Pastaria International DE 2/2025 • March

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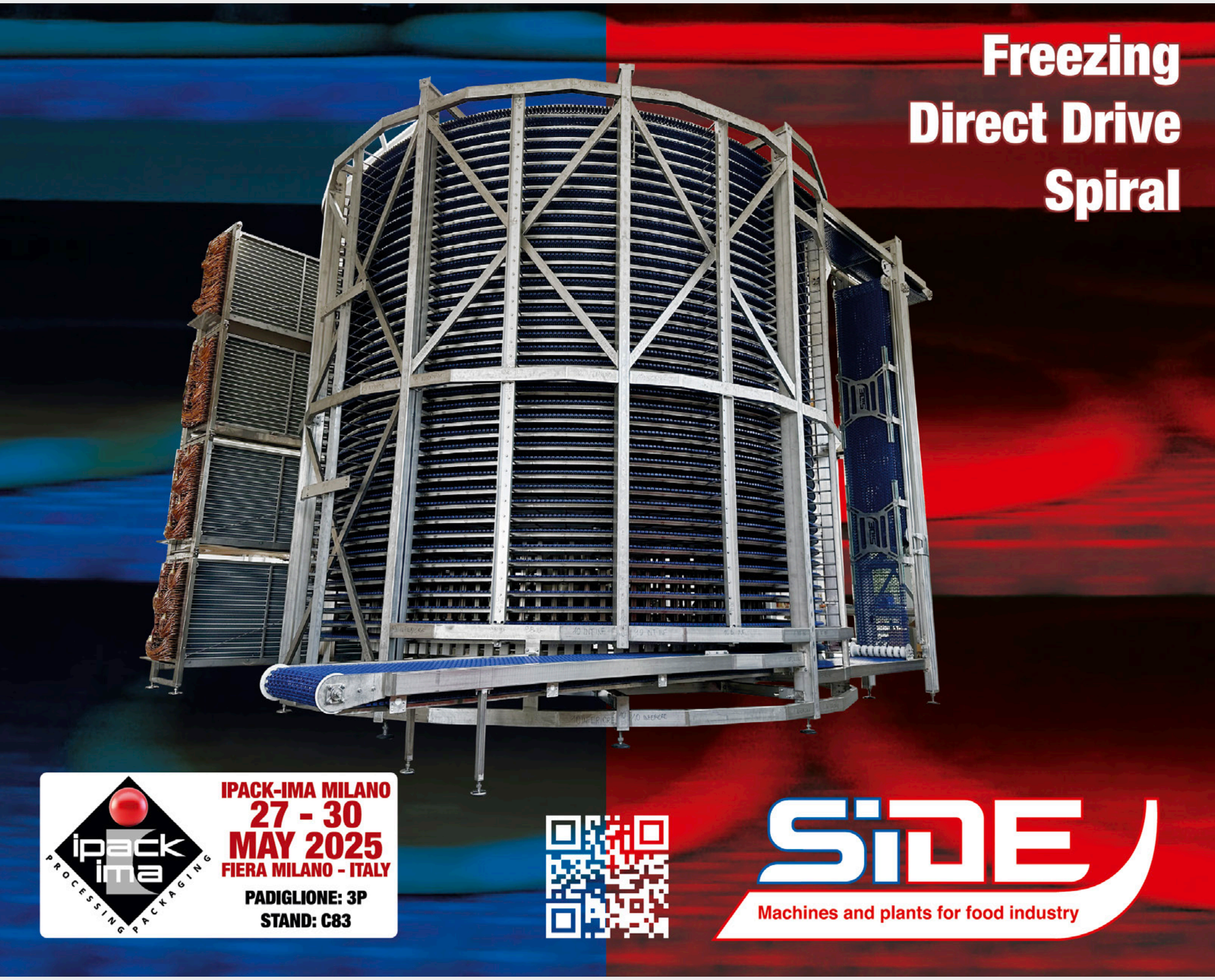

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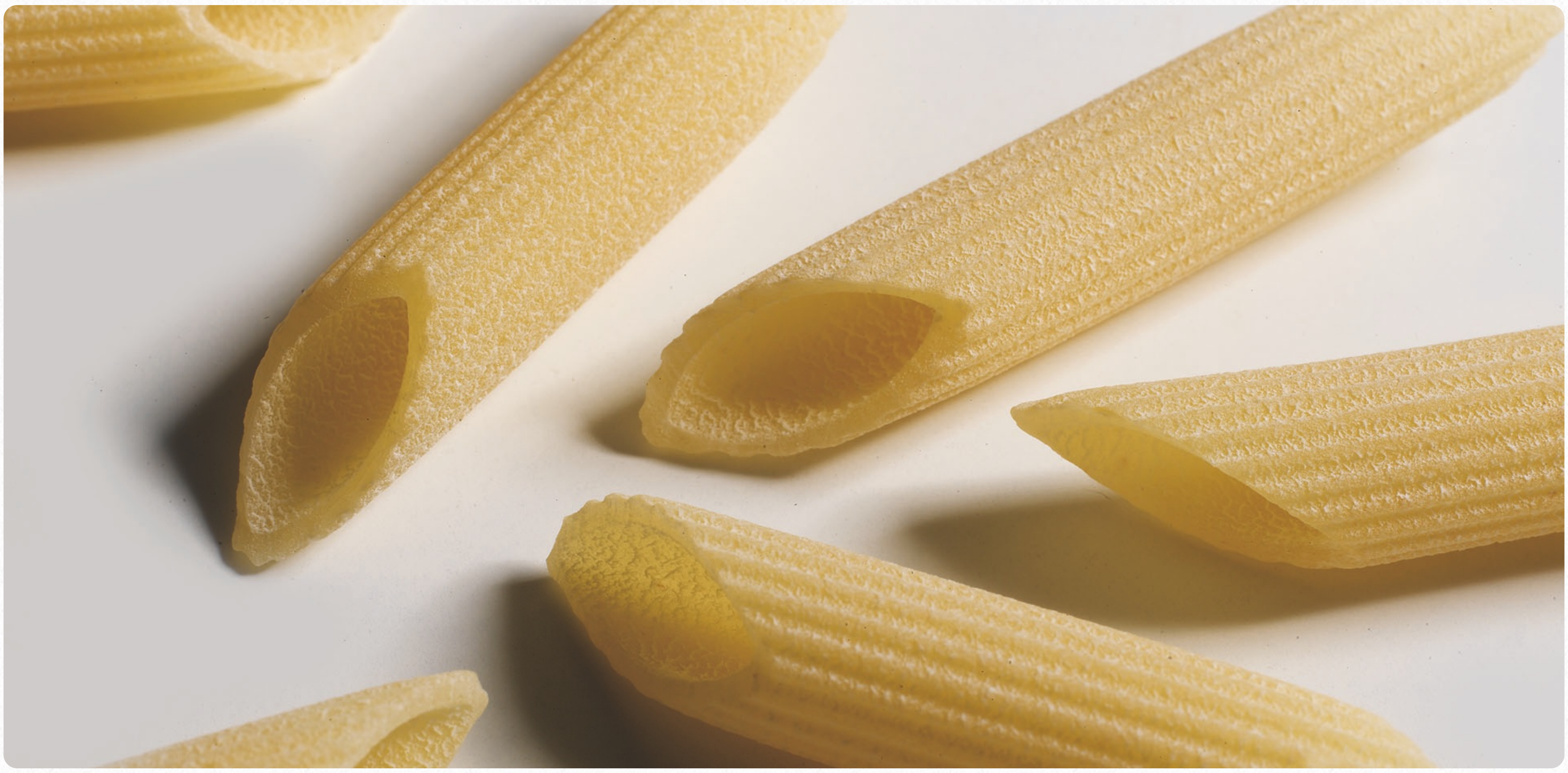

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Insects infesting pasta and considerations on pasta packaging

Pasquale Trematerra
University of Molise
Sara Savoldelli
University of Milan

Due to the structure of pasta factories, the possible use of contaminated grain and the large quantities of dust in the work environment and on the machinery, the pasta can become infested with insects, leading to negative economic and commercial consequences. The pests that exist in the fields, silos and mills can be found in pasta factories where they can multiply. To this end, new Integrated Pest Management (IPM) techniques are being adopted in many Italian pasta factories. Notwithstanding these regulations, attacks by *Lasioderma*, *Plodia*, *Rhyzopertha*, *Sitophilus* and *Stegobium*, ranging from packaging to the consumer's dinner plate are still unresolved, due to issues with the packaging materials used and to negligence on the part of warehouse workers, compounded by the particularly long shelf-life of pasta.

Pasta factories, like any other national or international food industry can be susceptible to infestations by insects (as well as mites, rats and birds), leading to negative economic and commercial consequences (Süss and Locatelli, 1996; Riudavets *et al.*, 2002; Trematerra, 2002, 2004; Barros *et al.*, 2003; Stejskal *et al.*, 2004). In this context, given Italy's importance as a producer and exporter, pasta has been the subject of many surveys and research studies (e.g: Frilli, 1965; Dal Monte, 1985; Süss and Locatelli, 1996, 1997; Trematerra, 2002, 2004, Trematerra and Savoldelli, 2014; Trematerra *et al.*, 2021, 2024).

As is well-known, pasta factories mainly use semolina, a raw material obtained from durum wheat (*Triticum durum* Desf.), which is produced in milling plants where, due to the structure of the buildings and the large quantities of dust always present in the environment, conditions are particularly favourable for the development of various insects.

The most common harmful species are *Ephestia kuehniella* Zeller, *Plodia interpunctella* (Hübner), *Cryptolestes* spp, *Gnathocerus cornutus* (F.), *Lasioderma serricorne* (F.), *Oryzaephilus* spp, *Rhyzopertha dominica* (F.), *Sitophilus* spp., *Stegobium paniceum* (L.), *Tribolium* spp. (Figure 1), which, if already existing in farm warehouses, silos and mills, can be transported to the pasta factories where they find conditions in which to reproduce and multiply. Furthermore, in the pasta factory, high temperatures and environmental humidity may favour the colonisation and development of *Blatta orientalis* L., *Thermobia domestica* (Packard) and *Musca domestica* (L.); in the presence of particularly conspicuous moulds, saprophagous and mycetophagous insects may also be observed, including various Psocoptera, *Typhaea stercorea* (L.) and mites (*Glycyphagus* spp. and *Tyrophagus* spp.) (Trematerra and Gentile, 2008).

In some modern industrial plants, the mill and the pasta factory are contained in a single industrial unit and, if the simplest prevention rules are not observed, it is even easier for the above-mentioned species to travel and infest the processing and packaging departments as well.

