Pasta-making properties of the new durum wheat variety biensur suitable for the northern mediterranean environment

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PAPER

PASTA-MAKING PROPERTIES OF THE NEW DURUM WHEAT VARIETY *BIENSUR* SUITABLE FOR THE NORTHERN MEDITERRANEAN ENVIRONMENT

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ABSTRACT

Industrial pasta is commonly made from mixtures of semolina from different durum wheat varieties, and there is a very low market presence of mono-varietal pasta from local, short supply chains. In this work, dough rheological properties and pasta quality traits of the new durum wheat cv. *Biensur*, which has a high HMW/LMW-GS ratio, were evaluated with a view to developing short-chain, mono-varietal pasta production in NE Italy. Chemical and sensory analyses on short-cut pasta, *viz.* tubetti, made with semolina from cv. *Biensur* at two drying temperatures revealed that it has good technological characteristics and stability, excellent cooking and sensory properties, and is comparable to the high-quality commercial reference cv. *Aureo*. We conclude that *Biensur* provides farmers and traders with new market opportunities and offers improvements to the environmental and economic sustainability of the durum wheat chain.

Keywords: mono-varietal pasta, short-chain production, pasta texture, HMW and LMW GS, gliadins, technological characteristics

1. INTRODUCTION

Durum wheat (*Triticum durum* Desf.) is one of the most important crops worldwide with an average annual production of 32.6 million tons (MMT), and is the most widely grown crop in the Mediterranean area with an annual production of about 18 MMT (INTERNATIONAL GRAIN COUNCIL, 2015). Italy is a major producer of durum wheat in the Mediterranean, with an average production of about 4.0 MMT/year, about 67% of which is grown in the south of Italy and used mainly for pasta production (D'EGIDIO, 2007). Pasta is made from the kneaded dough of semolina flour and water, which is shaped by a press and stabilised by drying. The pasta-making industry generally uses mixtures of different durum wheat varieties as blending yields semolina with high technological properties. As a consequence, there is very little mono-varietal pasta currently on the market, therefore it would be worthwhile studying the effects of individual cultivars on pasta quality (PADALINO *et al.*, 2014).

Protein content and gluten characteristics are the main factors influencing pasta quality (SISSONS *et al.*, 2005; CUBADDA *et al.*, 2007), but their relative importance depends on many factors, including genotype, and environmental and processing conditions, such as drying temperature (D'EGIDIO *et al.*, 1990; NOVARO *et al.*, 1993). The performance of durum wheat in pasta making is related, in particular, to the storage proteins of grains, i.e., glutenins and gliadins, which influence dough strength, extensibility and stability (SISSONS, 2008). Glutenins are large aggregates of sub-units of either low molecular weight (LMW; 31–51 kDa) or high molecular weight (HMW; 80-140 kDa) joined by disulphide bonds (VARZAKAS *et al.*, 2014). Gliadins are alcohol-soluble proteins, which fall into four groups, ω, γ and α/β, based on their electrophoretic mobility and molecular weight (45-25 kDa). Glutenins are mainly polymeric proteins responsible for dough elasticity, whereas gliadins are monomeric and determine characteristics related to extensibility.

Aside from the amounts of proteins and types of gluten proteins, the glutenin to gliadin and the HMW-GS to LMW-GS ratios are also directly related to the balance between dough strength and extensibility (SAMAAN *et al.*, 2006; SISSONS, 2008).

Drying temperature, one of the most important factors in the pasta production process, gives rise to highly aggregated proteins that are cross-linked via covalent bonds and disulphide bonds. A higher drying temperature intensifies polymerisation of the proteins into a protein network, which entraps the starch granules thereby preventing starch leaching during cooking and increasing the pasta's sensory properties and cooking quality (ZWEIFEL *et al.*, 2003; PADALINO *et al.*, 2016).

In recent years, the environmental impact of the entire pasta production cycle, from the cropping system in the field to semolina production techniques and packaging, has been reviewed (BEVILACQUA *et al.*, 2007). Moreover, under a recent Italian decree (LEGISLATIVE DECREE, 2017), it is now obligatory to declare the origin of the durum wheat grains used in pasta production.

