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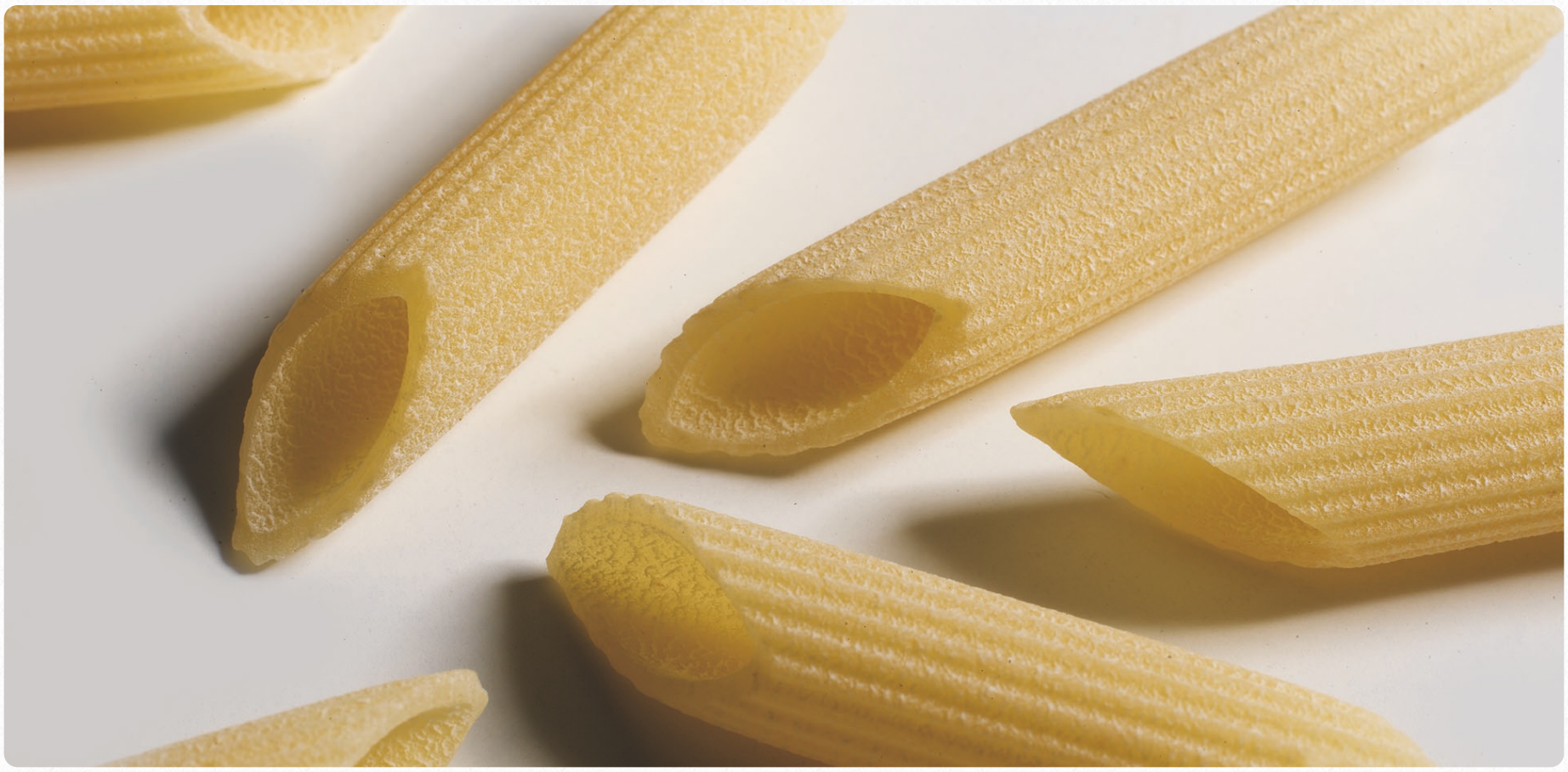
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registered office
Via Possioncella 1/1 • 42016 Guastalla
operational headquarters
Via Dall'Aglio 21/2 • 43122 Parma (Italy)
tel. +39 (0)521 1564934
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Distinguishing between whole-grain and reconstituted products: the role of wheat germ as a marker

Luigia di Stasio
Institute of Food Sciences – National Research Council (ISA-CNR)



WGA (Wheat Germ Agglutinin), a lectin found in wheat germ, has been found to be a reliable protein marker for verifying the authenticity of whole-grain products. The aim of the study was to develop a quantitative method that can distinguish between authentic whole grain products and those that have been reconstituted, i.e. produced by adding bran to refined flour. Following a thorough characterisation of the protein using a combined proteomic and immunochemical approach, a method was developed for its quantification. The proposed approach serves as a robust and innovative tool for quality control and for distinguishing between genuine whole-grain and reconstituted products, laying the groundwork for the development of rapid kits to detect the germ in wheat-based products.

Introduction

Whole-grain wheat products have attracted growing interest in recent years thanks to the nutritional benefits associated with the consumption of cereals containing all parts of the grain, i.e. the endosperm, bran and germ. Numerous epidemiological studies have, in fact, shown a correlation between the consumption of whole-grain cereals and a reduced risk of metabolic and cardiovascular diseases. However, the growing demand for whole-grain wheat products has highlighted the need for analytical tools capable of verifying their authenticity. Currently, it is difficult to distinguish between genuinely whole-grain products and those that have been reconstituted, i.e. produced by adding bran after milling. This makes it necessary to identify specific biomarkers that make it possible to verify the presence of the grain's original components, particularly the germ. WGA is a lectin found exclusively in wheat germ and accounts for approximately 3% of the soluble proteins in this fraction. Its specific localisation makes WGA one of the most promising biomarkers for assessing the integrity of wheat-derived products. While this protein has traditionally been identified using immunochemical techniques, which present a number of limitations, modern proteomic methods now allow for a more detailed characterisation and a more accurate quantification of the protein. The aim of this study was to develop an analytical method for quantifying WGA, using a combination of proteomic and immunochemical techniques, and to verify its applicability in complex matrices for distinguishing between authentic whole-grain and reconstituted products.

Materials and methods

The study was structured in accordance with the workflow shown in Figure 1. The initial stage involved the selection of representative samples from the various matrices derived from durum wheat (*Triticum durum*), including wheat germ and flours obtained at various degrees of debranning, together with the associated by-products. In order to assess the method's applicability to real food products, the study also analysed

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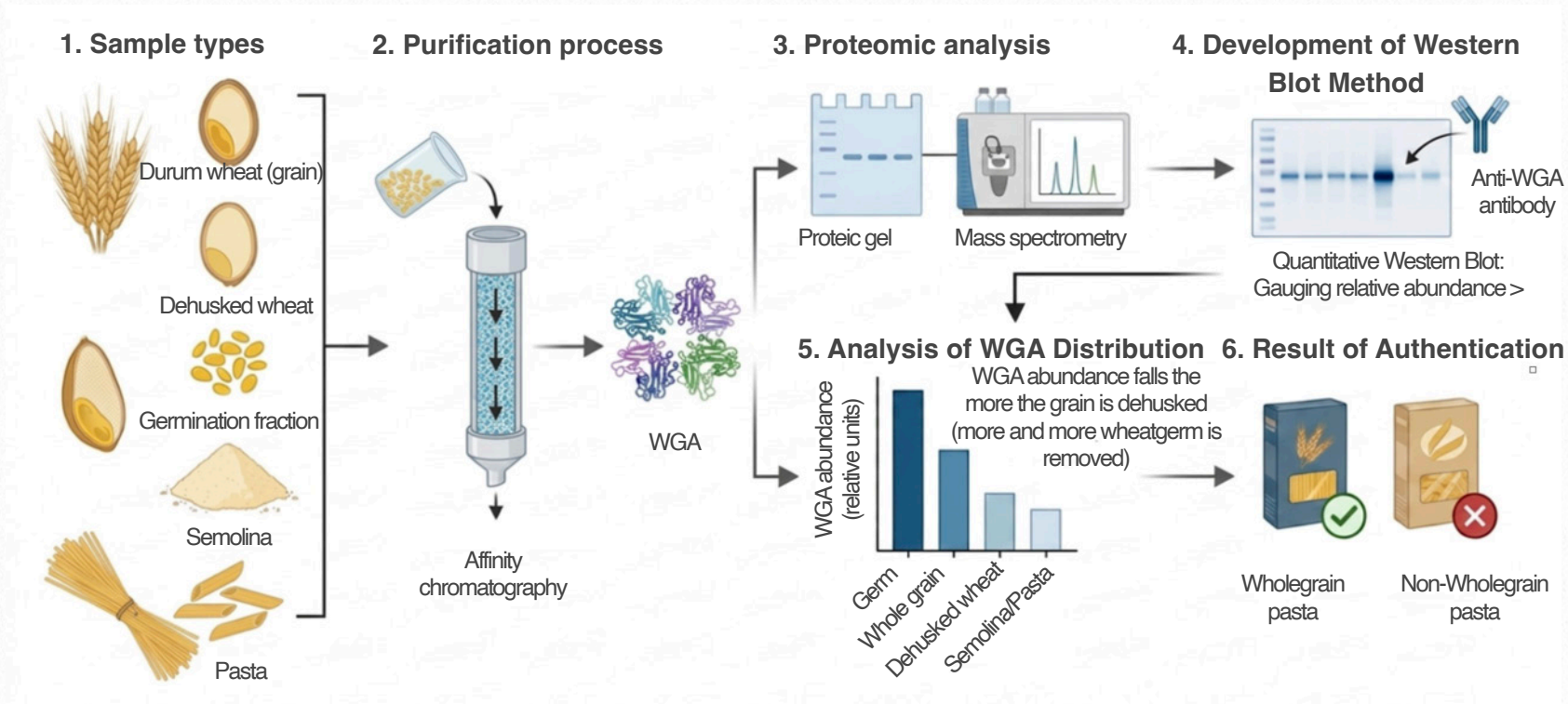
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Figure 1 EXPERIMENTAL WORKFLOW TO ISOLATE AND CHARACTERISE WGA AND USE IT AS A BIOMARKER TO AUTHENTICATE "WHOLE GRAIN" WHOLEMEAL PASTA



The various sample types (durum wheat grain, dehusked wheat and relative waste, germination fraction, semolina and pasta) undergo WGA purification by means of affinity chromatography. The isolated protein is characterised by means of proteomic analysis (electrophoresis and mass spectrometry) and used to develop a Western blot quantitative method with an anti-WGA antibody. The analysis of WGA relative abundance shows that the greater the degree of dehusking, the more the protein content falls, due to the removal of the germ. This approach makes it possible to distinguish between products actually obtained from whole grain from those not authentically "whole grain".

commercially available pasta products labelled as whole-grain, artisanal pasta products made from whole-grain flours, and pasta products made with refined durum wheat semolina, used as a control. The entire experimental approach was broken into four sequential stages:

(i) extraction of WGA from the various matrices;
(ii) purification by affinity chromatography;
(iii) structural characterisation using proteomic and immunochemical techniques;
(iv) quantification of the protein and assessment of its correlation with germ content.