Additionally, it is important to realise that during the summer months, some of them can multiply outside the facilities, hidden underneath

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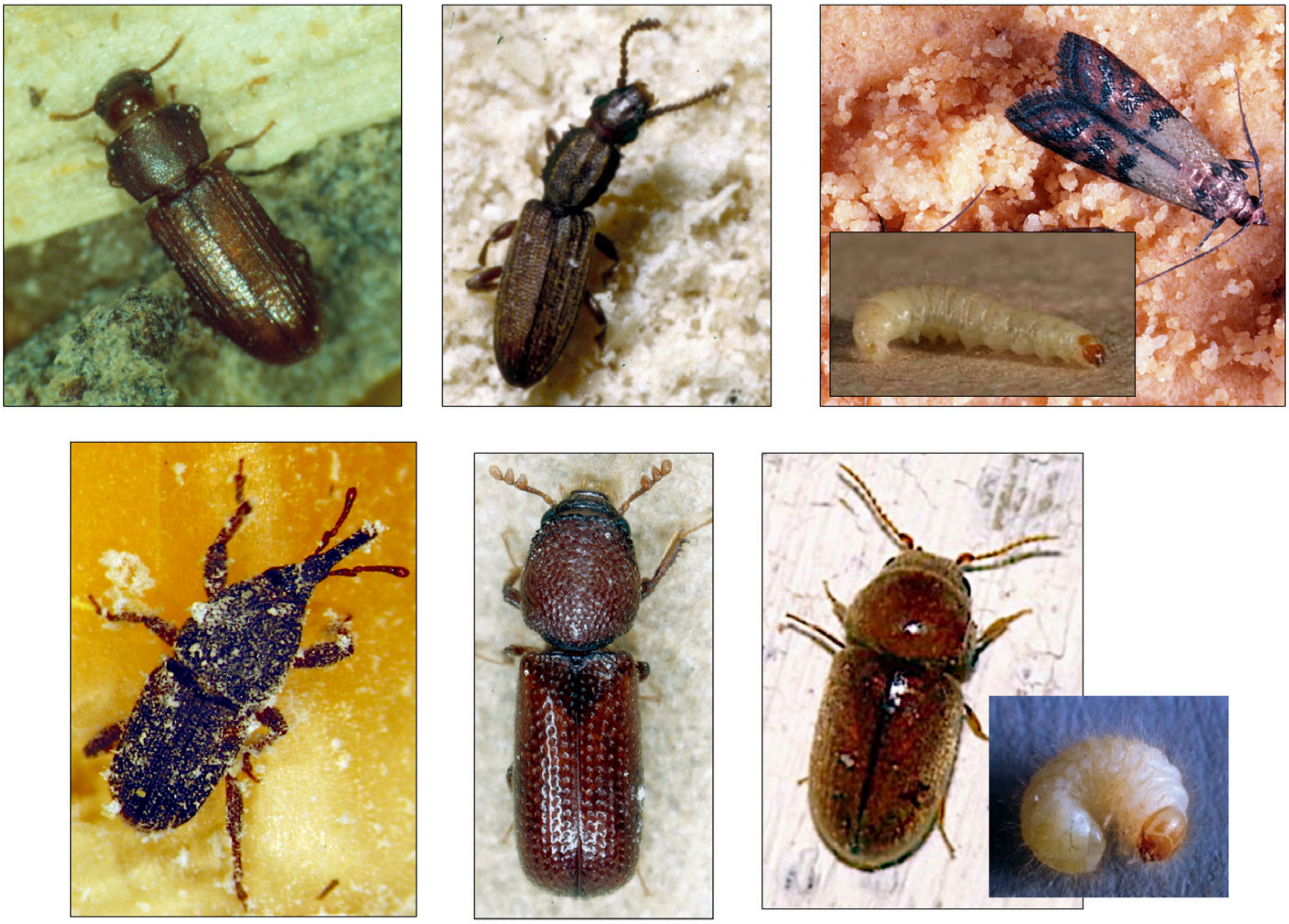
Figure 1 **SOME ADULT INSECTS AND LARVAE INFESTING THE PASTA FACTORY: *TRIBOLIUM*, *ORYZOPHILUS*, *PLODIA* WITH LARVAE, *SITOPHILUS*, *RHYZOPERTHA*, *LASIODERMA* AND LARVAE**

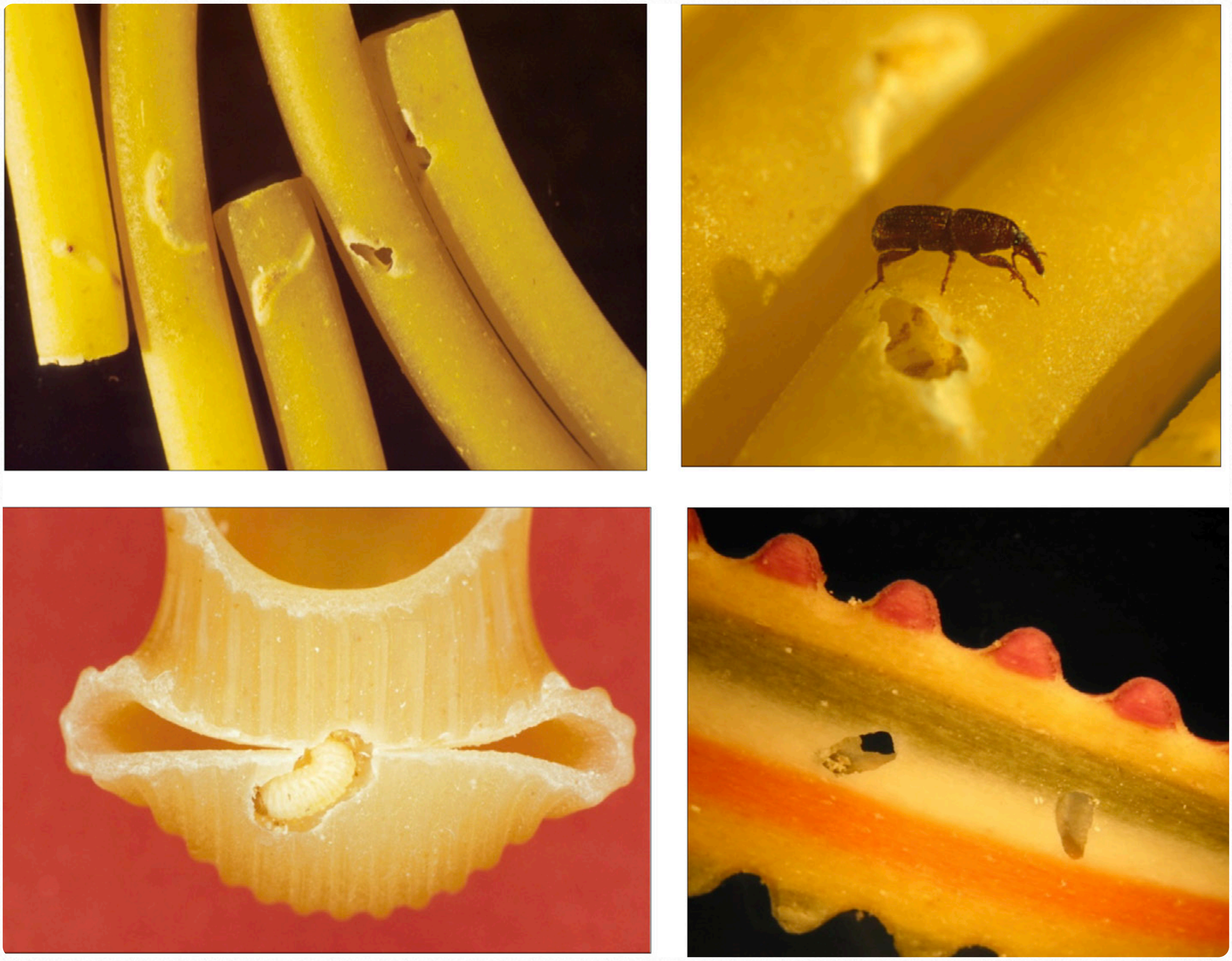


encrustations of semolina or on debris and abandoned waste.

Operationally, the inspection of raw materials is key, even though from the samples of incoming semolina, it is not always easy to detect an infestation in progress, especially in the presence of eggs and larvae in early stages of development hidden inside the grains. The activity of adult insects, such as *Cryptolestes* and *Tribolium*, on the surface of the semolina is easier to identify through simple visual inspections, especially when the raw materials come from heavily infested mills.

It is, however, believed that the pasta production process kills any insects that may be present in the semolina, as verified in the case of *P. interpunctella*, *L. serricorne*, *S. oryzae* and *T. confusum* eggs (Süss and Savoldelli, 2010). They are unable to survive the kneading phases, the pressure and high temperature and only their fragments are found in the finished

Figure 2 PASTAS WITH CLEAR SIGNS OF INSECT ATTACK, A *SITOPHILUS* ADULT AND A LARVA ARE VISIBLE



product, testifying that an infestation was in progress in the raw material (Trematerra *et al.*, 2011). Freshly produced pasta is, therefore, free from ongoing contamination, but is prey to infestation from the moment it leaves the dryer. It is, therefore, important not to overlook points in the plant that might host potential outbreaks of insects, such as conveyor belts, hoppers and electrical devices. Short pasta, in particular, which is stored for long periods before being packaged, may be more susceptible to attack by these undesired guests (Figure 2).

Along the supply chain, infestations also spread during the storage and distribution process. The shelf-life of pasta is particularly long, usually two years. During this period, insects have plenty of time to penetrate the packaging and reproduce for many generations, often taking advantage of the micro-holes drilled to remove air

during the packaging phase, or small tears and sealing failures. This has been confirmed by several – also foreign – Authors, who have observed how adult insects penetrate pasta packages through holes and openings, or tears created by imperfect seals or mechanical damage (Cline, 1978; Locatelli and Süss, 2004; Stejskal *et al.*, 2004; Murata *et al.*, 2008; Parkin, 2008; Riudavets *et al.*, 2007; Germinara *et al.*, 2008; Trematerra, 2009; Athanassiou *et al.*, 2011; Trematerra and Savoldelli, 2014; Stejskal *et al.*, 2017). In order to prevent such problems, it is of paramount importance to understand when, where and how insects invade foodstuffs. In this respect, the sense of smell plays a major role in food infestations in response to odours released by the food. One possible solution, which also involves research, could undoubtedly be the development and use of airtight packaging.
In order to avoid infestations, suggestions have been made at international levels to create packaging aimed at physical and chemical resistance and better sealing (e.g. Hou *et al.*, 2004;

Figure 3 **DETAILS OF PASTA PACKAGES SHOWING POSSIBLE ACCESS ROUTES AND HOLES MADE BY INSECTS**

Riudavets *et al.*, 2007; Germinara *et al.*, 2010; Athanassiou *et al.*, 2011; Mullen *et al.*, 2012; Trematerra and Savoldelli, 2014; Scheff *et al.*, 2018; Schöller *et al.*, 2018; Vrabič Brodnjak *et al.*, 2020).Commercially packaged products can be attacked by *P. interpunctella* (larvae), *R. dominica*, *Sitophilus* spp. (adults), *L. serricorne* and *S. paniceum* (adults) and in some cases the different susceptibility to infestation of

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Figure 4 NEW TOOLS ADOPTED IN THE IMPLEMENTATION OF INTEGRATED PEST MANAGEMENT

the various types of pasta on the market has been studied, with results of practical and operational interest for the food companies involved (Trematerra, 2009; Trematerra and Savoldelli, 2014; Trematerra *et al.*, 2021; Trematerra *et al.*, 2024) (Figure 3).

Pest management should be implemented according to Integrated Pest Management (IPM) criteria, which emphasises the integration of multiple disciplines and control measures, including natural enemies, sanitation, and the correct use of insecticides, in a system designed to prevent pests from reaching harmful levels of infestation. In this respect, in recent years, new methods of protection of the production cycle have been introduced, in a supply chain logic predominantly aimed at prevention. Prevention practices are, in fact, one of the most important and fundamental aspects of IPM. In order to protect pasta, it is essential to implement a series of measures to prevent pests from entering production departments and company warehouses, at the same time, paying special attention to cleaning, getting rid of any processing waste lying on the floor, or any debris building up inside the machinery, or dust settling on the overhead parts of the system.

Standard cleaning procedures must be properly planned and staff must be trained to clean the less accessible areas, which are generally neglected and, therefore, sure sources of infestation. The removal of debris and processing dust guarantees more effective results than any localised chemical treatment. In this regard, it is particularly important in pasta factories to investigate how to reduce processing waste and how to protect the pasta

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conveyor belts that transport unpackaged pasta.

Another aspect of fundamental importance is the monitoring of insects in order to detect their presence in the early stages, thereby preventing the spread of infestations. Lepidoptera and Coleoptera can be effectively monitored with pheromone traps and food traps, together with visual inspections searching for traces on dust. With experience, the severity of the infestation can be assessed by observing the number and frequency of such signs.