In light of this, an advantageous strategy would be to promote local, short food supply chains in order to improve environmental and economic sustainability. In this regard, a recent study assessed the new cv. *Biensur* and found it offered a suitable combination of high grain yield [7.31 t/ha, 132% higher than the Italian mean (3.15 t/ha) and 37% higher than the Veneto regional mean (5.32 t/ha) (source: ISTAT, averages of the 12-year period 2006-2017)] and high quality semolina when grown under sustainable agronomic management on the edge of the cultivation area of this species in the Mediterranean (VISIOLI *et al.*, 2018).

The aims of this research, therefore, were: a) to evaluate the dough rheological properties and the quality of the pasta obtained from *Triticum durum* cv. *Biensur* cultivated in

Northern Italy with a view to its possible use in the production of mono-varietal pasta; b) to evaluate the effects on pasta quality of two different drying temperatures during industrial processing. Comparative analyses were made against a high-quality standard represented by cv. *Aureo*.

2. MATERIALS AND METHODS

2.1. Field experiment and grain production

A field experiment was carried out in a sandy loam soil at the Miana Serraglia farm (Mira, Venice, Italy), located close to the Venetian Lagoon, during the 2012-2013 growing season. The durum wheat cv. *Biensur* (Apsovsementi, Voghera, Italy) was grown in a 13.6 ha field. In accordance with local recommendations, 215 kg/ha of nitrogen fertilizer was applied: 200 kg N/ha to the soil as ammonium nitrate and 15 kg N/ha (UAN, urea-ammonium-nitrate) by foliar spraying at the flowering stage. The wheat was sown late in October and harvested early in July. Grain samples of 100 kg were collected to carry out dough tests and manufacture the pasta.

2.2. Gluten protein quantification and chemical composition

Grains of the cv. *Biensur* (*Triticum durum* Desf.) were ground in an experimental laboratory mill (Buhler MLU202 roller mill; Braunschweig, Germany) at the Scientific Technology Park of the Molise Region (Campobasso, Italy) in order to obtain fine semolina with a particle size similar to that of the reference control (200 to 350 μm). The reference control was a high-quality commercial semolina (cv. *Aureo*) used in industrial, mono-varietal pasta production. Protein, starch, fat, total fibre and ash contents were quantified in the semolina samples.

Total protein content was quantified by the Kjeldahl 2001.11 method (AOAC, 2000). In addition, relative quantification of the gliadin and the high-molecular-weight (HMW) and low-molecular-weight (LMW) glutenin (GS) fractions in the semolina of both *Biensur* and *Aureo* was carried out using the protein sequential extraction procedure (VISIOLI *et al.*, 2016) followed by quantification by Bradford assay (BRADFORD, 1976). Three technical replicates were performed for each variety. SDS-PAGE was performed on a Mini-PROTEAN Tetra Cell (Bio-Rad) on 8%, 12% and 15% acrylamide gel for the HMW-GS, LMW-GS and gliadin fractions, respectively, as previously described (VISIOLI *et al.*, 2016). Following gel staining and image acquisition, protein molecular weights (MW) were identified and relative quantification of the gliadin, LMW-GS and HMW-GS in each gel was carried out using the IMAGE lab 4.5.1 (Bio-Rad) software.

The total starch content in the semolina samples was determined according to the 996.11 method (AOAC, 2000), while the fat content was estimated according to the 2003.05 method (AOAC, 2000).

Total fibre content was measured according to the official 991.43 method (AOAC, 2000), and ash content according to the 942.05 method (AOAC, 2000). Chemical analyses were performed in triplicate and the results expressed on a dry matter basis.