Extraction, purification, characterisation and quantification of WGA

The initial stage was devoted to characterising WGA in wheat germ, the matrix in which the lectin is naturally concentrated. In accordance with protocols previously described in the literature, the protein was extracted using a 0.05 M HCl solution, which facilitates

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the enrichment of the protein fraction containing WGA. The extracts obtained were subsequently purified by affinity chromatography, taking advantage of the ability of WGA (lectin) to recognise specific carbohydrate structures present on the chromatographic matrix (egg white glycoproteins). The purified protein was then used as a reference standard for subsequent qualitative and quantitative analyses and for characterisation using advanced proteomic techniques. Specifically, the purified WGA was characterised using an integrated approach involving SDS-PAGE, Western blot, reverse-phase high-performance liquid chromatography (RP-HPLC) and high-resolution mass spectrometry (LC-MS/MS). These analyses made it possible to confirm the identity of the protein and to verify its purity before using it as an analytical standard. During application of the method to processed food matrices, and dried pasta in particular, significant analytical challenges emerged. The acid extraction protocol, effective for the germ and raw materials, showed reduced WGA recovery efficiency in pasta samples. This behaviour can be attributed to the structural changes that occur during pasta production. The processes of



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mixing, extrusion and drying promote the formation of a complex protein network consisting mainly of glutenins and gliadins (gluten), within which WGA can be trapped or stably bound via hydrophobic interactions, non-covalent bonds and disulphide bridges. Additionally, the heat treatment applied during drying can cause denaturation of the protein, altering its structural and functional properties. To improve WGA extraction from these matrices, an alternative protocol was therefore developed using reducing and chaotropic agents capable of enhancing protein solubilization. Optimising this stage made it possible to significantly increase WGA recovery and to obtain extracts that are more representative of the actual protein content in the processed products. The quantification of WGA in the various samples was carried out by densitometric analysis of the electrophoretic bands obtained by SDS-PAGE, comparing the signal intensity of the samples with that of known quantities of purified WGA. This approach made it possible to estimate the relative lectin content in the various matrices and to assess the relationship between WGA concentration and the presence of the germ in the samples analysed.

Results and discussion

Quantification of WGA in debranned flours and in pasta products using an immunochemical approach

The effectiveness of the method developed was initially evaluated on durum wheat samples that had undergone various degrees of debranning. Immunochemical analysis revealed a progressive reduction in the signal intensity associated with WGA corresponding to the increased removal of the outer layers of the grain. This pattern is consistent with the anatomical distribution of WGA, which is predominantly localised in the germ and absent from the more peripheral parts of the caryopsis. The progressive decrease in WGA observed in the more heavily debranned samples therefore reflects the gradual loss of the biologically most active components of the grain, and confirms the close relationship between WGA content and presence of the germ. This hypothesis is further supported by an analysis of the debranning by-products. Indeed, the fractions removed during technological processing were found to have significantly higher concentrations of WGA at low debranning levels (3% and 6%). This result confirms that WGA can be used



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as a direct indicator of the degree of refining of whole-grain semolina or flour.

A further key step in assessing the robustness and practical applicability of the method in quality control involved applying it to the processed matrices. Following optimisation of the extraction protocol using reducing and chaotropic agents, the WGA in various types of pasta made from durum wheat was quantified. As expected, pasta products made from refined semolina (control samples) showed very low levels of WGA, often approaching the method's limit of detection. This result is consistent with the milling process used to produce the semolina, which involves the almost complete removal of the germ and the outer fractions of the grain. The low presence of WGA therefore confirms the biomarker's high specificity and its ability to identify products derived from refined raw materials. Artisanal whole-grain pasta products, meanwhile, showed the highest levels of WGA of all products analysed. This finding suggests a greater preservation of the original components of the caryopsis during the milling and processing stages, as well as the use of less intensive technological treatments, thus reducing

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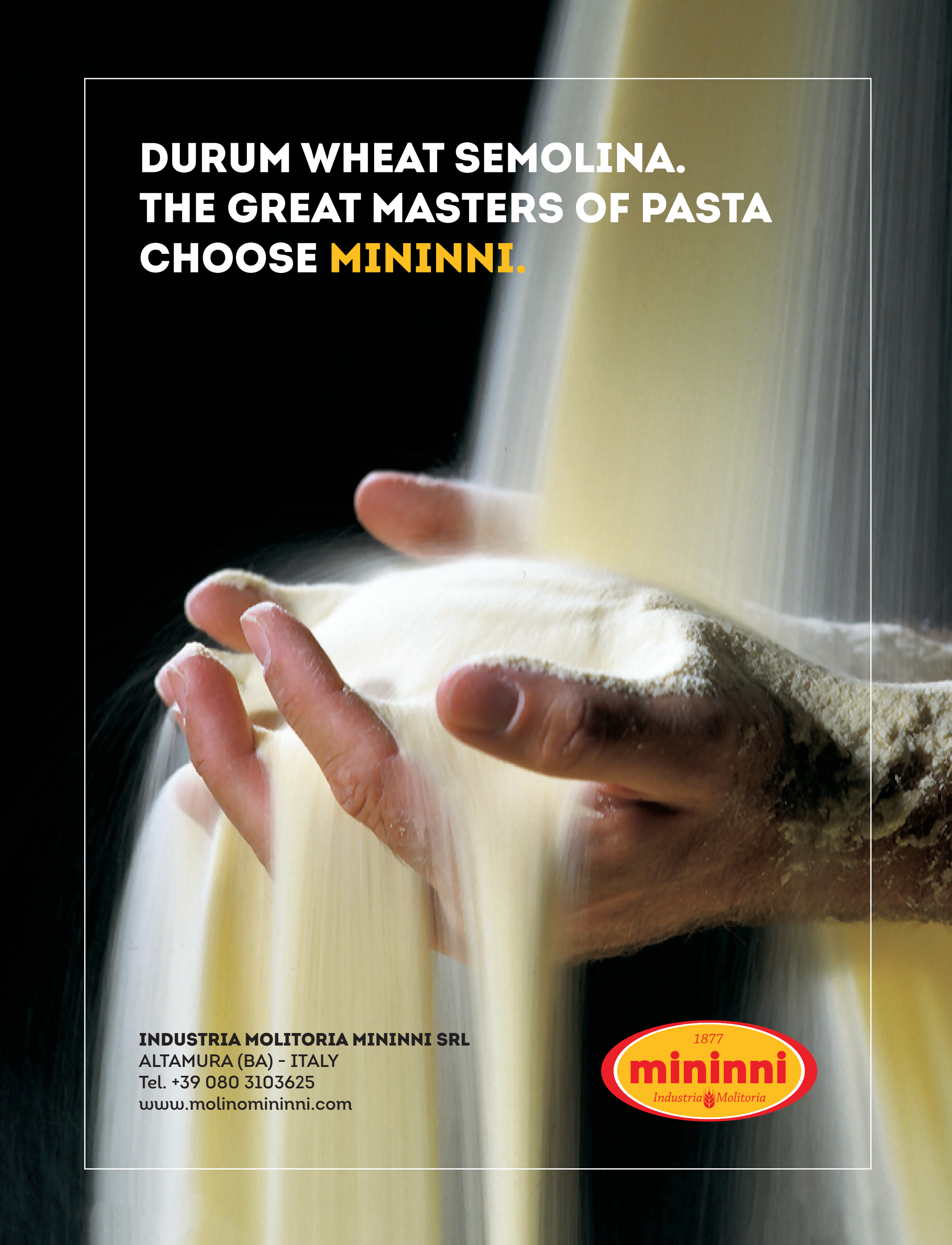
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protein denaturation (low-temperature drying).
By contrast, commercially available whole-grain pasta products showed greater variability in WGA levels. Though the protein was detected in all samples classified as whole-grain, the concentrations observed were variable; in some cases, they were lower than those found in artisanal products and comparable to the values recorded in the control samples. This variability may be attributed to the different formulations used by manufacturers, particularly in cases where reconstituted flours are used, i.e. flours produced by subsequently adding bran to refined flour. Such practices may, in fact, affect the WGA content of the end product and raise questions about the authenticity of the whole-grain products and the transparency of information provided to consumers. Overall, the results obtained show that WGA content is closely correlated to the actual presence of the germ in the various matrices analysed. WGA was found to be sufficiently stable to allow its detection even in products that had undergone complex technological processing, while retaining adequate sensitivity to distinguish between various degrees of product integrity. These findings confirm the potential of WGA as a biomarker for assessing the authenticity of whole-grain products and suggest that its monitoring could represent a valuable complement to the traditional parameters used for the characterization of whole-grain products.