Concluding remarks

The systematic use of these methods has improved situations in the pasta factories that have adopted the new IPM methods. The results obtained from a number of case studies have been extended to other Italian pasta factories, reducing the use of toxic insecticides, thanks also to the spread of alternative control techniques, such as the use of heat or pheromones to create mating disruption among lepidopterans (Figure 4).

It is clear to see that only by managing the entire pasta supply chain and production cycle in an integrated manner, from the purchase of raw materials to the distribution and consumption of the finished product, will it be possible to reduce the risk of undesirable insect infestations.

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2

National Pasta Association prepares for the 2025 Annual Meeting

Editorial team

Nora Stabert, President of the National Pasta Association

Consumer trends, innovation and sustainability will be the focus of the 2025 Annual Meeting of the National Pasta Association, which will bring together key players in the industry for three days of meetings and in-depth analyses and insights. Pastaria will follow the event as a media partner.

The annual event of the National Pasta Association (NPA) returns in 2025 with a full programme and a host of networking opportunities for pasta industry professionals. The event will be held from 16 to 18 March at the impressive Omni Amelia Island Resort & Spa, an exclusive location on the Florida coast, so as to combine training and networking with a stimulating but relaxing setting.

A high-level programme

The 2025 Annual Meeting will offer strategic update sessions, with industry experts ready to share market analyses, innovations and regulatory insights.
Among the most eagerly awaited meetings:

- *State of the industry* (17 March, 8:00-8:30 ET): Nora Stabert, President of the National Pasta Association, will provide an overview of the state of the pasta industry and the association's main initiatives;
- *Culinary trends & consumer insights* (17 March, 8:30-9:30 a.m. ET): a session dedicated to emerging trends in the pasta sector: from evolving consumer tastes to new culinary techniques and

A moment from the 2024 Meeting of the National Pasta Association. From left: Randy Gilbertson (Pasta Montana), Jaume Mas (Pastas Gallo), Esteban Abascal (La Moderna), Rodrigo Iglesias (ABIMAPI), and Manoj Venugopal (Virginia Park Foods) innovation in the sphere of health and wellness.

- *Regulatory updates* (18 March, 8:00-8:20 ET): Veronica Colas, NPA's legal advisor, will elucidate the latest regulatory updates relevant to the sector;
- *Economic Updates* (18 March, 8:20-8:45 ET): Chris Kuehl, Managing Director of Armada CL, will present an overview of economic trends and forecasts for the pasta market;
- *The Future of Pasta*: New Ingredients & Market Expansion (18 March, 8:45-9:30 ET): Dr. Fatemeh Zare from the Northern Crop Institute will review the innovations in food safety and new ingredients;
- *Sustainability & Packaging Regulations* (18 March, 10:15-11:00 ET): details and insights on sustainability and packaging regulations with moderator Stefano Giusti (Policarta) and presentations by Lon Pschigoda (Inspired Fiber LLC) and Giovanni Frosini (Ricciarelli).

Networking opportunities and leisure time

In addition to the training contents, the meeting will offer several opportunities to meet colleagues and professionals.

Planned activities include:

- Customised business meetings to establish strategic contacts;
- golf, pickleball and bocce tournaments for informal networking;
- exclusive gala evenings with gourmet dinners and live entertainment.

An unmissable opportunity

The event is an unmissable opportunity for pasta professionals who wish to keep abreast of market trends, meet experts and consolidate their professional relationships.

Registration is now open and early booking of accommodation at Omni Amelia Island Resort & Spa is recommended.

For further details and the full programme, see the website of the National Pasta Association.

Pasta protagonist at Ipack-Ima 2025 with the Pastaria Festival

Press release

Ipack-Ima, the international trade fair specialising in packaging, processing, and innovative materials scheduled to run from 27 to 30 May 2025 at the Fiera Milano Rho conference centre. A new partnership intended to step up interaction with the pasta market will be launched at the show with a not-to-be-missed event for the industry: the Pastaria Festival. Promoted by Pastaria, leading international trade journal for pasta producers, the festival will be held, exceptionally, as part of Ipack-Ima on 28 and 29 May 2025. An event within the event, conceived to offer pasta producers a unique opportunity to keep up with the latest developments, meet up with experts, and explore new products and solutions.

"The market revolving around pasta and grain-based food is part of an extensive supply chain that ranges from food processing to bakery, from packaging machinery to end-of-line, without forgetting automation, robotics, traceability, labelling, and innovative materials, all of which are vital for a mass-market product like pasta – said

Pastaria Festival 2024

Pastaria Festival 2024

CEO Simone Castelli –. Introducing an event with the reach of Pastaria, Ipack-Ima aims to build an even closer, more beneficial connection with an industry that has always played leading role in the fair, with the prospect of developing that role still further".

"The Pastaria Festival was created with the aim of offering pasta producers a unique opportunity for professional development and discussion: this year it will continue its mission within Ipack-Ima, a global event aimed at outstanding participants – announced director and publisher of Pastaria Lorenzo Pini. The pasta industry is evolving rapidly, and our goal is to create an opportunity for meaningful exchange that brings together technology, trade, and expertise to offer new prospects for development. We are excited to bring the Pastaria Festival to Ipack-Ima 2025, launching a partnership that strengthens our commitment to giving voice and value to a key industry by connecting all the main players in the supply chain".

Now at its ninth festival, Pastaria is the leading international event for the pasta industry and offers a line-up of high-profile conferences and meetings facilitated by simultaneous interpretation in Italian and English and enhanced by contributions from universities, businesses, and trade specialists. Focus areas range from technological innovation to sustainability, food safety to the dynamics of the global market, with a view to providing practical tools to take on the challenges of the future.

An opportunity brimming with synergies

As the festival is a key part of IPACK-IMA, it will offer visitors not only an extensive conference programme, but also the chance to explore the most recent technological innovations showcased by exhibitors and engage directly with suppliers of solutions for pasta production and packaging, creating new business synergies. Admission to the Pastaria Festival 2025 is free and open to pasta producers only. A detailed programme of the festival will soon be available at www.pastaria.it

Racking up successes in production, consumption, and technologies

In 2024, the global pasta market reached revenues of €130 billion with a 6.6% annual growth rate forecast by 2028. This growth can be attributed to rising urbanisation, changing lifestyles, and the global spread of cuisines (Asian and Italian, for example) that make extensive use of pasta and pasta-like products and are driving up consumption across the world. On average, 17 million tonnes of pasta are produced and consumed every year. Industry leader in production terms is Italy, with a yearly pasta output of almost four million tonnes, revenues in excess of €8 billion, and exports accounting for 47% of total production. Italy is followed by the United States (two million tonnes produced), then Turkey (almost two million), Egypt (1.2 million), and Brazil (almost 1.2 million).

Some of the qualities of pasta, such as the fact that it is a non-perishable, easily transported food item with a long shelf life, contribute to its commercial success while also having a knock-on effect for the machinery sector aimed at this market niche. The latest surveys on the Italian packaging technology sector aimed specifically at bakery and grain-based food show an industry worth €579 million per year, with exports making up 72%. Broadening the field of observation to include packaging technologies for the food sector in general, the latest analyses forecast a 4.4% growth in the sector in Italy by 2028 (source: IPACK-IMA Observatory, MECS data).


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4

Incorporating malted legumes in the production of fresh egg pasta

Alessio Cimini, Alessandro Poliziani, Lorenzo Morgante e Mauro Moresi
University of Tuscia

This study evaluated the effectiveness of malting three typical Lazio legumes (Purgatorio di Gradoli beans, FPG; Onano lentils, LO; Solco Dritto chickpeas, CSD) to reduce their antinutrient content and use them in the preparation of fresh egg pasta. The fresh pastas were free of the oligosaccharides, which cause flatulence, had a low phytate content (0.6-0.80 g/100 g dry matter, dm), a protein content of approximately 20 g/100 g dm and a glycaemic index *in vitro* between 28% and 38%. Pasta with malted FPG flour showed not only a significantly lower glycaemic index (28%±3%), but also a resistant starch/total starch ratio above the threshold value (14%) set by Regulation (EC) No 432/2012 for labelling foods with the health claim that it improves the postprandial glucose metabolism.

Introduction

Despite the growing interest in legume-based gluten-free foods specifically formulated for coeliac, diabetic and high-cholesterol patients (Abu-Ghannam and Gowen, 2021), the high nutritional profile (Maphosa and Jideani, 2017) and the low environmental impact (Nemecek *et al.*, 2008) of legumes, their per capita consumption does not exceed 21 g/day (Rawal and Navarro, 2019). This is probably due to the long cooking time, the unpleasant taste, the presence of poorly digestible proteins, gastrointestinal problems (de Almeida Costa *et al.*, 2006) and the high antinutrient content (Gebrelibanos *et al.*, 2013).
Among the legume varieties cultivated in Italy, the Purgatorio di Gradoli beans (FPG), Solco Dritto chickpeas (CSD) and Onano lentils (LO), traditionally grown in the province of Viterbo (Di Giovannantonio et al, 2019), were subjected to a malting process (Cimini *et al.*, 2021, 2023, 2024a, 2024b) in order to assess the degree of reduction of the main antinutrients, such as oligosaccharides and phytic acid, responsible for flatulence and metal malabsorption, respectively.
In this study, the aforementioned legumes were subjected to the malting process in a pilot malting machine for the purpose of converting them, once dehulled, into flours that could then be incorporated into fresh egg pastas, according to the diagram shown in Figure 1. The cooking quality and glycaemic index *in vitro* of these pastas were then evaluated.

Materials and methods

Were used in this study Solco Dritto chickpeas (CSD: *Cicer arietinum*), Purgatorio di Gradoli beans (FPG: *Phaseolus vulgaris*) and lentils from Onano (LO: *Lens Culinaris*, syn. *Lens esculenta Moench*), supplied by Il Cerqueto Srl (Acquapendente, Viterbo, Italy). Type 00 soft wheat flour (Molino Profili Giuseppe sas, Viterbo, Italy) with a dough strength (W) of 180-200 (10^{-4} J) nd an alveographic ratio between maximum pressure (P in mm) and extensibility (L in mm)] of 0.5-0.6, was used for the preparation of the reference fresh egg pasta.