Short-cut pasta (*tubetti*) made from both the *Biensur* and reference (*Aureo*) semolina samples (Fig. 1) was processed using a pilot system at the Pavan-Map Impianti factory (Galliera Veneta, Padua, Italy). Briefly, pasta samples were prepared in accordance with Italian legislation (PRESIDENTIAL DECREE n°187, 2001) by mixing water and semolina to form a dough with a 30% moisture content. The dough was driven through a vacuum system then extruded to mould the pasta. Samples of *Biensur* and *Aureo* pasta were dried at two different temperatures, low (maximum temperature 60°C, for 9 h) or high (maximum temperature 85°C, for 5 h), to obtain a final moisture content of 11% DW. The pasta samples from the two wheat varieties dried at the low and high temperatures are henceforth referred to as Biensur LT, Biensur HT, Aureo LT and Aureo HT.

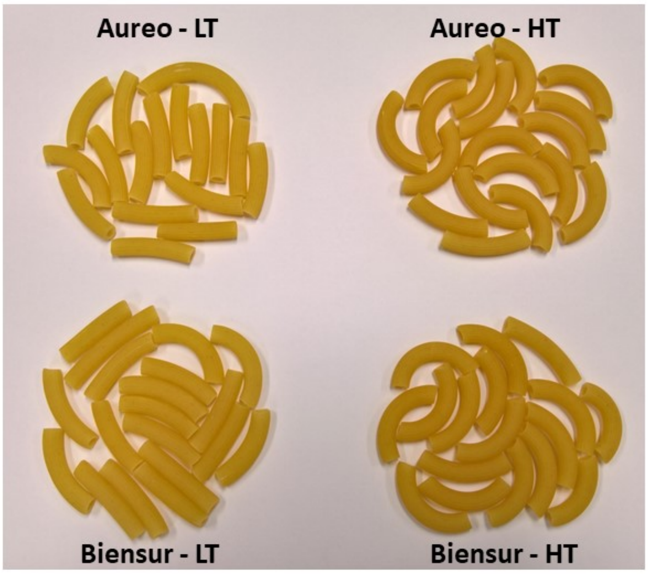


Figure 1. Appearance of the "Tubetti" pasta made from mono-varietal semolina of cv. *Biensur* compared with the reference cv. *Aureo* at two drying temperatures, 60°C for 9 h (LT) or 85°C for 5 h (HT).

2.3. Farinographic evaluation

The properties of the semolina samples were measured with a farinograph (T6, Promylograph, Max Egger, Austria) according to the approved 54-21 method (AACC, 2000). Farinograph tests allowed us to determine: (i) the water absorption (g water per 100 g of semolina) required to reach a dough consistency of 500 PU (promylograph units); (ii) dough stability, defined as the length of time the dough maintains its maximum consistency; (iii) dough weakening, defined as the reduction in dough consistency (as PU) after 20 minutes of mixing. The analyses were performed in triplicate.

2.4. Cooking properties

2.4.1 Determination of optimal cooking time

Pasta samples (50 g) were cooked in deionised boiling water (500 mL). Optimal cooking time (OCT), defined as "al dente", was determined by pressing the pasta between two glass slides at different times during cooking and observing the time it took the starchy white core of the pasta to disappear (ABÉCASSIS *et al.*, 1994).

2.4.2 Cooking loss and water absorption

The pasta samples were drained immediately at the OCT to halt the cooking process. Cooking loss was defined as the amount of solids lost in the cooking water (D'EGIDIO *et al*., 1990). In brief, the cooking water was collected in a beaker, placed in an air oven at 110°C and evaporated until dry. Cooking loss was the weight of the residue expressed as a percentage of the initial weight of the pasta (g solids per 100 g of dry pasta). Water absorption was measured as the increase in the weight of the pasta after cooking and expressed as a percentage of the weight of the uncooked pasta. Cooking losses and water absorption were determined with 3 individual measurements (replicates).