Conclusions

This study has shown that WGA is a specific and reliable protein biomarker for assessing the authenticity of whole-grain products. By combining affinity chromatography, immunochemical and proteomic techniques, and high-resolution mass spectrometry (data not shown), it was possible to characterise the protein and develop a method for its quantification in various matrices derived from durum wheat. Application of the method to samples that had undergone varying degrees of debranning revealed a progressive decrease in WGA corresponding to the increased removal of the germ, confirming the close association of the lectin with this fraction of the grain. Similarly, the analysis of commercially produced and artisanal whole-grain pasta products revealed significantly higher levels of WGA compared to pasta made from refined semolina, demonstrating the biomarker’s effectiveness even in processed food matrices.

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Overall, the results obtained confirm the potential of WGA as an objective indicator of the presence of the germ and the integrity of wheat-derived products. The proposed approach therefore represents an innovative tool for quality control and the verification of the authenticity of whole-grain products, laying the groundwork for the development of rapid and easily applicable analytical methods for the food industry and certification systems.

Note

This study is funded by On Foods—Research and innovation network on food and nutrition Sustainability, Safety and Security—Working ON Foods"-National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.3—Call for proposals No. 341 of 15 March 2022 of the Italian Ministry of University and Research funded by the European Union—NextGenerationEU; Award Number: Project code PE00000003, Concession Decree No. 1550 of 11 October 2022 adopted by the Italian Ministry of University and Research; Project PRR.AP022.022 Spoke 4 "FOOD QUALITY AND NUTRITION-PE10-ON Foods.

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2

The language of pasta

Editorial team



From medieval vermicelli to industrial-era penne: a new volume traces the linguistic history of Italian pasta.

Valentina Iosco's *I nomi del pane e della pasta in Italia dal Medioevo agli anni Trenta del Novecento* [The Names of Bread and Pasta in Italy from the Middle Ages to the 1930s] is a work of rare breadth and depth, sure to become a key reference work for those interested in Italian food culture.
More than simply a linguistic compendium, the volume – published by Leo S. Olschki as part of the *Iter Gastronomicum* series – takes the reader on a journey through the history of pasta, by exploring the words that have described its shapes, uses, techniques and imagery throughout the centuries. From medieval vermicelli to penne created during the industrial age of the nineteenth century, and from lasagne to fusilli, each name becomes a tangible record of changes in production methods, cultural influences, and social transformations.
Of particular interest to Pastaria readers is the interweaving of linguistic and technological histories of pasta in the book: the introduction of dies, the emergence of "pasta d'ingegno", the evolution of Neapolitan pasta factories, right up to the revolution brought about by the Braibanti continuous press in 1933.
Perhaps the book's greatest achievement lies in restoring cultural dignity to an immense lexical heritage that is often taken for granted. The more than 170 entries examined reveal how the language of pasta has been, throughout history, extraordinarily creative, rooted in popular culture, and deeply connected to identity.
The significant scholarly work carried out as part of the AtLiTeG project, together with the high standards of the research group coordinated by Giovanna Frosini (of which the author is a member), is also evident throughout the volume. The result is a thorough yet surprisingly vibrant work that will appeal not only to linguists, but also to those who make, study, or simply love pasta.

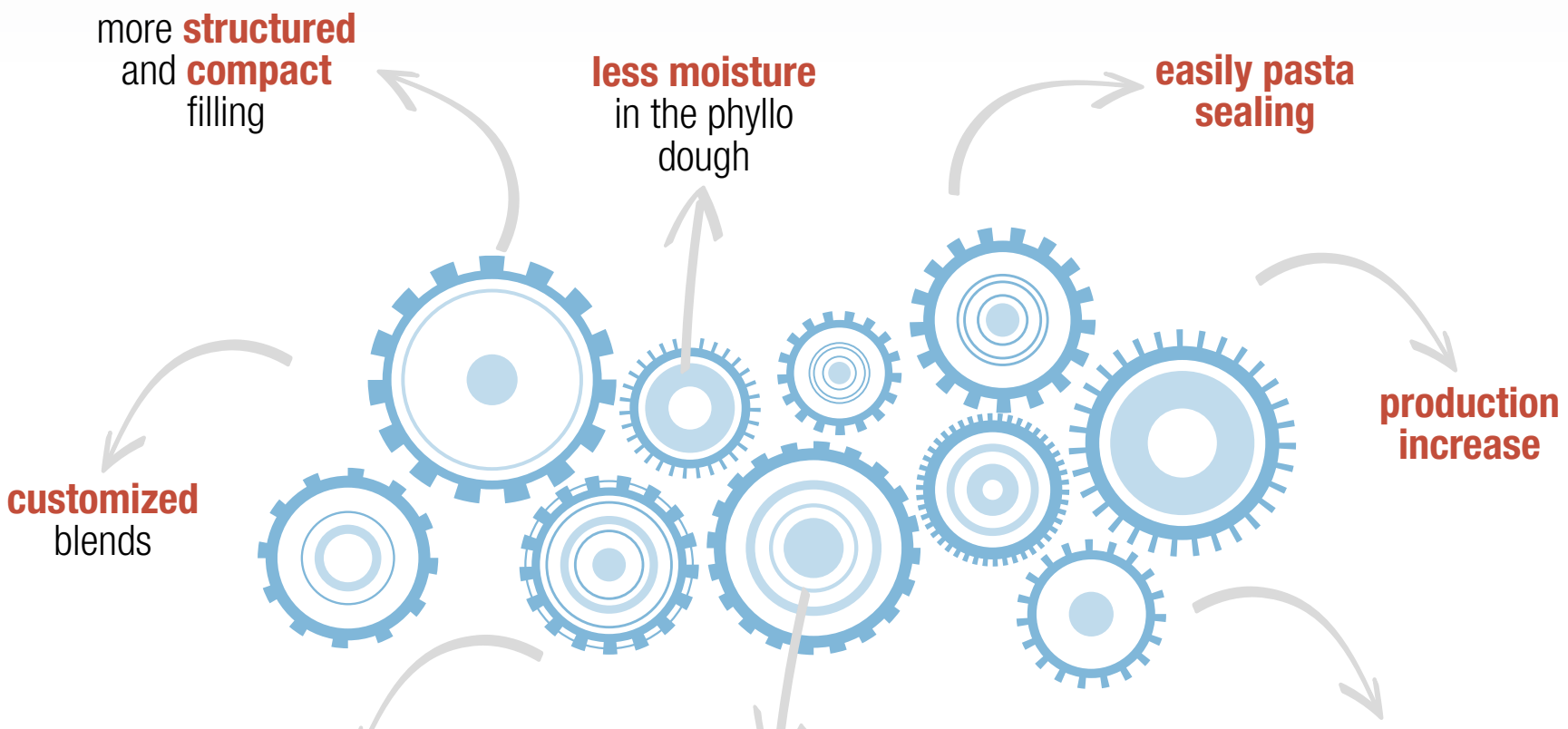


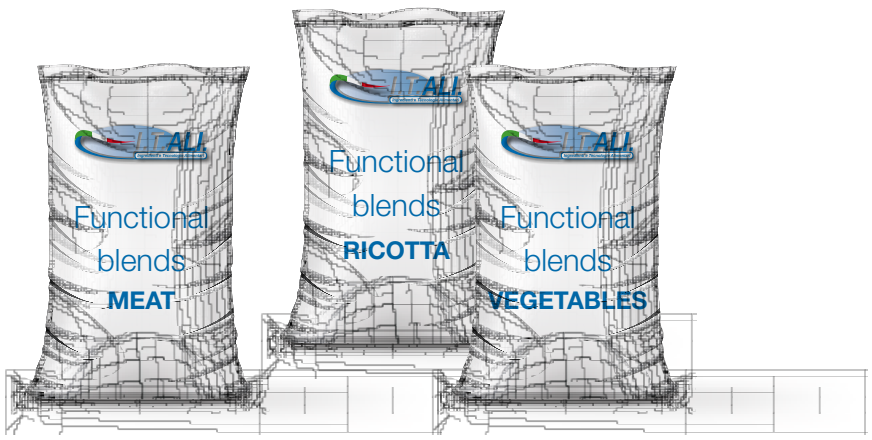
Valentina Iosco, *I nomi del pane e della pasta in Italia dal Medioevo agli anni Trenta del Novecento*. Origine, storia e classificazione, Leo S. Olschki, Florence, 2026, pp. 397, €39.

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3

2025: the year pasta realised that being loved is no longer enough

Matteo Figura
Circana



We publish a summary of Matteo Figura's presentation at the conference *Global Pasta Outlook: New Consumer Trends and the Evolution of Distribution Channels*, held during the latest edition of Fiera Pastaria & Festival (Florence, March 30–31, 2026).