Figure 1 DIAGRAM OF THE PRODUCTION PROCESS OF FRESH EGG PASTA WITH TYPE 00 SOFT WHEAT FLOUR OR MALTED AND HULLED LEGUME FLOUR, REVISED BASED ON PREVIOUSLY PUBLISHED STUDIES (CIMINI *ET AL.*, 2021, 2023, 2024A, 2024B)

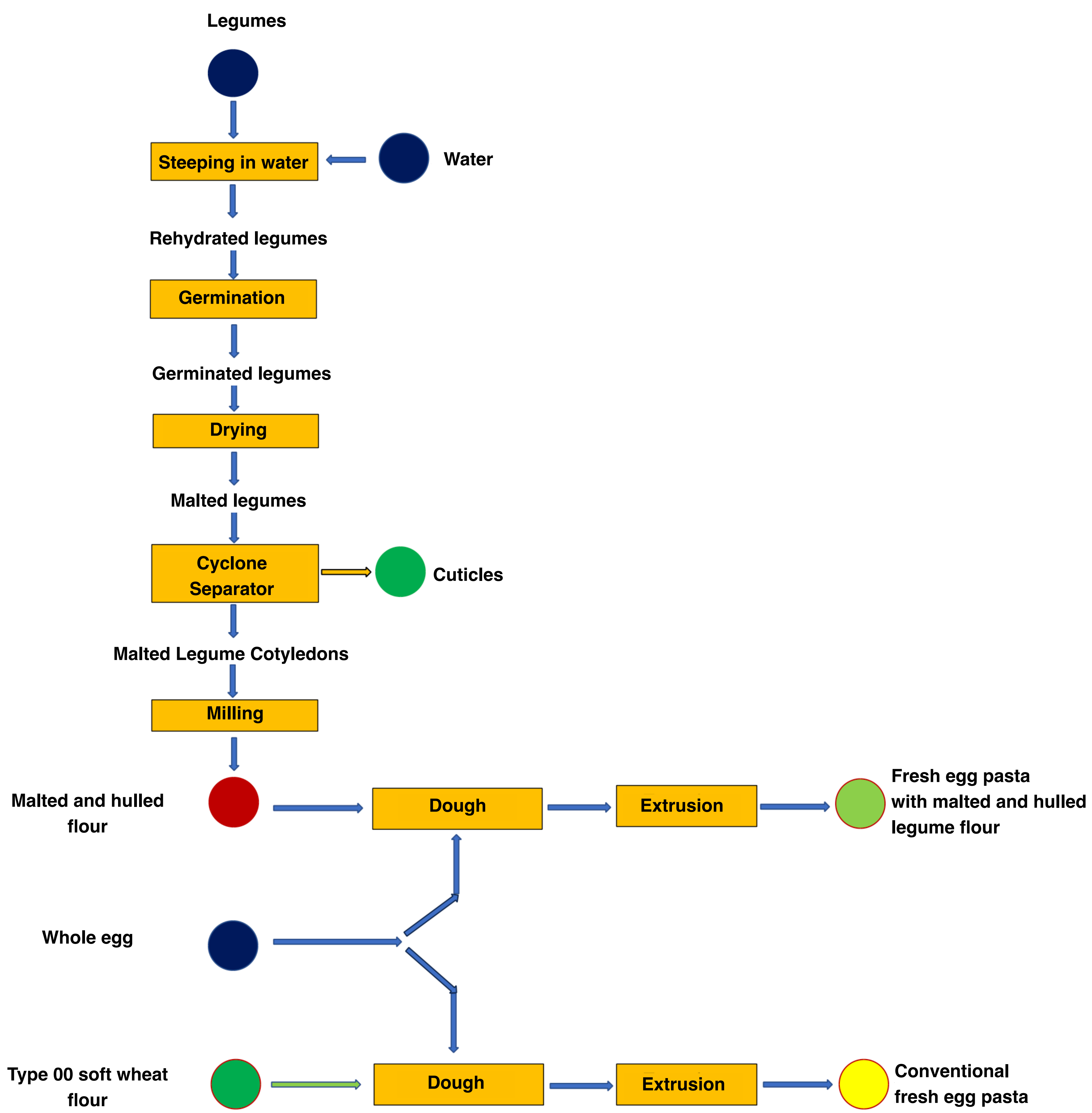


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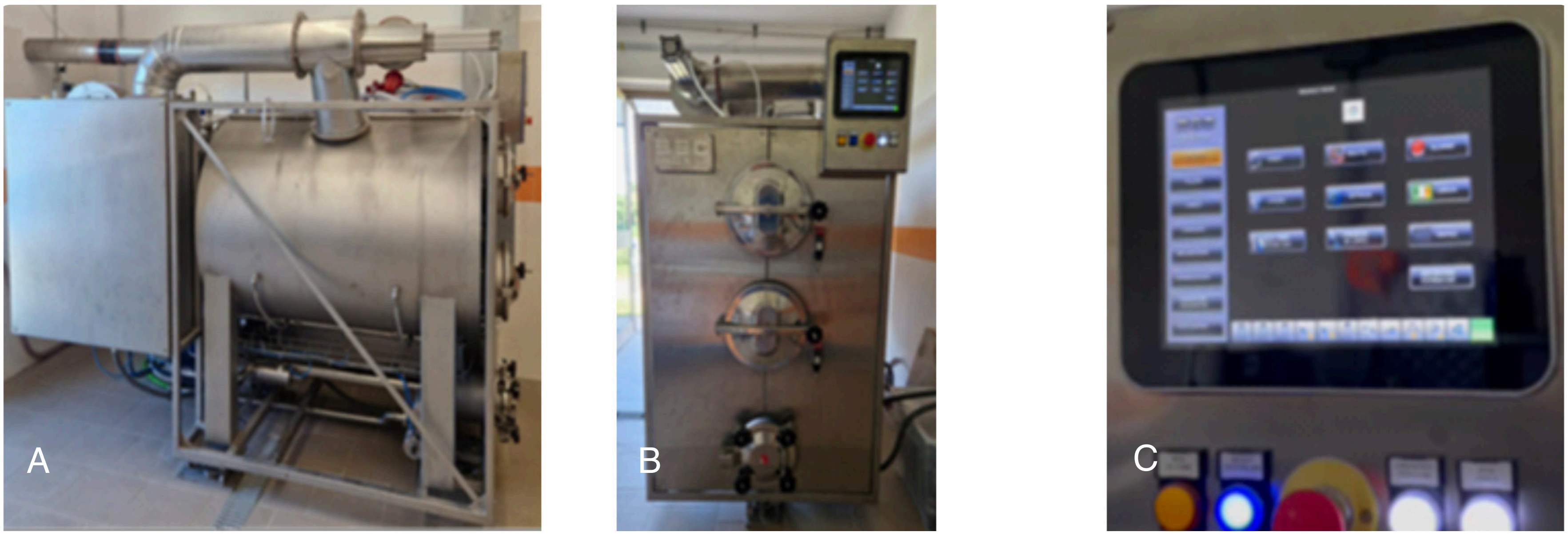
Figure 2 **PHOTOS OF THE PILOT MALTING PLANT USED: (A) SIDE VIEW, (B) FRONT VIEW, (C) CONTROL PANEL**



The malting process of the above-mentioned legumes was conducted in the pilot plant (BBC Srl, Possagno, TV), which has a rated capacity of 100 kg/cycle. The pilot malting machine shown in Figure 2 consists of a drum made of micro-perforated AISI304 stainless steel sheet, a watertight tank with hydraulic circuits for recycling air and water, batteries with 8 kW resistor banks for drying and final roasting, if required, a fan and a centrifugal pump for the air and water circuits, a gear motor for drum rotation and a 4-way valve for clean air interchange complete with position sensor. The malting machine is equipped with a control panel with programmable logic control (PLC) for the fully automatic management of all stages of the malting process, assisted by three weighing cells, two probes for detecting the temperature of the air and water and a probe for detecting the water level in the storage tank. The malting machine can be likened to a star connection of impedances, where the resistive contribution predominates, connected to a neutral supplied with a 380 V voltage at a frequency of 50 Hz.

In this study, the pilot malting plant was loaded with about 40 kg of dry legumes and launched according to the following programmed steps:

1. steeping phase in water at 25°C for 5 h;
2. germination phase at 25°C for 72 h;
3. drying phase at a temperature ≤60°C for 12 h.

The moisture content of the seeds sampled was determined using a Kern DAB 100-3 thermobalance (Kern & Sohn







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GmbH, Balingen, Germany) set at 110 °C for approximately 20 min. The malted seeds thus obtained were subjected to optical calibration to recover just the cotyledons, which were ground using an electric stone mill (Mockmill 200, Wolfgang Mock, Otzberg, Germany), set at level 2 out of 10.

The chemico-physical properties of both original and malted cotyledons were determined in the hulled and split seeds, as described by Cimini *et al.* (2023a, 2024). The following were also analysed: total starch content (TS), resistant starch (RS), α-galactosides and phytic acid, using the required kits from Megazyme Ltd. (Bray, Ireland); crude protein fraction according to Method 992.23 (AOAC, 1998) with a nitrogen conversion factor of 6.25; colour according to the CIELAB colour space using a portable colourimeter model D25-PC2 (Hunterlab, Reston, VA, USA).

Each malted and hulled legume flour, or soft wheat flour, was mixed with whole eggs in a ratio of 63:37 g/g using a PF40E pasta machine (Fimar Spa, Villa Verucchio, Italy), as shown in the diagram in Figure 1. The dough was extruded in the form of tonnarelli about 3 mm thick. These were stored in closed aluminium trays at +4 °C and analysed within a couple of days.

The optimal cooking time (OCT) of conventional fresh egg pasta was determined according to ISO method no. 7304-1 (2016). For the fresh egg pasta made from malted and hulled legume flour, the OCT was determined by six experienced tasters, who evaluated the texture of the cooked pasta every 30 s from 4 min cooking onwards. Fifty grams of each type of egg pasta was cooked in a stainless steel pot with a lid, using a 2 kW induction hob model INDU (Melchioni Spa, Milan, Italy) with a water-to-pasta ratio of 10 L/kg (Cimini *et al.*, 2020).

The cooking process of each fresh pasta sample was extended until its OCT was reached. The cooked pasta was removed from the cooking water by a colander and cooled according to Method 66-50.01 of the American Association of Cereal Chemists (AACC, 2009). Both fractions removed were weighed. The solids dispersed in the cooking water were evaluated after drying at 105°C for 24 h and referred to the mass of fresh pasta used (AACC, 2009), thereby obtaining the so-called cooking loss (CL). The specific water uptake (WU) was determined by comparing the amount of water absorbed by the cooked pasta to the uncooked pasta used. The content of total starch and resistant starch in the cooked pastas was analysed using the corresponding kits (Megazyme Ltd., Bray, Ireland).

The texture of the cooked pasta was

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evaluated using a UTM dynamometer mod. 3342 (Instron Int. Ltd., High Wycombe, UK), equipped with a 1000 N load cell. Seventeen tonnarelli were lined up on a stainless steel plane and shear-tested using a trapezoidal probe (Cimini *et al.*, 2019ab). The average thickness (sPC) of the cooked tonnarelli was calculated as the difference between the displacements of the probe up to the points of contact with the support surface and the sample. Each test was performed by setting the probe speed at 1 mm/s.
The first and second compression of the TPA (Texture Profile Analysis) were performed at 30% and 70% of the initial thickness, respectively. According to Bourne (2002), peak force at the 1st or 2nd compression cycle was defined as pasta texture at 30% (F_{30}) or 70% (F_{70}) of deformation. The ratio of the force-time are (AC_{70}) during the second compression to the force-time area (AC_{30}) during the first compression was defined as cohesiveness (CER). The recovery in height of the tonnarelli during the time elapsed between the end of the first compression and the beginning of the second compression was defined as elasticity (S). Each test was repeated at least five times.
The *in vitro* digestion of the pasta starch was performed as suggested by Zou *et al.* (2015). All tests were replicated at least three times. The so-called digestogram was plotted by detecting the concentration of the glucose released, $C_G(t)$, using the enzyme kit D-Glucose K-GLUC 07/11 (Megazyme Ltd, Bray, Ireland) as the digestion time varied. The area enclosed under each digestogram (AUC) for a digestion time of 180 min was calculated numerically using the trapezoidal rule and related to that estimated for the reference product (white bread, according to Giuberti *et al.*, 2015). This ratio, multiplied by 100, represents the so-called starch hydrolysis index (SHI), which enables the calculation of the *in vitro* glycaemic index (GI) using the following empirical formula (Granfeldt *et al.*, 1992):

$$GI = 8.198 + 0.862 \times SHI \qquad (1)$$

where the SHI of white bread was assumed to be 100.
The statistically significant difference between the parameters measured was analysed using the Tukey Test at $p = 0.05$. Additionally, a one-way analysis of variance (ANOVA) was performed using SYSTAT, version 8.0 (SPSS Inc., Chicago, IL, USA, 1998).