2.4.3 Texture analyses and colour determination

Pasta firmness, *viz.* the resistance to a bite with the incisors through the cooked pasta, and stickiness, i.e., the material adhering to the surface of the cooked pasta, were determined using a TA.XT plus Texture Analyser (Stable Micro Systems, UK) equipped with a 5 kg load cell. The firmness test was performed according to the AACC 16-50 method. A single *tubetto* (12 mm thick) was oriented perpendicularly to a knife probe, cut, then compressed at a speed of 0.5 mm/s. Firmness was measured as the maximum peak force curve (N) required to compress the pasta sample.
For the stickiness test, the pasta was oriented perpendicularly, as described above, to a rectangular probe. Excess water was removed before testing. The probe applied a compression force to the pasta sample (1 kg), was held in contact for 2 seconds then withdrawn at the same speed as above (0.5 mm/s). Stickiness was measured as the maximum peak force curve (g/s) required to withdraw the probe from the surface of the sample. The average value of five replicates was reported for each test.
The colour of cooked pasta was determined using a reflectance colorimeter (Minolta®, CR300, Japan) following the CIE-*L*a*b** colour system, where the L* value (brightness) ranges from black (0) to white (100), the chroma *a** value ranges from green (-60) to red (+60), and the chroma *b** value ranges from blue (-60) to yellow (+60) (MINOLTA, 1993). Each colour data represents the mean of three measurements on different pasta samples.

2.4.4 Sensory evaluation of pasta

To assess acceptability of the pasta made from cv. *Biensur*, a sensory evaluation was carried out by 15 panel members (9 women, 6 men; ages ranging from 22 to 40 years) with experience in general food evaluation. The four pasta samples (*Biensur* HT and LT, and *Aureo* HT and LT) were cooked "al dente" without the addition of salt, drained and kept warm until serving in randomised order on plastic plates labelled with random 2-digit codes. Panellists were asked to evaluate colour, flavour and texture properties (firmness, stickiness) on a five-point scale from 1, low intensity, to 5, high intensity. They were also asked to score the overall quality of the product based on these same attributes using the same five-point scale. The attribute scores for each sample and panel member were subjected to a one-way analysis of variance (ANOVA) to obtain mean sensory scores for each of the 15 panel members.

2.5. Statistical analysis

Statistical analysis of the data was performed with the Statgraphics Centurion XIV software (StatPoint Technologies, Inc., Warrenton, VA, USA) and the results compared by one-way ANOVA. Significant differences between treatments were determined by Tukey's test.

3. RESULTS AND DISCUSSION

3.1. Chemical composition of the semolina and rheological properties of the dough

Table 1 shows a comparison of the compositions of the refined semolina from cv. *Biensur* and the commercial high-quality semolina from cv. *Aureo*, which is already used in Italy to produce the mono-varietal pasta Voiello® (Naples, Italy). Although *Biensur* had a lower protein content (138.8 *vs*. 146.8 mg/g DW), the levels were high in both compared with the minimum levels (105 mg/g DW) required by Italian legislation (Presidential decree n° 187, 2001) and were commercially acceptable. In pasta making, the quantity and quality of wheat storage proteins is important in determining essential dough properties, such as stability and firmness (SAMAAN *et al*., 2006; SISSONS, 2008).

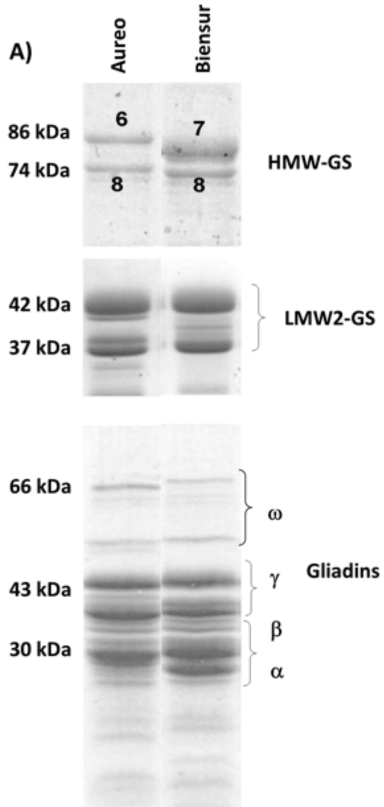
Table 1. Chemical and gluten protein composition of semolina samples (mg/g of DW) of cv. *Biensur* compared with the commercial reference cv. *Aureo*.