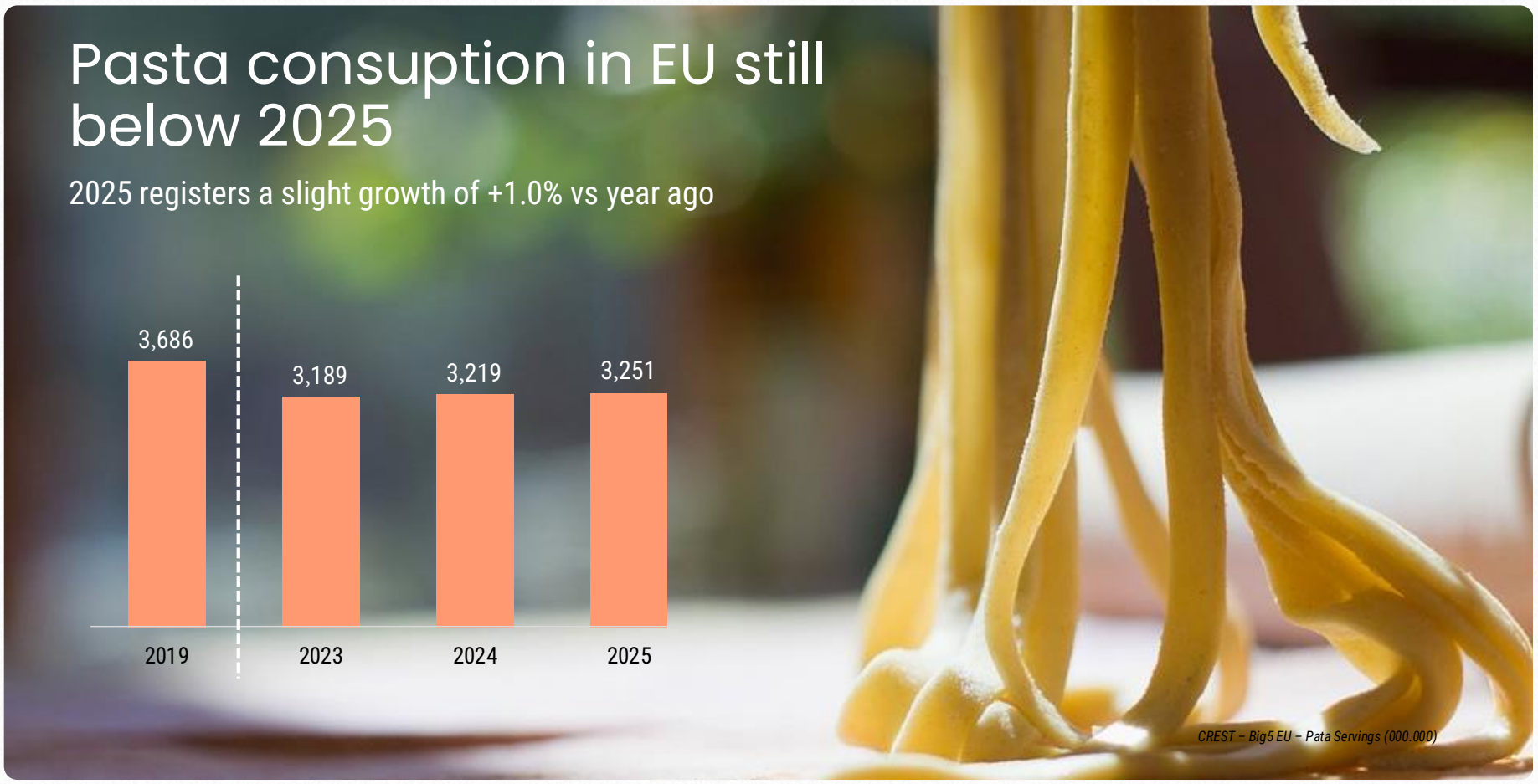
There is a curious paradox in the European foodservice world: never before has pasta been seen as such a reliable, comforting, even essential dish. And yet, never before has its position in the market been under such pressure. Not because of any fault of its own, but because consumers are rewriting their relationship with eating out – driven by new value logics, new domestic habits, and a new geography of consumption occasions.

The Great Consumer Retreat

The first truth is simple: people are going out less. Across Europe's Big Five markets, spending in 2025 increased by 1.8%, but only because prices went up; visits, however, fell by 0.9% in a single year and by 11% compared to 2019. This is not a decline – it is a cultural repositioning. Consumers are stepping out of the market entirely. This is the phenomenon known as Trading Out: 437 million visits vanished in just one year. When consumers stay home, they often turn to readymeals or readytoeat pasta from retail, turning the home kitchen into a true competitor of the restaurant.

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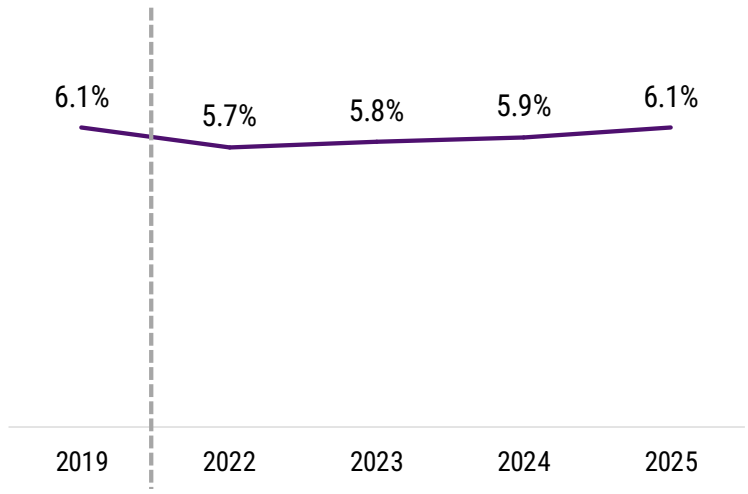






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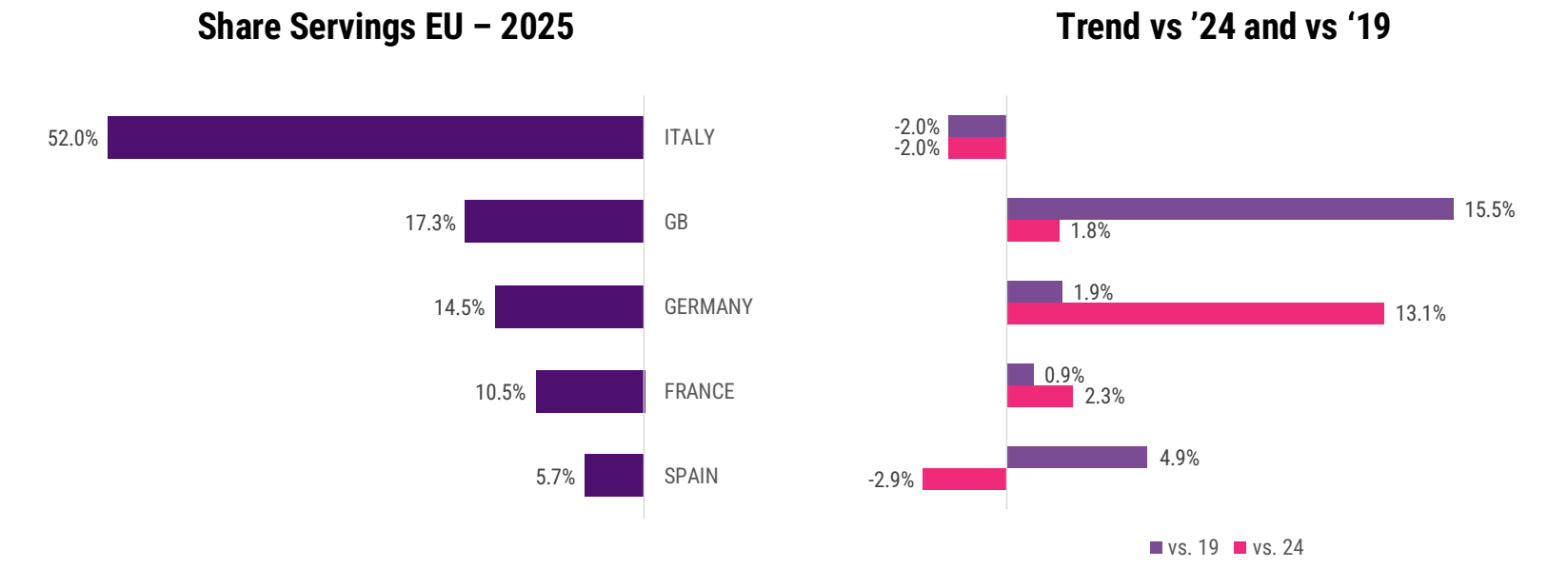
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perceived as honest in price, filling, comforting, and familiar. In a market worried about spending, pasta does not intimidate; in one that seeks social connection, it brings people together; in one that cuts extras, it remains at the center of the plate. But today, this is no longer enough.