Results and discussion

Production and characterisation of the malted and hulled legume flours

The crude protein, phytic acid and


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Table 1 **MAIN CHEMICO-PHYSICAL PROPERTIES AND CIELAB COORDINATES (L*, a* AND b*) OF THE SEEDS OF THE SOLCO DRITTO CHICKPEAS (CSD), PURGATORIO DI GRADOLI BEANS (FPG), AND ONANO LENTILS (LO), ORIGINAL AND MALTED (M), PREVIOUSLY EVALUATED (CIMINI *ET AL.*, 2023, 2024A, 2024B)**

Parameter	CSD	CDM, 2024	FPG	FPGM	LO	LOM	UdM
Proteins	22.3±1.7^{b}	23.6±1.9^{b}	22.7±1.7^{b}	23.4±2.1^{b}	26.1±2.0$^{a.b}$	28.7±2.2^{a}	g/100 g
Total starch (TS)	46.8±0.6^{b}	45.2±2.0^{b}	33.81±1.66^{c}	34.96±0.19^{c}	50.9±0.4$^{a.b}$	52.1±2.8^{a}	g/100 g
Resistant starch (RS)	1.77±0.22$^{b.c}$	1.19±0.43^{c}	23.59±0.34^{a}	22.0±1.8^{a}	2.30±0.17^{b}	1.88±0.47^{b}	g/100 g
Phytic acid (AF)	1.15±0.12^{a}	0.79±0.09^{b}	1.15±0.12^{a}	0.78±0.13^{b}	1.09±0.09^{a}	0.80±0.02^{b}	g/100 g
Raffinose (R)	3.80±0.15^{b}	1.65±0.11^{c}	5.31±0.28^{a}	1.95±0.20^{c}	3.78±0.04^{b}	0.79±0.07^{d}	g/100 g
L*	69.5±1.6^{c}	75.1±1.8^{a}	71.0±1.7$^{b.c}$	73.3±1.5$^{a.b}$	64.6±1.6^{d}	65.2±3.0^{d}	-
a*	3.7±0.5^{a}	2.3±0.6^{b}	0.6±0.5$^{b.c}$	0.01±0.61^{c}	5.7±1.6^{a}	1.3±0.7^{b}	-
b*	27.0±2.3^{b}	27.0±1.3^{b}	15.6±1.7^{c}	19.0±1.9^{c}	44.3±3.2^{a}	40.9±2.5^{a}	-

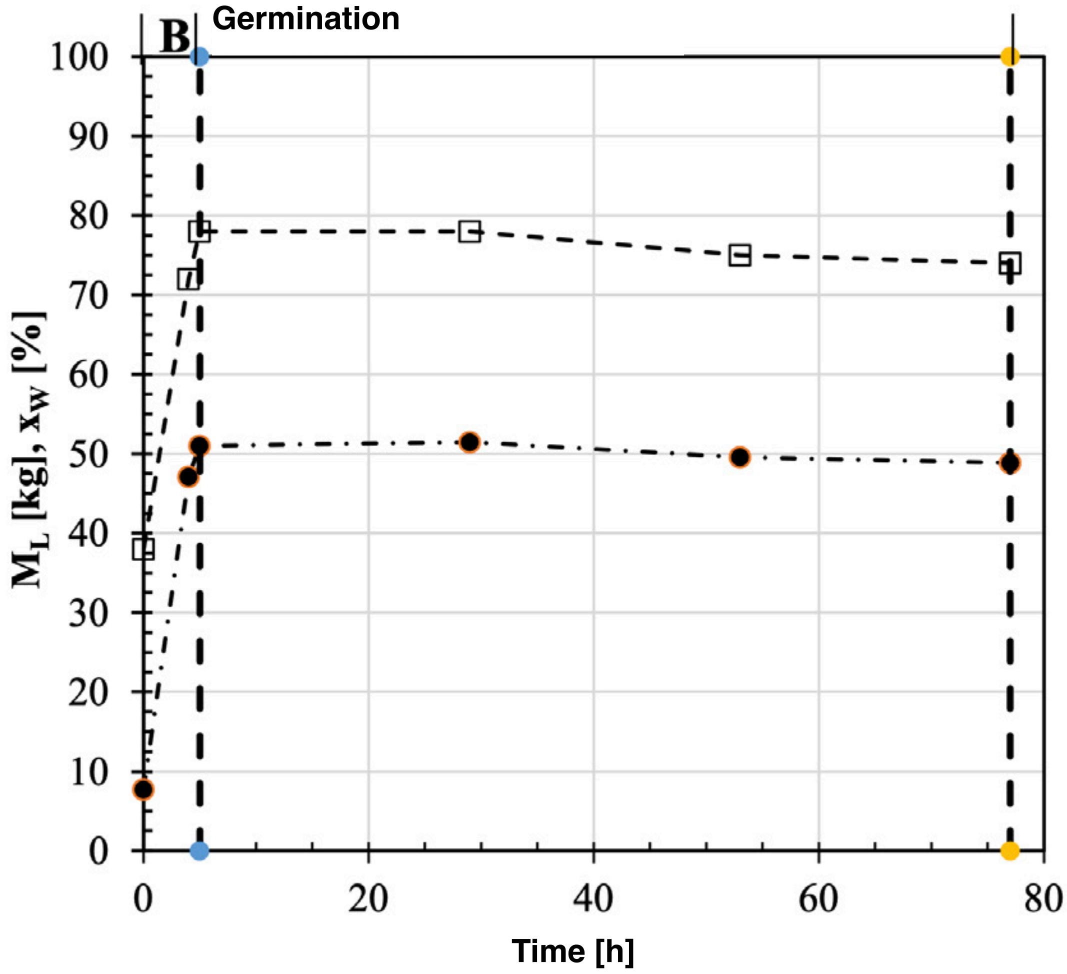
In each row, the data with the same superscripts are not statistically different at the probability level $p < 0.05$.

raffinose contents referred to the dry matter of the Solco Dritto chickpeas (CSD), Purgatorio di Gradoli beans (FPG) and Onano lentils (LO), reported in Table 1, do not differ from those of numerous varieties cultivated worldwide (Basso Los *et al.*, 2018; Cappa *et al.*, 2018; de Barros *et al.*, 2016; Frias *et al.*, 2000; Johnson *et al.*, 2013; Rawal and Navarro, 2019; Rawal *et al.*, 2019; Sparvoli *et al.*, 2015; Xu *et al.*, 2019).

After steeping, the seeds of CSD, FPG and LO, with an initial moisture content of 12% (w/w), reached a moisture content between 49 and 55% (w/w). As an example, Figure 3 shows the development of the moisture (x_W) and the lentil mass (M_L) during the steeping and germination phases in the pilot malting machine used here. 38 kg of dried lentils with a moisture content of 7.74% (w/w) were fed. These were washed with 114 L of water.

152 L of water at approximately 25°C was then added to the steeping tank. After 5 h of steeping, 78 kg of lentils with a moisture content of 51% were obtained. Once the steeping water was drained, the lentils began to germinate while the humidity of the air was controlled by spraying water into the germination chamber.

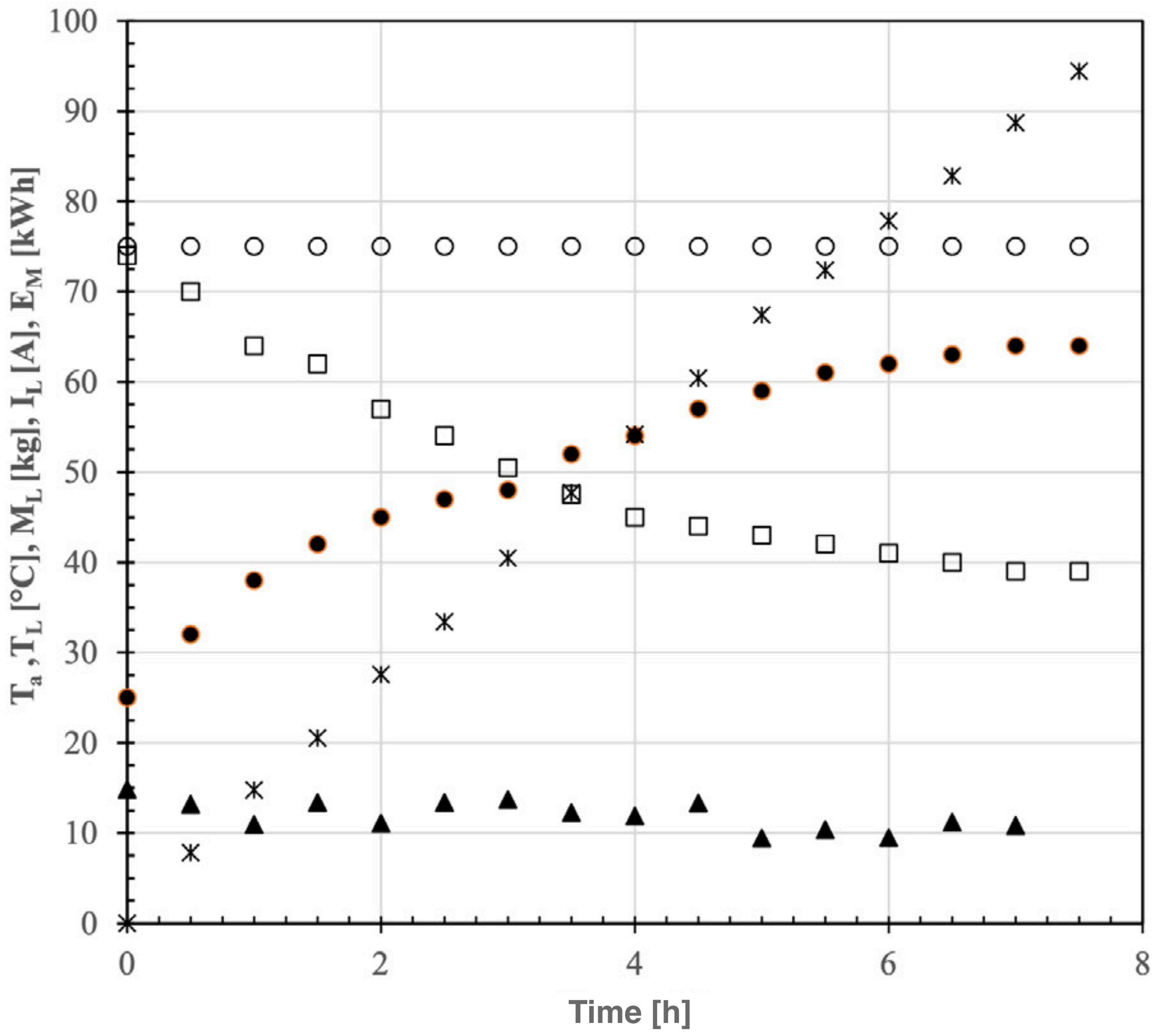
Figure 3 MOISTURE CONTENT OVER TIME (X_W: ⬤) AND THE MASS OF LENTILS (M_L: □) DURING THE STEEPING (B) AND GERMINATION PHASES IN THE PILOT MALTING MACHINE USED HERE



Notwithstanding this precaution, the mass and moisture of the lentils at the end of the germination phase had decreased slightly to 74 kg and 48.9 % (w/w), as shown in Figure 3. In total, water consumption during the malting process amounted to 7 After 72 h of germination, the raffinose content in the malted and hulled seeds of the Solco Dritto chickpeas (CSD), the Purgatorio di Gradoli beans (FPG) and the Onano lentils (LO) was reduced to 43±3%, 37±4% and 21±2% of their original content, respectively, while that of phytic acid was reduced to 68% of its original content in the malted CSD and FPG seeds and to 73±2% in the malted LO seeds (Cimini et al, 2023, 2024a).