	Total protein[1]	Gli[2]	HMW-GS[2]	LMW-GS[2]	GS/Gli	HMW/LMW-GS	Moisture	Total fibre	Starch	Ash	Lipids
Biensur	138.8[b]	64[a]	12[a]	24[b]	0.56[b]	0.51[a]	14.11[a]	3.17[a]	74.9[a]	0.79[a]	1.73[a]
Aureo	146.8[a]	58[b]	12[a]	30[a]	0.72[a]	0.42[b]	13.65[a]	3.10[a]	73.2[b]	0.80[a]	1.80[a]

Within each parameter, different letters indicate significant differences (Tukey test, $P \leq 0.05$; n = 5).
[1]Kjeldahl method.
[2]Percentage of total gluten proteins, which were: *Biensur* 22.3±0.33, *Aureo* 24.2±0.06 mg/g semolina.

Biensur has been recently recognised as a high-yielding variety, with higher GS/gliadin and HMW/LMW-GS ratios than other Italian cultivars, and an optimal allelic GS configuration (Bx7 and By8) (Fig. 2), suggesting that high productivity can be combined with good quality through suitable breeding programmes (VISIOLI *et al*., 2018).
The HMW-GS configuration is indicated as Bx7 and By8 for cv. *Biensur* and as Bx6 and By8 for cv. *Aureo*. The LMW-GS pattern in the two varieties is indicated as the LMW-2 protein group, which, in the modern cultivars, replaced the low quality LMW-1 protein configuration (D'OVIDIO and MASCI, 2004). The gliadin fractions $\omega, \gamma, \alpha/\beta$ were indicated according to the molecular weight range in relation to molecular weight markers.
Besides protein content, the types of gluten proteins, and the ratios between glutenins and gliadins, and between HMW-GS and LMW-GS are known to be directly related to the balance between dough strength and extensibility (SAMAAN *et al*., 2006; SISSONS, 2008). *Biensur* semolina had a lower total gluten protein content than *Aureo* (22.3±0.33 *vs*. 24.2±0.06 mg/g flour; $P \leq 0.05$), a lower percentage of the LMW-GS fraction and a higher gliadin fraction with respect to total gluten proteins (Table 1). However, our results confirm *Biensur* as having a higher HMW/LMW-GS ratio than *Aureo* (0.51 *vs*. 0.42) and an acceptable GS/Gli ratio (0.56), which are important parameters for gluten technological quality (Table 1). We also found differences between the varieties in the abundances of the HMW-GS x-type and y-type sub-units and the most common LMW-GS (42 and 37 kDa), as

previously reported (VISIOLI *et al.*, 2018). *Biensur* had higher proportions of x-type HMW sub-units and 37 kDa LMW-GS than *Aureo* (Fig. 2). Regarding the gliadin fractions, *Biensur* had a greater amount of α/β gliadins (rich in Cys residues) and a lower fraction of ω-gliadins (poor in Cys residues) than *Aureo,* although they had similar amounts of γ-gliadins, which are very rich in Cys residues. Gluten composition and the relative amounts of sub-units are known to contribute to the technological quality of semolina. *Biensur* also had more starch than *Aureo* (749 *vs*. 732 mg/g DW).



B)

	Gliadins			HMW-GS		LMW-GS	
	ω	γ	α/β	x-type	y-type	42 kDa	37 kDa
Aureo	18.8	37.5	43.7	47.3	52.7	73.5	26.5
Biensur	14.7	36.8	48.5	65.7	34.3	67.3	32.7

Figure 2. SDS-PAGE of HMW-GS, LMW-GS and gliadin sub-units extracted from cv. *Aureo* and *Biensur* semolina (A), and their relative abundances (%) obtained by densitometric analysis (B).

We compared samples of *Biensur* and *Aureo* for dough stability and weakening using a farinograph (Table 2) and found the two varieties to have very similar levels of dough stability, while cv. *Aureo* had better indices of dough weakening and water absorption. Although there were no significant differences between the two varieties in dough stability, after 20 minutes of mixing the *Biensur* dough was found to have a higher dough weakening index, meaning a lower tolerance to mechanical mixing.