Pasta share and trend

Italy and Spain register a negative trend in 2025 while all other countries growing



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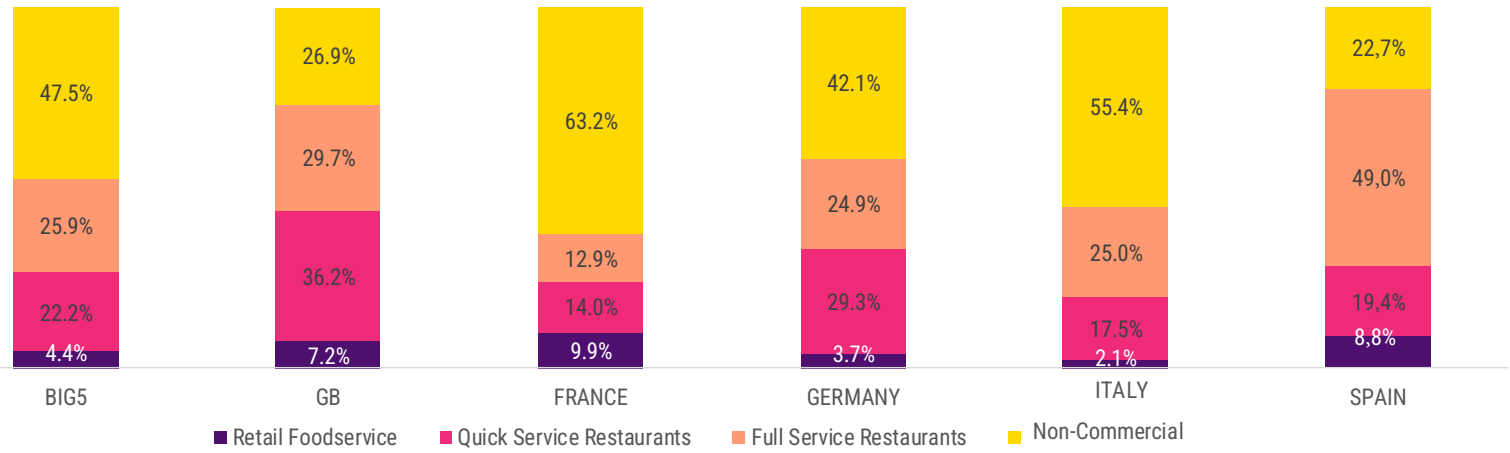
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The Italy Case: Immense Loyalty, Troubling Signals

Italy remains the temple of pasta: more than 10% of all foodservice occasions involve a pasta dish – almost double the European average. Yet volumes are falling: 34 million fewer servings in just one year. Pasta itself is not in crisis – but

Pasta Share per Channel

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CREST – Italy – Pasta Servings (000.000)

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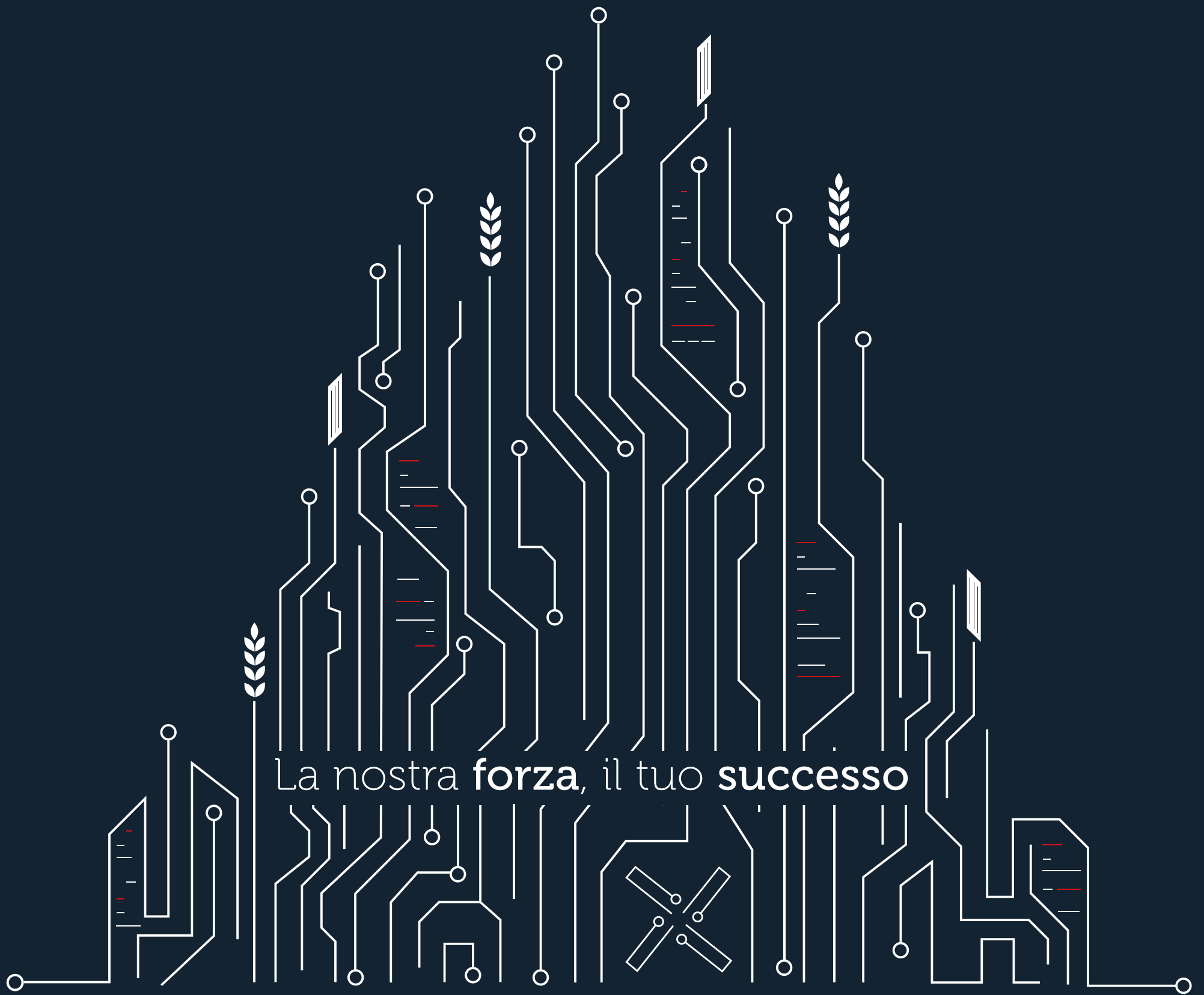
the broader context is. And pasta must respond accordingly.

My View: The Border Between Two Eras

The past was shaped by positive inertia: pasta performed well on its own. The



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future demands intentionality. Pasta must be designed for foodservice – becoming a solution for kitchens with fewer staff, shorter menus, more volatile customers, and tighter margins.

Three Strategic Directions

In light of the above, we can identify three strategic directions:

- Industrialize quality – fresh, filled, long, and short pasta formats with consistent performance, fast service, and shelf life suited to modern kitchens.
- Reclaim fast and hybrid formats – evolved bakery cafés, modern fast-casual concepts, and smart environments where pasta can once again become an everyday choice.
- Speak the language of value – not price, but meaning: clear ingredients, transparent supply chains, credible sustainability, and confident flavors.

Conclusion

Pasta remains one of the strongest categories in foodservice. But it must do what it has never had to do before: evolve at the pace of the market, not the pace of tradition. Those who succeed will lead the future of the industry.

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Food Tech Master - Fresh Pasta Processing 2026: training, innovation and networking for fresh pasta professionals

Press release



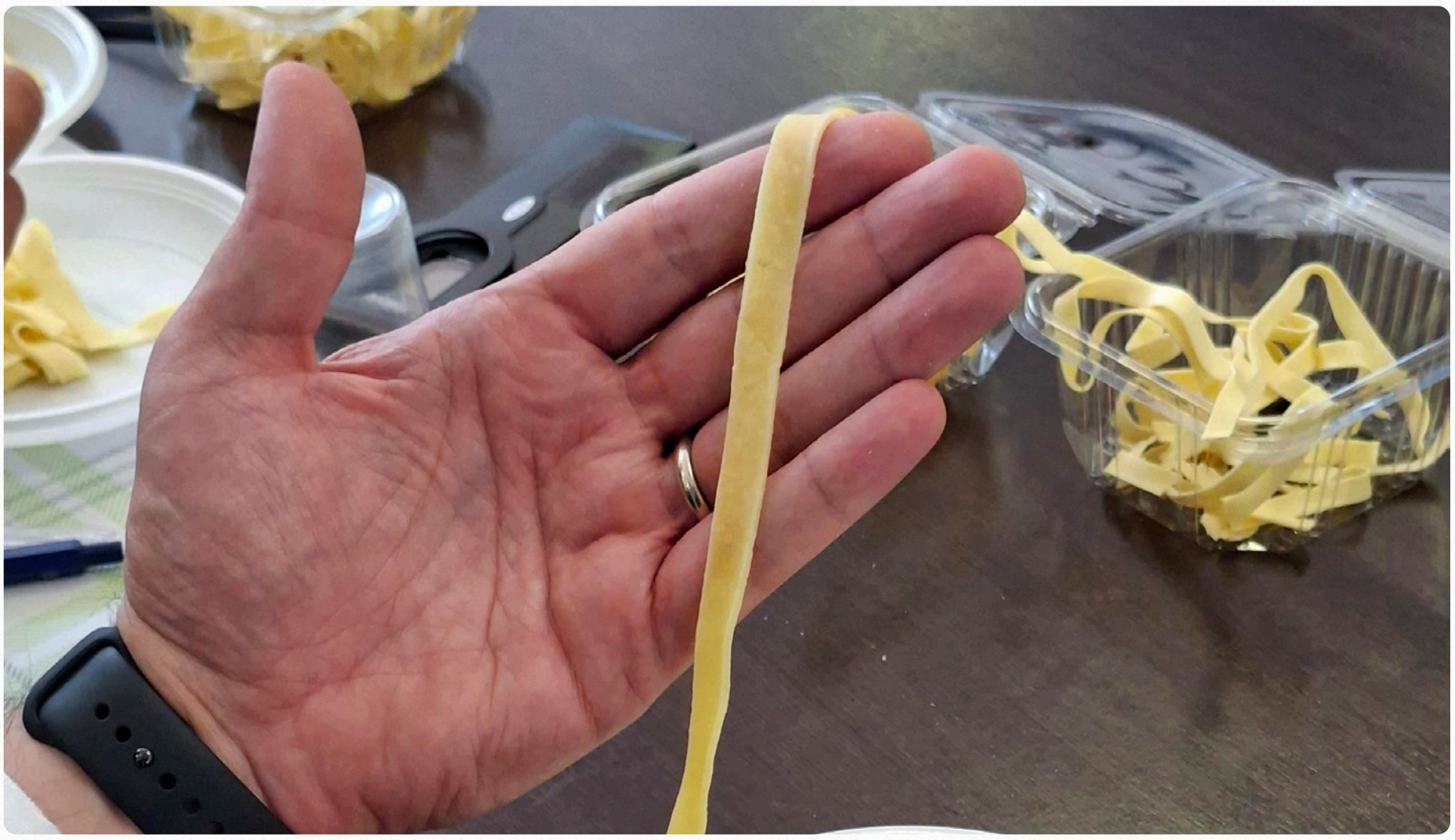
Con partecipanti provenienti da 11 Paesi, si è conclusa con successo l'edizione dedicata alla pasta fresca. GEA apre ora le iscrizioni al *Food Tech Master 2026 – Dry Pasta*.