The final drying phase was conducted by recirculating hot air at approximately 75°C for 8 h, as illustrated in Figure 4. During this process, the sprouted lentils underwent dehydration, reducing their mass from 74 to 39 kg with a final moisture content of 8.4 % (w/w). The current intensity (I_L), measured with a current clamp on a line of the three-phase system, was 12.0±1.6 A. Considering an average power factor of 0.8, given the predominant

Figure 4 **TREND OVER TIME OF THE WARM AIR TEMPERATURES (T_a: ○) AND THE LENTILS (T_L: ●), OF THE MASS OF LENTILS (M_L: □), OF THE CURRENT INTENSITY IN ONE PHASE (I_L: ▲) AND OF THE ELECTRICAL POWEr (E_M: ✳) ABSORBED BY THE ELECTRICAL EQUIPMENT OF THE THREE-PHASE POWER SUPPLY SYSTEM OF THE MALTING MACHINE USED HERE DURING THE DRYING PHASE**



contribution of the electric resistors, an energy consumption of approximately 94 kWh was estimated (Figure 4), equivalent to a consumption of 2.48 kWh per kg of processed dry legume.

In brief, the malting process for the legumes studied involved a steeping phase at 25°C for 5 h, followed by a 72 h germination phase and a 7 h drying phase (Figures 3 and Figure 4). In comparison, the malting process of barley generally takes a longer time, about 9 days, comprising a 48 h steeping phase, a 96 h germination phase and a 24 h drying phase, followed by the separation of the rootlets and the sorting of the grains (FAO, 2009).

The average ratio of initial barley to malt is approx. 1.27 g/g, while in the case of malted and hulled legumes, the recovery is about 0.85±0.02 kg of malted legumes for every kg of processed dry legumes,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corresponding to an average ratio of approx. 1.18 g/g. In terms of the consumption of resources, barley malting needs approximately 7 L of water, 0.75 kWh of heat energy (99% of which is attributed to the drying phase) and 0.13 kWh of electricity per kg of barley (FAO, 2009).

Malting tests conducted on a pilot scale for legumes required the same specific water consumption, but significantly higher energy consumption per kg of legumes. This aspect will require further verification on a larger operational scale, where electrical energy is used to drive the centrifugal pump and rotating drum, while thermal energy is used to dry the sprouted legumes.

The colour of the cotyledons of the seeds of the Solco Dritto chickpeas (CSD), Purgatorio di Gradoli beans (FPG) and Onano lentils (LO), both before and after malting, was assessed using the CIELAB coordinates, as shown in Table 1.

According to the Avery colour list, the cotyledons in the original and malted form showed dark brown, light cream and metallic gold colours, respectively (https://convertingcolors.com; accessed 25 June 2024).

After milling, each malted and hulled legume flour maintained the same levels of crude protein, total starch (TS), resistant starch (RS), raffinose and phytic acid found in the corresponding cotyledons of the malted and hulled legumes (Table 1). In particular, the flour derived from malted and hulled Purgatorio di Gradoli beans (FPG) showed the lowest TS content (~35 g/100 g dm), but the highest RS content (~22 g/100 g dm). With a RS/TS ratio of around 63%, this flour could be used to formulate functional foods with a final RS content ≥ 14% TS, thereby meeting the requirements to benefit from the improved postprandial glucose metabolism health claim, as specified in European Commission Regulation (EC) No 432/2012.

Production of fresh egg pasta

The production of fresh egg pasta was carried out by mixing whole eggs with two types of flour: type 00 soft wheat flour and malted and hulled legume flour, according to a weight/weight ratio of 37:63. This procedure is illustrated in Figure 1. The appearance of the fresh pasta samples is visually depicted in Figure 5, while the details of their composition are reported in Table 2.

Conventional fresh egg pasta was characterised by a higher total starch (TS) content than the pasta made with the malted and hulled legume flour. However, it had lower crude protein, resistant starch (RS) and phytic acid contents than the

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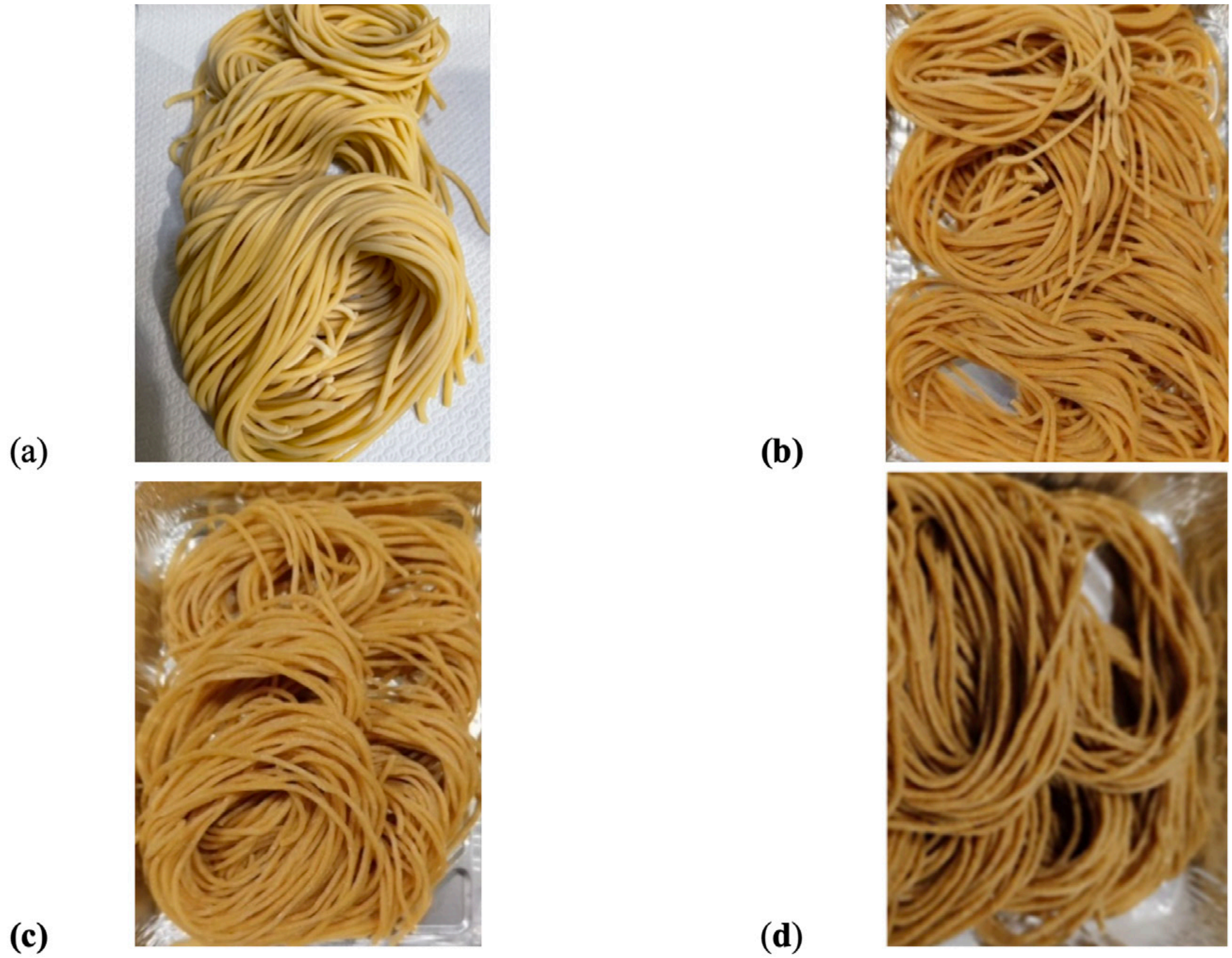
Figure 5 PHOTOS OF FRESH EGG PASTA MADE BY MIXING WHOLE EGGS WITH FLOUR FROM (A) TYPE 00 SOFT WHEAT, (B) CSD, (C) FPG, OR (D) LO, MALTED AND HULLED



fresh pasta variants prepared with the malted and hulled legume flour. In detail, in the fresh egg pasta variants prepared with flour from malted and hulled Solco Dritto chickpeas (CSD) or Onano lentils (LO), the RS content was significantly higher, about two to three times higher than in the conventional fresh egg pasta. Last but not least, in the pasta containing the malted and hulled Purgatorio di Gradoli (FPG) Bean Flour, the RS content was particularly high, measuring approximately 20.3±1.8 g/100 g dm.

These results highlight the potentially beneficial nutritional characteristics of the fresh egg pasta variants with malted and hulled legume flour, particularly in terms of RS content, indicative of a potential metabolic health benefit compared to traditional pasta.

When comparing the traditional fresh egg pastas with those enriched with malted


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Table 2 CHARACTERISATION OF THE EGG PASTAS OBTAINED BY MIXING WHOLE EGGS WITH FLOUR (F) OF TYPE 00 SOFT WHEAT (GT) AND FLOUR OF MALTED AND HULLED LEGUMES (MD), SUCH AS SOLCO DRITTO CHICKPEAS (CSD), PURGATORIO DI GRADOLI BEANS (FPG) AND ONANO LENTILS (LO): COMPOSITION, OPTIMAL COOKING TIME (OCT), WATER UPTAKE (WU), COOKING LOSS (CL), TEXTURE AT 30% (F_{30}) AND 70% (F_{70}) COMPRESSION, COHESIVENESS (CER), ELASTICITY (S), INITIAL THICKNESS (S_{PC}), AREA ENCLOSED BY THE DIGESTOGRAM FOR A DIGESTION TIME OF 180 MIN (AUC), STARCH HYDROLYSIS INDEX (SHI), *IN VITRO* GLYCAEMIC INDEX (GI) AND CLASSIFICATION ACCORDING TO THE GLYCAEMIC INDEX TABLE

Egg pasta with	FGT	FCSDMD	FFPGMD	FLOMD	UdM
Protein (Nx6.25)	16,6±1,5[b]	20,0±1,8[b]	20,8±1,9[a]	23,6±2,1[a,b]	[g/100g dm]
Total starch	71,4±1,5[a]	32,4±2,3[c]	32,4±2,3[c]	51,3±2,5[b]	[g/100g dm]
Resistant starch	0,54±0,04[c]	1,1±0,8[b]	20,3±1,8[a]	1,63±0,22[b]	[g/100g dm]
Phytic acid	0,03±0,01[c]	0,58±0,01[b]	0,84±0,03[a]	0,60±0,05[b]	[g/100g dm]
Raffinoso equiv.	0[a]	0[a]	0[a]	0[a]	[g/100g dm]
OCT	8,0±0,1[a]	6,0±0,1[b]	6,0±0,1[b]	6,0±0,1[b]	[min]
WU	0,76±0,10[b]	0,94±0,07[b]	0,93±0,16[a]	1,08±0,01[a]	[g/g]
CL	0,048±0,002[c]	0,080±0,002[b]	0,096±0,007[a]	0,101±0,015[a]	[g/g]
F_{30}	6,6±0,8[b]	8,1±0,8[b]	8,4±1,0[b]	9,3±0,6[a]	[N]
F_{70}	16,5±1,1[a]	16,3±1,5[a]	11,8±0,9[b]	12,5±0,7[b]	[N]
CER	5,3±0,7[a]	3,3±0,6[b]	2,1±0,7[b,c]	1,8±0,2[c]	[-]
S	2,13±0,10[a]	1,50±0,07[b]	1,39±0,16[b,c]	1,27±0,11[c]	[mm]
S_{PC}	3,07±0,09[a]	2,86±0,06[a]	2,86±0,14[a]	2,40±0,02[b]	[mm]
AUC	51,4 ± 4,0[a]	23,0±1,2[b,c]	19,0 ± 2,8[c]	28,0±4,0[b]	[g min/L]
SHI	63,3 ± 4,9[a]	28,4±1,5[b,c]	23,4 ± 3,5[c]	34,4±4,9[b]	[%]
GI	62,8 ± 4,2[a]	32,7±1,3[b,c]	28,4 ± 3,0[c]	37,9±4,3[b]	[%]
GI level	Medio	Basso	Basso	Basso	-

The values in each row with the same letter show no significant differences at $p < 0.05$.