Table 2. Farinographic indices (means; n = 3) of dough samples of cv. *Biensur* compared with the commercial reference cv. *Aureo*.

	Water absorption (%)	Dough stability (min)	Dough weakening (PU)
Biensur	52.4^{b}	11.5^{a}	35^{a}
Aureo	55.7^{a}	12.0^{a}	25^{b}

Within each parameter, different letters indicate significant differences (Tukey test, $P \leq 0.05$).

3.2. Physical and sensory characteristics of pasta

We looked at the most important quality indicators to properly compare the pasta obtained from the two varieties. Good quality pasta should meet the criteria of high water absorption, low cooking losses and good texture (CUBADDA *et al.*, 2007; BRUNEEL *et al.*, 2010). After cooking, it should be firm enough to resist surface disintegration and have no excessive stickiness.
The data regarding water absorption, cooking loss, firmness and stickiness of all pasta samples at the optimal cooking time are similar for the two durum wheat varieties (Table 3).

Table 3. Cooking properties [optimal cooking time (OCT), water absorption and cooking loss (n = 3)], firmness and stickiness measured by Texture Analyzer (n = 3), and colour indices of pasta samples of cv. *Biensur* compared with the commercial reference cv. *Aureo* dried at different temperatures (LT = 60°C for 9 h; HT = 85°C for 5 h).

	Cooking quality					Colour		
	OCT (min.sec)	Water absorption (%)	Cooking loss (%)	Firmness (N)	Stickiness (g/s)	L*	a*	b*
Biensur HT	9.0	111.90^{a}	2.96^{a}	5.70^{a}	81.6^{a}	57.10^{a}	-1.15^{a}	17.6^{a}
Biensur LT	8.3	111.58^{a}	3.00^{a}	5.65^{a}	82.3^{a}	58.67^{a}	-2.4^{b}	18.0^{a}
Aureo HT	9.0	111.90^{a}	2.96^{a}	5.80^{a}	80.1^{a}	60.57^{a}	-1.9^{ab}	18.4^{a}
Aureo LT	8.3	111.70^{a}	2.97^{a}	5.71^{a}	81.1^{a}	59.40^{a}	-2.41^{b}	17.7^{a}

Within the same parameter, values with the same letter are not significantly different from each other (Tukey test, $P \leq 0.05$).

Analyses of variance for these parameters did not reveal any significant differences between *Biensur* and *Aureo* pasta dried at the same temperature. This provides confirmation that *Biensur*, despite having a lower protein content than *Aureo*, has good gluten quality and is therefore suitable for high quality pasta production. There were also no significant differences between *Biensur* and *Aureo* pasta dried at different temperatures: in all cases the gluten network seems to provide similar shear resistance and equally restricts starch swelling and leaching. This was probably because the gluten quality of cv. *Biensur* has a better HMW-GS configuration (Bx7-By8) and a higher HMW/LMW-GS ratio than *Aureo*, as well as an acceptable GS/Gli ratio, as previously described (Table 1), which plays an important role in the formation of a strong protein network.
Moreover, we consider that the difference between the LT and HT drying temperatures is not so great as to affect the pasta structure. Indeed, only large increases in drying temperature would modify the pasta structure, with positive effects on the sensory

