	33.6±0.59	35.34±2.46	22.84±0.01	33.44±1.25	28.8±0.82	37.64±0.21
Hemicellulose	28.69±0.47	13.07±1.68	32.94±1.08	19.89±1.66	11.84±1.62	17.47±0.3	22.13±0.95	27.09±3.19	19.67±1.2	13±0.04	22.96±1.85	21.78±1.26

Conclusion

Among cereals, oat is characterised by its high nutritional value and its nutrient content. The results of this study show that, due to the recorded high fat and protein contents and lower ADL proportion, flour derived from some of those developed cultivars may appear very promising for the oat milling industry. Furthermore, with a line having a fat content higher than 8%, the economic feedback for biogas and cosmetic industries may be increased through the

selection of more lines with high fat content in groat.

In general, the new developed tetraploid oat lines of *A. magna* have shown a good technological potential and can be of great interest when used to develop oat products for human consumption. The tetraploid species are known to be a good reservoir of useful genes controlling technological parameters, and therefore, hybridisation of the obtained lines with wild accessions of *A. magna* may further improve the nutritive value of the derivative lines, thus adding new value to human health.

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