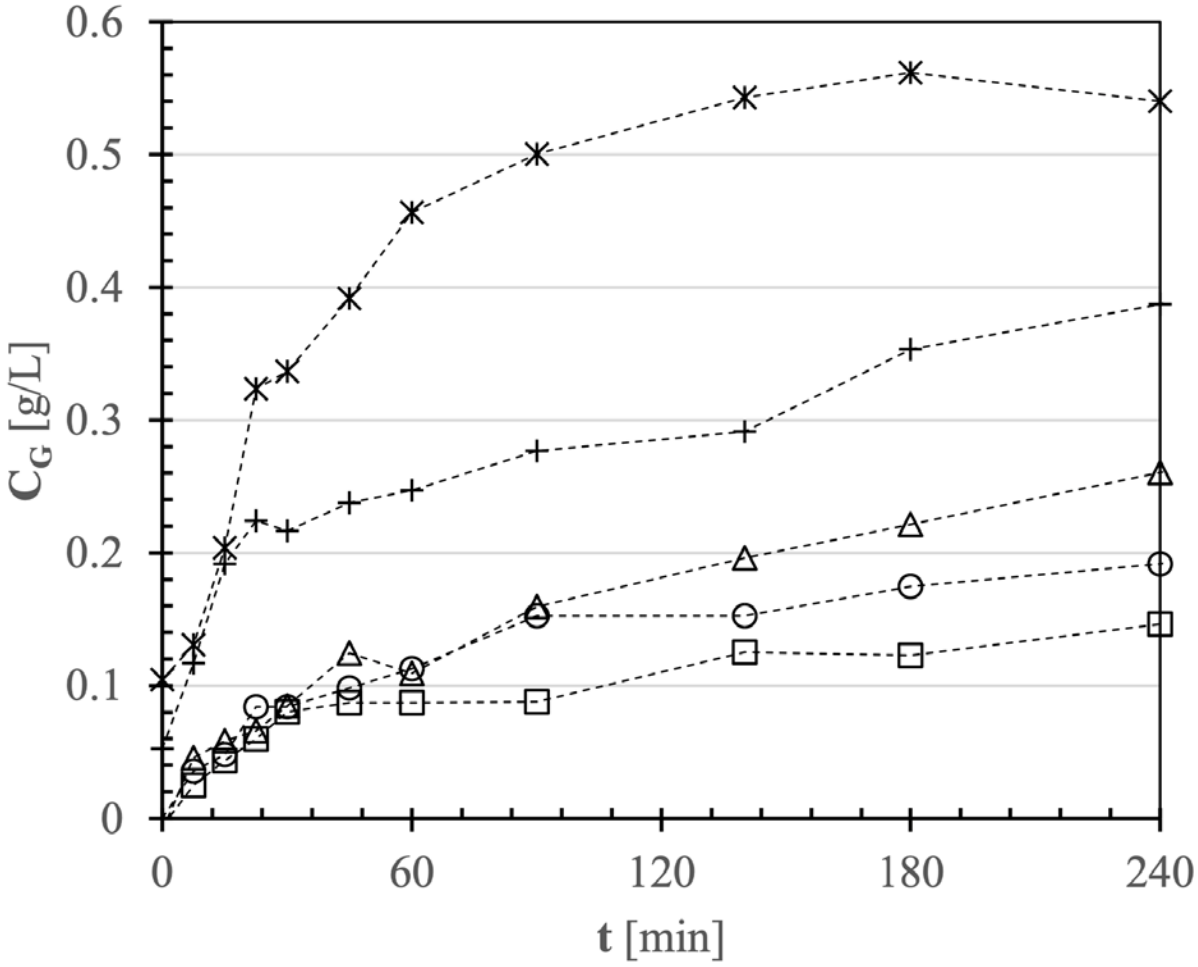
and hulled legume flour, several significant results emerged:

1. α-galactoside and crude protein content: all fresh egg pastas, including those made with malted legume flour, had virtually no α-galactoside content. The crude protein content did not differ significantly between the fresh

egg pasta and the commercial lentil or chickpea pasta, amounting to 26 or 22 g/100 g dm, respectively (Cimini *et al.*, 2024b);

2. *raffinose and phytic acid content*: commercial lentil and chickpea pastas had a raffinose content of approx. 0.6 and 1.2 g/100 g dm, respectively. Furthermore, they had a phytic acid content approx. one-third higher than the fresh pastas made with malted and hulled legume flour (Cimini *et al.*, 2024b);
3. *optimal cooking time (OCT)*: the optimal cooking time for the conventional fresh egg pasta was about 8 min, while for the fresh pastas made with malted and hulled legume flour, it was only 6 min. This indicates a shorter cooking time for pastas enriched with legume flour and, therefore, a lower energy consumption;
4. *specific water uptake (WU) and cooking loss (CL)*: conventional fresh egg pastas showed a relative water uptake (WU) of 0.76 g/g and a cooking loss (CL) of 0.048 g/g, lower values

Figure 6 COURSE OVER TIME OF SIMULATED *IN VITRO* STARCH DIGESTION USING WHITE BREAD (∗), FRESH BAKED PASTA SAMPLES CONTAINING 37% (W/W) WHOLE EGG AND 63% (W/W) SOFT WHEAT FLOUR (+); FLOUR FROM MALTED AND HULLED FPG (□), CSD (○) AND LO (△)



than those recorded for the egg pastas made with malted and hulled legume flour (WU = 0.98 g/g; CL = 0.09 g/g). This suggests a higher water absorption capacity and a higher loss of substance during cooking in pasta enriched with legumes;

5. the *textural properties* of the fresh egg pastas are not significantly affected by the use of the malted and hulled legume flour as opposed to the type 00 soft wheat flour. This suggests that pastas with legume flour can be prepared with a similar texture and consistency to traditional pastas, while benefiting from the nutritional improvements provided by the legumes. For example, a commercial lentil pasta previously assayed by Cimini *et al.* (2024b) had a significantly higher consistency at 70% compression (28.6±0.6 N).

Figure 6 shows digestograms showing the evolution of the glucose concentration (C_G) ver the digestion time for the different fresh egg pasta samples analysed. The data

were processed using the Trapezoidal Rule to calculate the area under the curve (AUC) for an incubation period of 180 min, as shown in Table 2.

The AUC values show that fresh egg pasta with malted legume flour had a smaller area under the curve (19-28 g min/L) than conventional fresh egg pasta (51 g min/L) and white bread (81 g min/L), indicating a slower release of glucose during digestion. The calculated Starch Hydrolysis Index (SHI) and Glycaemic Index (GI) indicate that fresh pasta with malted legume flour has a GI *in vitro* of between 28% and 38%, classifying it as a low GI food according to the ranking of Foster-Powell *et al.* (2002) and Atkinson *et al.* (2021).

These results suggest that the use of malted legume flours in fresh egg pasta would limit not only the intake of oligosaccharides, which cause flatulence, and phytic acid, which is responsible for mineral malabsorption, but also the increase in blood glucose levels after meals, offering an advantageous nutritional option for the management of the glucose metabolism, especially in individuals sensitive to increases in blood glucose levels, such as those with type 2 diabetes, or in the prevention of obesity and cardiovascular disease (Brand-Miller *et al.*, 2003). More specifically, the fresh egg pasta with malted and hulled LO flour had a glycaemic index of 38%, which was not statistically different from that found for fresh egg pasta with malted CSD flour (~33%), but significantly higher than that assessed for fresh egg pasta with malted FPG flour (~28%). Furthermore, this pasta was characterised by a low TS content (~32 g/100 g) and a high RS content (~20 g/100 g) with an RS/TS ratio of approximately 63%, much higher than the threshold value of 14% specified by EC Regulation 432/2012 for the labelling of foods with the health claim related to improved postprandial glucose metabolism.

Conclusions

The malting of three legume varieties (CSD, FPG and LO) cultivated in Upper Lazio was studied on a pilot scale. After separating the rootlets and cuticles, the cotyledons of the malted legumes were ground and used to prepare fresh egg pasta, free of the oligosaccharides mainly responsible for flatulence, with a low phytate content (0.6-0.80 g/100 g dm), approximately 20 g/100 g crude protein and a low GI *in vitro*. In particular, fresh egg pasta with malted and hulled Purgatorio bean flour showed a significantly lower GI (28±3%) and a high content of resistant starch, above the

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threshold value of 14% required for the health claim, according to EC Regulation 432/2012, that it improves the postprandial glucose metabolism.

It is important to verify the specific water and energy consumption of the malting process on a semi-industrial scale before estimating the production costs of these flours. Additionally, it is essential to assess consumer acceptability of these new gluten-free fresh egg pastas made from malted and hulled legumes.

These results support the use of fresh pasta with malted and hulled legume flour as a low glycaemic index dietary option that helps limit the increase in blood glucose levels after meals, potentially reducing the risk of metabolic diseases. They also provide a basis for more informed dietary and culinary considerations regarding the nutritional differences and potential health impacts of fresh egg pasta formulated with malted and hulled legume flour.

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Anselmo Group at Ipack-Ima 2025: advanced technologies for the production of pasta and snacks

Editorial team

The Anselmo Group companies will be in the spotlight at the next edition of Ipack-Ima, scheduled to take place at Fiera Milano Rho from 27 to 30 May.

In recent years, the consumption of plant-based foods has been growing apace, providing an alternative to animal protein for economic, nutritional and environmental reasons. The use of commodities such as wheat, corn and rice, enriched with pseudocereals, legumes and plant by-products, offers new opportunities in the food sector.

The Anselmo Group develops advanced technologies for processing these commodities, enabling the production of a wide range of products: dry pasta, fresh pasta (filled and unfilled), gnocchi and snacks, in both traditional and gluten-free versions.

From 27-30 May 2025, the Group will be present at Ipack-Ima (Fiera Milano Rho), the leading international event dedicated to food processing and packaging technologies. The most innovative solutions developed by the Group's various companies will be presented on a collective stand:

Anselmo: facilities for the production of dry pasta of all kinds, including couscous and Instant Pasta, both traditional and gluten-free;.

- Anselmo Braibanti: technologies for the production of premium pasta with long drying times, including combined lines for short pasta and nested pasta;
- Anselmo LTA: systems for the production of special pasta (lasagne, nests and cannelloni), in automatic and semi-automatic versions, also gluten-free;
- Omar and Facchini: solutions for the production of fresh, filled and unfilled pasta, in traditional and gluten-free versions, with the possibility for chilled, frozen and dry processing;
- FEN: systems for the production of snack pellets, breakfast cereals, prefabricated or directly expanded snacks, as well as solutions for the production of gluten-free pasta.

Participation in Ipack-Ima 2025 (hall 3, stand C22 D21) will be an opportunity to get a closer look at the latest innovations in the sector, confirming the Anselmo Group's commitment to the development of cutting-edge technologies for the food industry.