properties and cooking quality (PASINI *et al.*, 2015; PADALINO *et al.*, 2016), especially when total protein content is low (CUBADDA *et al.*, 2007). High drying temperatures, particularly >70 °C, are also known to lower protein digestibility (PETITOT *et al.*, 2009; STUKNYTE *et al.*, 2014).
In this trial, we detected slight improvements to pasta firmness and lower cooking losses in both varieties dried at the high temperature compared with the lower (85 °C *vs*. 60 °C), but they were not statistically significant. However, *Biensur* was slightly stickier than *Aureo*, probably due to its higher starch content, and the higher drying temperature seems to be effective in slightly reducing this effect.
The sensory properties of the cooked pasta, such as colour, flavour and texture (firmness and stickiness), play an essential role in determining consumer acceptability of the product, especially in traditional pasta-consuming countries (D'EGIDIO and NARDI, 1998).
Sensory evaluation of pasta made from the cv. *Biensur* and from the reference cv. *Aureo* showed there to be no significant differences between them for any of the parameters tested (Table 4), which is consistent with the texture analysis (Table 3) and hence shows good overall acceptability.
Texture and flavour appear to play a major role in sensory evaluation, but the initial impact is also highly influenced by colour. Similar brightness (L^*) and b^* values were observed for all cooked pasta samples. Differences between the HT and LT pasta samples were found, as indicated by a significant increase in the a^* value (redness) under the higher drying temperature (Table 3), which is known to be correlated with non-enzymatic browning (ANESE *et al.*, 1999).
Although it is difficult to compare results from different studies because of the different drying cycles and raw materials used, our results are in accordance with those of other authors who investigated the effects of drying temperatures and the role of gluten content in pasta quality (CUBADDA *et al.*, 2007; PADALINO *et al.*, 2016).

Table 4. Summary of the sensory properties (n = 15) of pasta samples of cv. *Biensur* compared with the commercial reference cv. *Aureo* dried at different temperatures (LT = 60°C for 9 h; HT = 85°C for 5 h).

	Colour	Flavour	Firmness	Stickiness	Overall acceptability
Biensur HT	2.7[a]	3.5[a]	4.4[a]	1.7[a]	3.0[a]
Biensur LT	2.5[a]	3.5[a]	4.1[a]	1.9[a]	2.8[a]
Aureo HT	3.0[a]	3.8[a]	4.8[a]	1.5[a]	3.5[a]
Aureo LT	2.6[a]	3.7[a]	4.5[a]	1.4[a]	3.4[a]

Each attribute was assessed on a 5-point scale from 1, low intensity, to 5, high intensity

4. CONCLUSIONS

To cultivate durum wheat in the northern latitudes of the Mediterranean region, greater attention needs to be paid to varietal choice and crop management, particularly nitrogen nutrition and pathogen control, as the climatic conditions are extreme for this species (lower temperatures, higher humidity). Currently, high quality semolina is mainly associated with high-protein cultivars, such as *Aureo*, the reference in our trial, although this variety commonly fails to reach high grain yield targets and may not be economically sustainable for farmers in the potentially high-yield, fertile soils of NE Italy.
One of many wheat cultivars, *Biensur* grown at the extreme northern edge of the Mediterranean region has been recently found to have high yield, appreciable protein

contents and a good gluten sub-unit configuration for pasta making (VISIOLI *et al.*, 2018). We therefore felt there was a need to assess whether the characteristics of this cultivar meet the requirements for producing high-quality pasta from large field cultivations, and whether the drying temperature may mitigate possible weaknesses during processing.
This study suggests that cv. *Biensur* is a good candidate to increase Italy's production of mono-varietal pasta by extending cultivation of it to the more fertile soils of the Po plain, given that the dough has high technological characteristics and the pasta very good sensory properties, comparable to well-established commercial mono-varietal semolinas. The effect of drying temperature (high or low) was minimal, suggesting that the intrinsic characteristics of individual varieties are of central importance, as reported by PADALINO *et al.* (2014), and that the most energy/economically sustainable technological processes can be selected without compromising pasta quality.
There is currently rising market demand for mono-varietal brands, a situation that could stimulate local cultivation of specific durum wheat cultivars to supply short-chain pasta production, thereby offering new market opportunities for farmers and traders, especially in light of the recent Italian decree (LEGISLATIVE DECREE, 2017) requiring the origin of the wheat to be indicated on the label. As all the steps in this project (cultivation, milling, pasta-making) were carried out on a large scale, we are confident that the results will be useful for future development of the chain in NE Italy. Furthermore, having demonstrated that essential sensory (mechanical) properties, such as firmness and stickiness, can be faithfully measured by a texture analyser and panellists' judgements, we are sure that consumers will find the quality of pasta made from cv. *Biensur* acceptable.

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