The 2026 edition of the *Food Tech Master - Fresh Pasta Processing* has successfully concluded at the GEA Technology Center in Galliera Veneta, Italy. Over three days, professionals from 11 different countries came together to explore the entire fresh pasta production process, from raw materials and forming technologies to thermal treatment, packaging solutions and shelf-life management.

The program combined theoretical lectures, hands-on pilot plant trials, laboratory activities and guided sensory evaluations, providing participants with the opportunity to engage directly with university professors, food technologists and GEA process experts. Key topics included sheeting and extrusion technologies, filling preparation and processing, microbiology and pasteurization, fresh pasta packaging, food safety, maintenance and process control.

One of the most appreciated aspects of the 2026 edition was its international dimension. Technologists, quality managers, R&D specialists, operators and production managers shared experiences, best practices and insights into the future of the industry, reinforcing the *Food Tech Master*'s role as a leading platform for advanced training and professional networking within the fresh pasta sector.

The program builds on more than twenty





Food Tech Master 2026 – Dry Pasta

The *Food Tech Master* journey now continues with its next edition dedicated to dry pasta processing. Registration is officially open for the *Food Tech Master 2026 – Dry Pasta*, a training program designed to provide an in-depth view of the main stages of dry pasta production, from raw materials to mixing, extrusion and drying technologies, as well as product quality, production efficiency and process control. Consistent with the *Food Tech Master* approach, this edition will combine technical content, hands-on activities and direct exchange with industry experts, offering pasta professionals a valuable opportunity for knowledge development, networking and professional growth.

years of training experience and a community of over 500 participants who have attended previous editions.
“Learn. Interact. Share. Grow.”: four words that perfectly capture the essence of the *Food Tech Master*, a program designed not only to enhance technical knowledge but also to encourage collaboration, professional exchange and the development of new skills across the fresh pasta industry. An experience that continues to demonstrate the value of specialized training as a driver of innovation and growth throughout the sector.



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Effects of the production process on bioactive compounds in dry pasta: from raw materials to the end product

Cristian Tardini



Dalla semola alla pasta: una delle tesi vincitrici del Premio Pastaria 2026 mette in luce come le scelte di processo influenzino il contenuto di composti bioattivi e il valore nutrizionale del prodotto finale.

Introduction

Pasta is one of the staples of the Mediterranean diet, a plant-based nutritional model inspired by rural traditions, prioritising a high intake of cereals, fruit, vegetables and pulses. If followed regularly, this diet favours a significant drop in the incidence of metabolic, neurodegenerative and cancer-related diseases, thanks to the synergistic action of nutrients and bioactive compounds naturally present in the foods ingested (Bach-Faig *et al.*, 2011). Pasta is situated at the base of the Mediterranean food pyramid, alongside other cereal products, playing the role of providing complex carbohydrates, fibres, micronutrients and molecules having antioxidant properties. It should come as no surprise, therefore, that Italy is the world's leading producer and consumer of pasta (ISMEA Mercati, 2021; Statista, 2022).

From a regulatory perspective, in Italy the term "durum wheat semolina pasta" is reserved for products obtained through the extrusion, rolling and drying of doughs made exclusively from durum wheat semolina, or semolato, and water, pursuant to the provisions of Presidential Decree no. 187/2001. The regulation in question defines semolina as the granular fraction obtained by milling and sifting the caryopsis endosperm of *Triticum turgidum* L. subsp. *durum*, while semolato is the product obtained by milling the grain before extracting the semolina.The use of soft wheat flour is prohibited, unless the relative content is less than 3%, or unless products are for the export market, in keeping with the quality requirements and preferences of Italian consumers (Nicola *et al.*, 2021).

Pasta production consists of three main stages: mixing, kneading/shaping and drying. The dough, prepared with a moisture content of 30–32%, is processed by rolling or extrusion using Teflon or bronze dies, which produce smoother (rolling) or rougher (extrusion) surfaces (Lucisano *et al.*, 2008; Bresciani *et al.*, 2022). Drying is a critical stage for the quality of the end product, with a number of possible cycles: low (LT-Lt, Low Temperature-Long time), high (HT-St, High Temperature-Short time) or very high (VHT-St, Very High Temperature-Short time). The cycle chosen has a significant impact on texture, stability and nutritional composition.HT/VHT-St treatments improve production yields and the cooking properties of the end product, however these processes may adversely affect the nutritional and organoleptic value of the product due to Maillard reactions, causing

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the thermal degradation of amino acids and bioactive compounds (Giannetti *et al.*, 2021).

In recent years, the market has witnessed a growing demand for wholemeal pasta and so-called “specialty” pastas (containing vegetable-based ingredients, such as tomatoes and spinach, to improve the product’s nutritional and functional profile). Wholemeal pasta is obtained by milling the entire grain, including the bran and germ, and has a higher content of fibres, lipids, minerals and bioactive compounds such as flavonoids, phenolic acids, phytosterols and tocols (Liu *et al.*, 2020). Despite some technological differences compared with traditional pasta, consumption of these types of pasta is recommended in order to increase the intake of fibre and protective nutrients (SINU, 2014; Vignola *et al.*, 2018).

Specialty pastas are a further category of products obtained by incorporating ingredients other than durum wheat flour whilst retaining the designation “durum wheat semolina pasta”, supplemented by the characterising ingredient (Presidential Decree no. 187/2001). Among these, pastas containing tomato or spinach are popular because they are rich in antioxidants. Tomatoes, incorporated as a powder or purée, provide carotenoids, polyphenols (in particular rutin and naringenin) and tocopherols, although they undergo changes in composition due to thermal processing and the presence or absence of the peel (Padalino *et al.*, 2015; Esmer *et al.*, 2022; Rizzo *et al.*, 2015). Spinach provides flavonoids, minerals and tocopherols, which have specific technological effects, including increased firmness, reduced water absorption and greater loss of nutrients during cooking due to the dilution of the gluten mesh (Cho *et al.*, 2008; Chun *et al.*, 2006; Wang *et al.*, 2021).

Scientific interest in wholemeal and “enriched” pastas is linked above all to the content of bioactive compounds, including phenols and tocols, which are important antioxidants and help to prevent chronic diseases (Biesalski *et al.*, 2009; Fernandez-Panchon *et al.*, 2008). In cereals, polyphenols are found mainly in the bran and the aleurone layer, and include both free and bound forms. Their concentration depends on the cultivar, stage of ripening and exposure to biotic and abiotic stresses (Dinelli *et al.*, 2009; Barros Santos *et al.*, 2018). Tocols—tocopherols and tocotrienols—are found mainly in the germ and bran, and play a key role in the antioxidant protection of cell membranes. In the same way, their concentration and profile depend on genetics, growing conditions and

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Pastaria

processing methods (Lampi *et al.*, 2008; Hidalgo *et al.*, 2010).
During pasta production, these compounds may undergo oxidation, thermal degradation and structural changes, with reductions depending on the matrix, production process adopted and the possible presence of vegetable-based ingredients. It is therefore essential to understand their stability throughout the production chain when gauging the nutritional quality of the end product and developing pastas that have a high added value.

Materials and methods

Samples

The matrices analysed comprised four raw materials and the respective pastas obtained using standardised production processes. The raw materials considered were: 100% Italian-sourced special durum wheat semolina, 100% Italian-sourced wholemeal durum wheat semolina, tomato powder and spinach powder. The corresponding pastas were: Durum wheat semolina pasta, produced on 23 February 2023 (use-by date 26 February 2026), with a protein content of 13%; Wholemeal semolina pasta, produced on 10 July 2023 (use-by date 10 July 2025), with a protein content of 13%; Tomato pasta, made with 70% semolina and 30% tomato powder; Spinach pasta, made with 70% semolina and 30% spinach powder. The enriched pastas were sold as part of the “pasta tricolore” range, which included semolina pasta, tomato pasta and spinach pasta, produced on 28 February 2023 (use-by date 28 February 2025).

Extraction of the phenolic component

Solvents and reagents: analytical-grade hexane, ethanol and methanol (Sigma-Aldrich, St Louis, MO, USA).
Equipment: vortex mixer (Usmate, Italy), analytical balance (Scaltec, Germany), ALC-PK110 centrifuge (UK), Transsonic TP 690 sonicator (New Zealand), Laborota 4001-efficient rotary evaporator (Heidolph, Germany). Procedure: Approximately 3 g of sample was weighed in 50 mL Falcon tubes and extracted with 30 mL of ethanol/water (4:1 v/v). The samples were sonicated for 15 minutes at room temperature, and then centrifuged at 4000 rpm for 10 minutes. The supernatant was collected in a 250 mL flask. The extraction process was then repeated, and the combined supernatants (≈60 mL) were dry-concentrated using a rotary evaporator at 40°C. The dry extract was then redissolved in 2 mL of methanol/water (1:1 v/v). The extraction was carried out in duplicate (n=2) for each sample.

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The extracts, containing the free phenolic fraction, were stored at -18°C until analysis.