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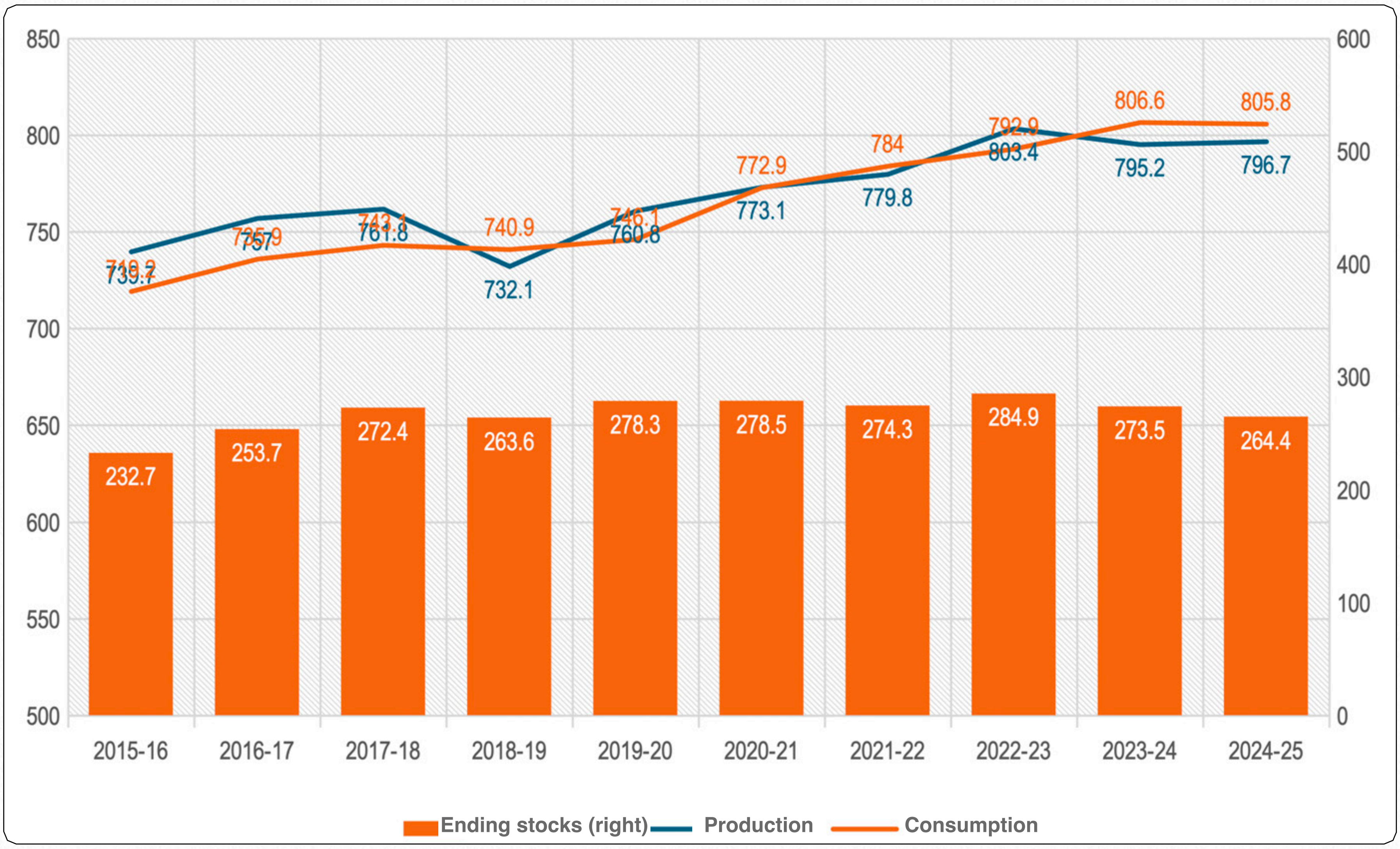
Durum wheat: 2025-26 uncertain due to climate and crisis in international relations

Pastaria Centre for Economic Research

After a year of strong production recovery and export growth, the durum wheat market is heading into the new season with prospects of stability, yet facing potential uncertainties linked to climate conditions and international competition.

After a season characterised by a strong recovery in terms of production and a significant expansion in exports, the durum wheat market is preparing for a new season, but with a more uncertain outlook overall.
The confirmation of above-average production levels in Canada and production growth in Europe and North Africa seal the prospect of a reliable supply on a global scale, but the climate variable could reshuffle the cards and affect the prices of staples.
Against this backdrop, competition between the major exporting countries and consumption trends, especially in the emerging markets, will be crucial factors for price developments and global trade dynamics in 2025-26, in a context which, under current conditions, is not expected to bring about any particular upheaval.
The ongoing crop year, which is due to close officially at the end of June, has experienced a marked rebound in durum wheat production in Canada, the world's largest producer and exporter. According to the February updates of Statistics Canada, the harvest was almost 5.9 million tonnes, a year-on-year improvement of 44%, thanks to an increase in the area under cultivation and a maxi-recovery in crop yields after a season heavily undermined by drought.
Overall availability rose to 6.3 million tonnes, analysts estimate, exceeding the previous crop year figure by 35% and the five-year average by 8%.
Cross-border, Canada has strengthened its presence especially in the European and North African markets, significantly increasing shipments and being able to leverage its prices, which are more competitive this year. In the first five months of the crop year (August-December 2024), exports reached 2.2 million tonnes, a year-on-year increase of 73%. Italy, Morocco, Algeria and Spain gave a strong boost to purchases of Canadian grain, while exports to the United States, amounting to just under 269,000 tonnes (+10%) – around 12% of the total – remain under close observation, due to the impact of the 25% tariffs which began on 4 March and the possible future implications of the current crisis in trade and political relations between Washington and Ottawa.
The closing forecast figure for the 2024-25 crop year puts Canadian exports at 4.9 million tonnes, a year-on-year increase of 38% and 10% above the historical average, while ending stocks are projected by experts to reach 600,000 tonnes, recovering 50% from the previous season's ending stock.

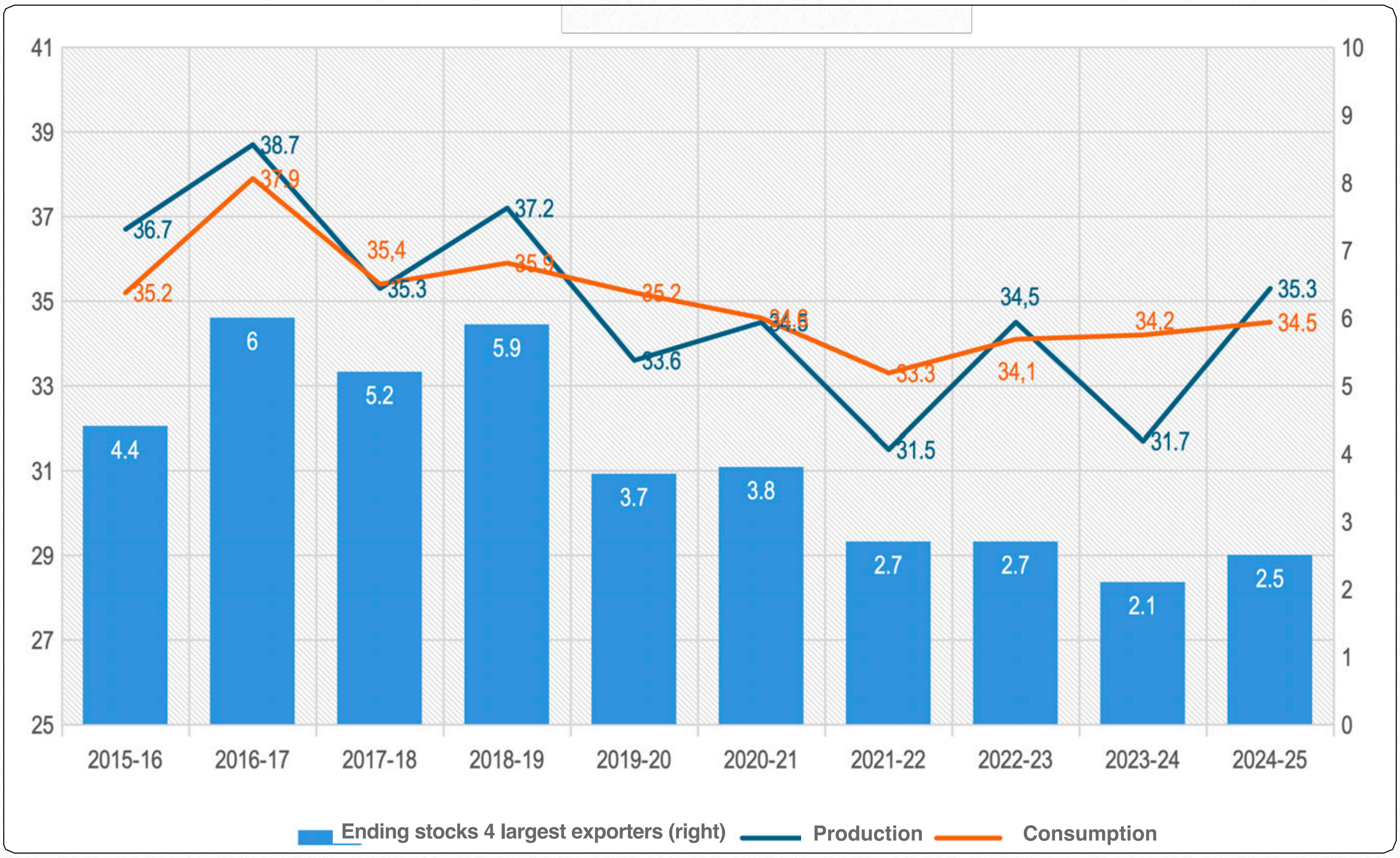
Chart 1 **SOFT WHEAT: IGC WORLD FORECAST (MILLION TONNES)**



At a global level, meanwhile, the International Grains Council (IGC) estimates a 3% increase in world durum wheat supply, which the UK board's latest calculations for the 2024-25 crop year puts at 40.6 million tonnes, thanks to an 11.3% increase in harvests, to 35.3 million, the highest in 6 years. Uses, estimated at 34.5 million tonnes, notwithstanding the slump in the feed circuit, are expected to grow by 1% in the end-of-year forecast, reaching a four-year high. This growth mainly reflects the boost in demand from the major consuming countries. Ending stocks are expected to grow by 14.1% to 6.1 million tonnes, due to the combined effect of an increase in the share held by the four largest exporting countries (with stocks 19% stronger, at 2.5 million) and a decline in the stocks in Russia and Egypt.

For the next crop year (2025-26), the market seems to be moving towards greater stability, with a more balanced relationship between supply and demand. In Canada, areas sown have been increased to 2.5 million hectares, thanks to the stability of prices and higher profitability compared to other crops, but are expected to decline slightly in twelve months' time. If average yields are sustained, production should be 5.3

Chart 2 **DURUM WHEAT: IGC WORLD FORECAST (MILLION TONNES)**



million tonnes, dropping 9% from 2024-25, but exceeding the five-year figure by 4%. Total availability, counting carried-over stocks, is expected to be around 5.9 million tonnes, a year-on-year drop of over 6%.

According to initial assessments, Canadian exports are likely to remain strong, albeit slightly down (-7%), due to increased competition from European producers, particularly in the North African market. In contrast, ending stocks are expected to fall sharply, to 500,000 tonnes, 17% below the crop year's opening levels.

On a global scale, early indications from the IGC point to a substantial balance between supply and demand, primarily due to increased production in Europe and Turkey. Tunisia and Algeria aim to increase their harvest (by 12%, according to estimates) in an attempt to reduce their dependence on imports. However, analysts note, any anomalies in rainfall or the impact of excessively high temperatures could change the scenario, affecting production results, albeit in a context that appears favourable at the moment, especially in the Mediterranean area.

As far as Italy is concerned, according to the latest ISTAT survey on sowing plans, the areas destined for cereal planting are expected to grow by 5.5% this year, reversing the -15% trend of 2024, dogged by difficult weather conditions in the autumn and winter months.
Durum wheat, the flagship crop of Italy's cereal production with almost 1.18 million hectares invested in 2024, is heading for a great rebound, with an estimated increase of 9.5%, which more than compensates for the 7.2% drop recorded last year. Soft wheat is also gaining hectares in the Italian countryside, albeit at a slower pace: after the 13% leap in 2024, the area allocated to this crop is expected to grow by 1%, based on farmers' declared intentions.
Globally, after the slight increase in 2024-25, the International Grains Council forecasts an increase in soft wheat production to 805 million tonnes (+1%), due to expected progress in Europe. Consumption is also on the rise, currently estimated at 812 million tonnes, corresponding to a year-on-year increase of 0.7%.

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