Determination of total phenols (Folin-Ciocalteu, 750 nm) (Singleton & Rossi, 1956):

Reagents: Folin–Ciocalteu reagent (Merck, Germany), Na_2CO_3 15%, Millipore ultrapure water.Equipment: Shimadzu UV 1800 spectrophotometer (Kyoto, Japan), Sartorius BL120S analytical balance.
Procedure: The following were added to a 10 mL flask: 0.1 mL of extract, 0.5 mL of Folin–Ciocalteu reagent, 6 mL of double-distilled water. After stirring for 1 minute, 2 mL of Na_2CO_3 (15%, w/v) was added.The solution was shaken again, made up to volume and left to react in the dark for 2 hours. Absorbance was measured at 750 nm.
A gallic acid calibration curve (25–1000 ppm) was used for quantification.
All samples and standards were analysed in duplicate (n=2).

Determination of the phenolic content by HPLC-ESI-QqQ-MS

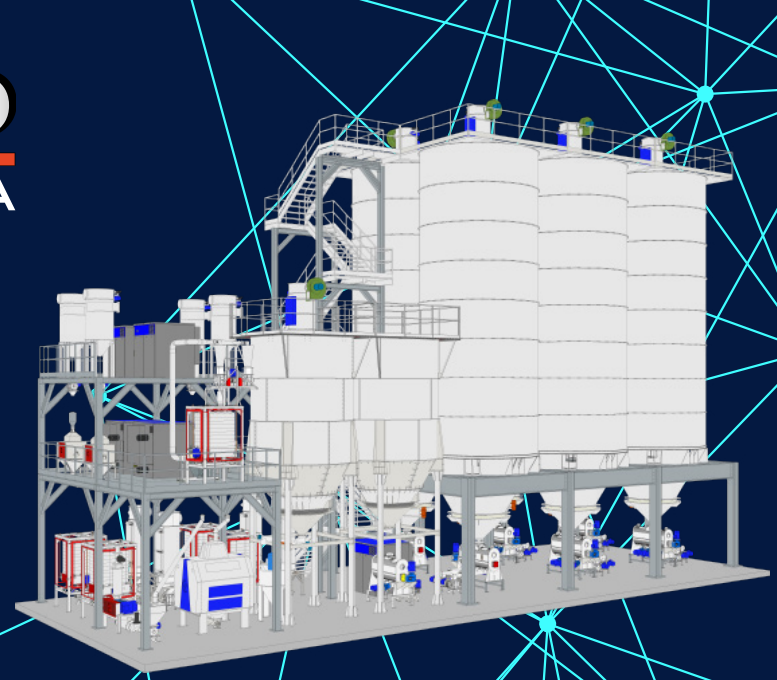
Equipment: Agilent 1290 Infinity LC system with an Agilent 6420 triple quadrupole; Poroshell 120 C18 column (3.0 × 100 mm, 2.7 µm), temperature-controlled at 25°C. Mobile phases and chromatographic conditions: For the tomato and spinach powder: Phase A: H_2O + 1% acetic acid, Phase B:ACN For semolina, wholemeal semolina and pastas: Phase A: H_2O + 1% formic acid, Phase B:ACN + 1% formic acid Gradient: 5% B (0 mins) → 30% B (12.5 mins) → 60% B (17.5 mins) → 5% B (22 mins).
Flow: 0.6 mL/min MS mode: MRM for the characterisation of phenols in vegetable powders; SCAN for semolina, wholemeal semolina and pastas. Characteristic transition patterns were used for identification. Quantification of ferulic acid, apigenin and rutin using calibration curves.

Assessment of antioxidant capacity (DPPH) (Parejo *et al.*, 2000; Brand-Williams *et al.*, 1995)

Reagents: DPPH solution (Sigma-Aldrich).
Equipment: Shimadzu UV 1800 spectrophotometer. Procedure: The working solution was prepared by dissolving 3.94 mg of DPPH in a 100 mL flask containing methanol/water (4:1 v/v). 2.9 mL of DPPH solution was added to 0.1 mL of extract directly in the cuvette. Absorbance was measured at 517 nm for 30 minutes. A Trolox calibration curve (30–500 ppm) was used for quantification.The procedure was carried out in duplicate, with the results expressed as µmol Trolox/100 g.

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Lipid extraction using the Soxhlet method

Reagents: n-hexane, isopropanol (Sigma-Aldrich). Equipment: Soxhletec System HT 1046 (Tecator), Scaltec analytical balance, IKA RV8 rotary evaporator. Procedure: Approximately 10 g of each sample was placed in cellulose thimbles and subjected to Soxhlet extraction using 60 mL of n-hexane for 180 minutes at 60°C. The solvent was removed by vacuum evaporation, then the sample was dried under a nitrogen stream until a constant weight was reached.The extracted fat was recovered using 2 mL of n-hexane/isopropanol (4:1 v/v) and stored at –20°C until analysis.

Determination of tocols by means of HPLC-FLD

Reagents: mixture of n-hexane, ethyl ether and acetic acid (97.3:1.8:0.9 v/v/v), n-hexane for analytical purposes (VWR). Equipment: Agilent 1200 HPLC with a fluorescence detector (FLD), ChemStation software. Procedure: A 1 g sample was taken from each lipid extract, made up to volume in a 10 mL flask with n-hexane and then filtered (0.2 µm). A Poroshell 120 HILIC column (100 × 3 mm, 2.7 µm) was used for separation, carried out under isocratic conditions, using a mobile phase of n-hexane/ethyl ether/acetic acid (97.3:1.8:0.9), with a flow rate of 0.8 mL/min and a total run time of 8 min. The FLD detector was set to: excitation wavelength (λ exc) = 290 nm, emission wavelength (λ em) = 330 nm. An α-tocopherol calibration curve (1.56–25 ppm) was used for quantification. All samples were analysed in duplicate, with results expressed as mg/100 g of fat.

Results and discussion

Bioactive compounds in raw materials

The TPC values showed marked differences between the matrices. Tomato powder had the highest concentration (408.7 mg GAE/100 g), followed by spinach powder (320.9 mg GAE/100 g), while wholemeal semolina and semolina had significantly lower values (29.0 and 13.3 mg GAE/100 g). The higher concentration of TPC in wholemeal semolina compared with semolina is attributable to the presence of bran and germ which, as is well established in the literature, are rich in phenolic compounds (Fu *et al.*, 2017). The very high concentrations of tomato and spinach powder are consistent with those reported for fresh produce (Dinelli *et al.*, 2009; Cho *et al.*, 2008; Gumusay *et al.*, 2015), and may be even higher due to the heat treatment involved in drying, which



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increases the release of phenols from the cell walls (Kim *et al.*, 2016).
With regard to the phenolic profile, chromatographic analysis revealed considerable variability between the matrices. The semolina contained 17 compounds (1257.7 mg/kg), predominantly phenolic acids (e.g. dihydroxyferulic acid, 66.8 mg/kg), anthocyanins such as chlorated cyanidin (159.2 mg/kg), known for protecting against UV radiation (Dinelli *et al.*, 2011), and lignans such as inochinine (641.4 mg/kg), typical of ancient durum wheat varieties (Dinelli *et al.*, 2009). Wholemeal semolina contained higher levels of phenolic acids (e.g. p-coumaric acid, vanillic acid and syringic acid), which were absent from the semolina, but had a slightly lower total free phenol content (1144.3 mg/kg). This result suggests a higher proportion of bound phenolics, as reported by Di Loreto *et al.* (2018). The tomato powder had a very high content of phenolic acids (7677.8 mg/kg), dominated by caffeic acid and chlorogenic acid derivatives, consistent with the findings of Tomas *et al.* (2017) and Borguini *et al.* (2009). The spinach powder, on the other hand, contained only flavonol glycosides, in line with the findings reported by Cho *et al.* (2008).

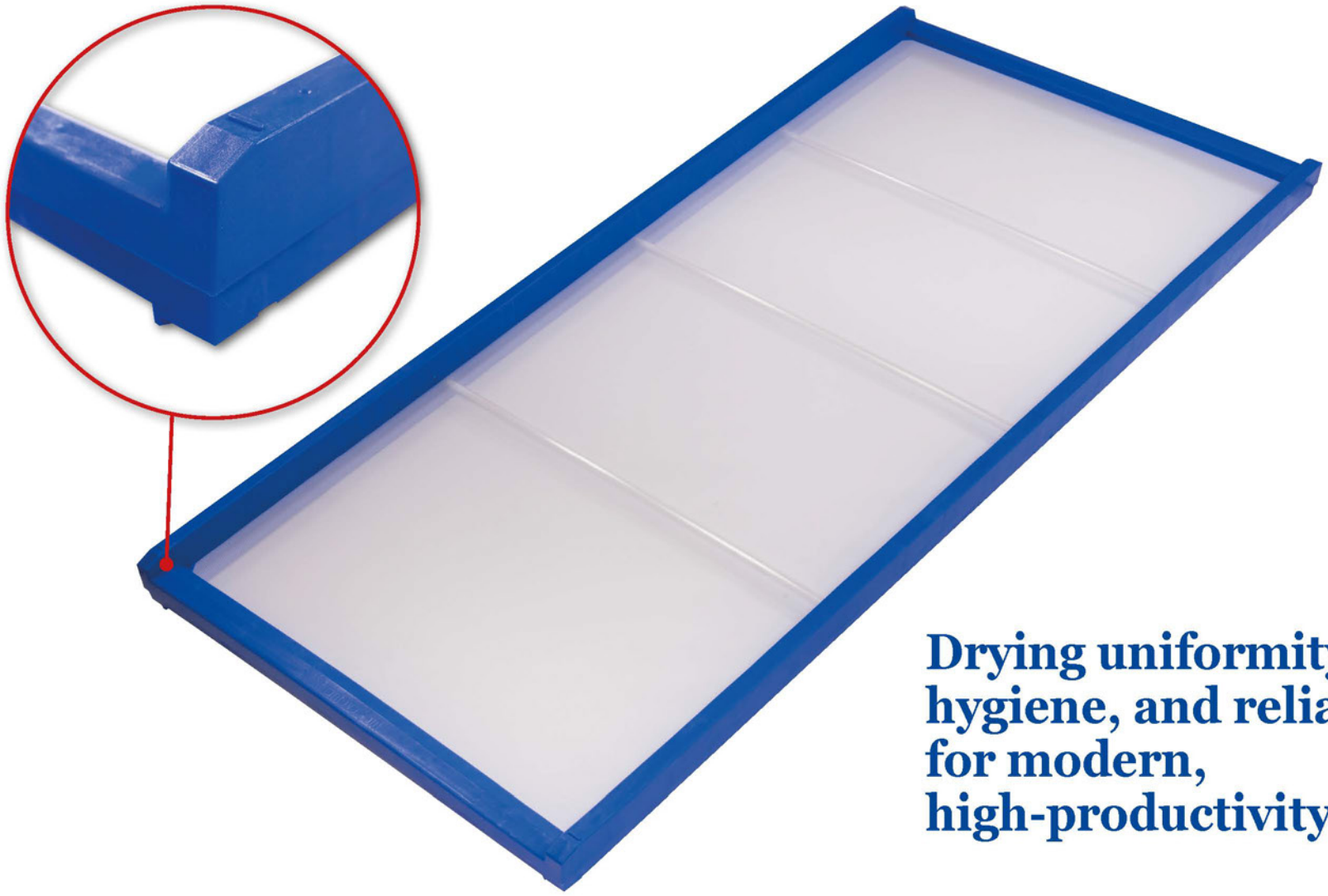
The antioxidant capacity fully reflected the trend observed for TPC: tomato powder (14,311 µmol TE/100 g) > spinach powder (9,324 µmol TE/100 g) > wholemeal semolina (3,304 µmol TE/100 g) > semolina (1,234 µmol TE/100 g). The correlation between total phenols and DPPH was very high ($r^2 = 0.9779$), suggesting that antioxidant activity is mainly attributable to phenols (Mishra *et al.*, 2012).
As for the tocotrienols, the semolina samples contained all identified tocotrienols, above all β-tocotrienol (107.7–92.7 mg/100 g of fat), in line with the findings of Becker (2013). The vegetable powders, on the other hand, had much lower concentrations: in tomato powder, only α- and γ-tocopherol were detected, with values in line with those found in fresh tomatoes (Chun *et al.*, 2006). For spinach powder, the lower α-tocopherol levels compared with fresh spinach may be due to degradation occurring during storage and drying (Syamila *et al.*, 2019).

Bioactive compounds in pastas

In terms of TPC content, the pasta containing tomato powder had the highest value (26.1 mg GAE/100 g), followed by wholemeal pasta (17.9 mg/100 g) and pasta with spinach (15.4 mg/100 g).

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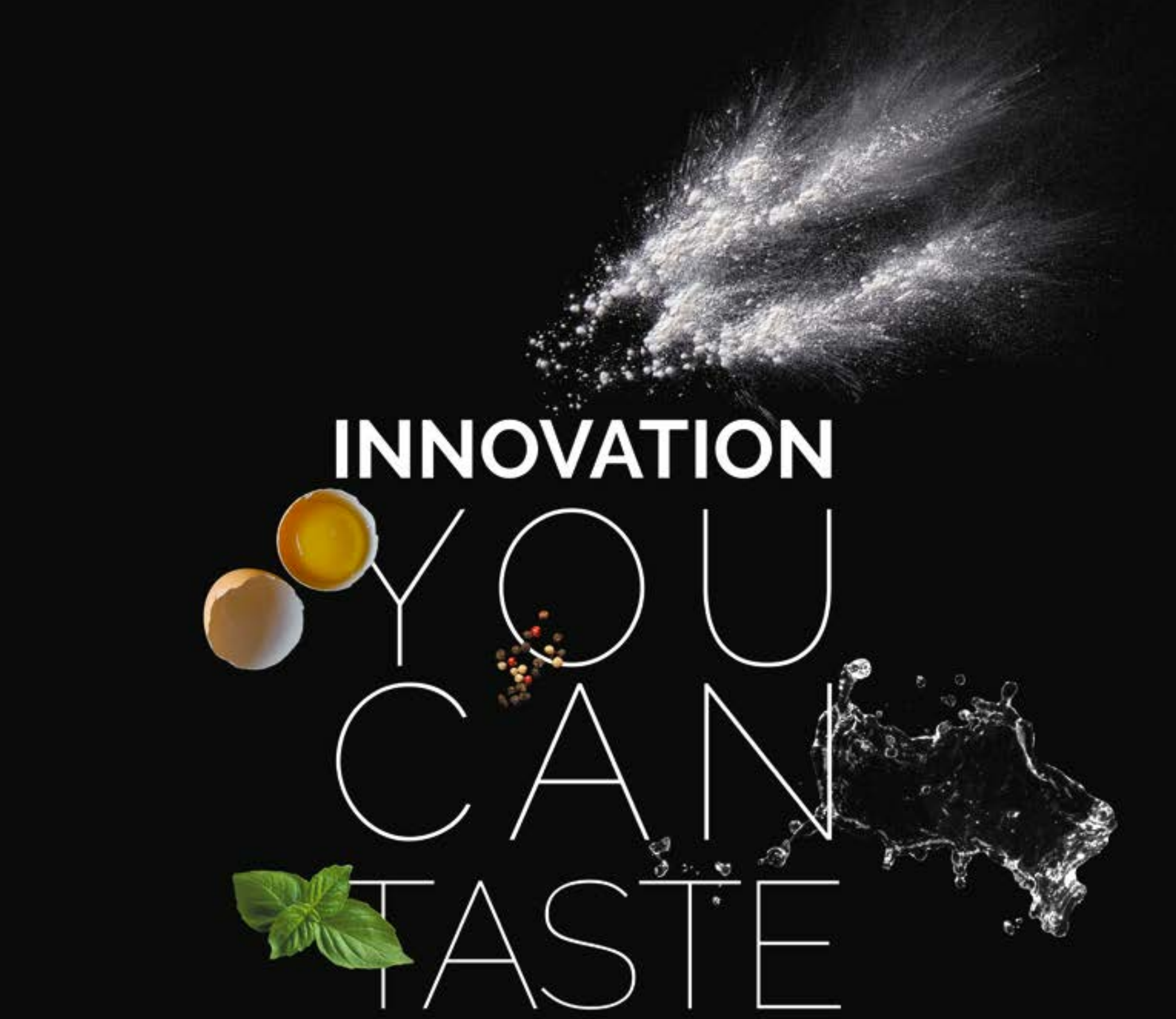
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Semolina pasta was found to be the least rich (12.8 mg/100 g). Although mitigated by processing losses, the increase resulting from vegetable fortification confirms the significant contribution made by tomato and spinach flours, the effects being more marked for the former.
In terms of phenolic profile, the semolina pasta contained 16 molecules (499.3 mg/kg), significantly lower than for the raw material, with the loss of the initially detected stilbene. A relative increase in flavones was observed, particularly 3,4,5-trihydroxy-3,7-dimethylflavone (350.1 mg/kg), while there was a significant reduction in anthocyanins and lignans.
Wholemeal pasta, on the other hand, had a higher total phenolic content than the original wholemeal semolina (1367.8 versus 1144.3 mg/kg), suggesting that bound phenols were released during the drying process. This was also hypothesised by Melini *et al.* (2020). The three dominant molecules were: 3,4,5-trihydroxy-3,7-dimethylflavone (1011.5 mg/kg), chlorinated cyanidin (106.4 mg/kg) and inochinine (47.7 mg/kg).
With regard to antioxidant activity, the tomato pasta exhibited the highest antioxidant activity (3689 µmol TE/100 g), above spinach pasta (1992 µmol TE/100 g), wholemeal pasta (1,781 µmol TE/100 g) and semolina pasta (898 µmol TE/100 g). These results mirror those recorded for the raw materials, and confirm the significant correlation between TPC and DPPH in the pastas ($r^2 = 0.8625$).
The tocol profile of the pastas mirrored that of the raw ingredients. β-tocotrienol was the predominant component in all the pastas containing semolina, while the contributions of vegetable flours were negligible, due to their low tocol content.
The wholemeal pasta showed values comparable to those of the original wholemeal semolina, with slight losses that were not statistically significant. The enriched pastas had a total fibre content similar to that of semolina pasta, as the contribution of vegetable flours was minimal.

Comparison between raw material and pasta

The TPC underwent a moderate drop in semolina pasta (–3.5 %) and a much more significant fall in wholemeal pasta (–38.2 %), probably due to lipid oxidation driven by the germ, which increases the consumption of antioxidants during processing (Fares *et al.*, 2010). As regards the enriched pastas, the lower content compared with the vegetable powders was to be expected, as the latter made up only 30% of the total mixture, but the figures



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confirmed a significant increase in content compared with semolina pasta (+51% for tomato; +17% for spinach). Similarly, antioxidant activity decreased during processing, but increased significantly for the enriched pastas compared with the semolina. The total tocol content remained practically unchanged in wholemeal semolina and increased slightly in semolina pasta; in the enriched pastas, the increase was almost entirely due to the semolina part.

Conclusion

This study shows that the pasta production process affects bioactive compounds in different ways. Although wholemeal semolina has a higher initial content of phenols and tocols, it loses more of these compounds during processing and drying than refined semolina. Fortification with vegetable flours high in phenolic compounds improves the overall content of antioxidant compounds in the finished pasta products, confirming the strong correlation between total phenols and antioxidant capacity. The results also highlight the fact that the final concentration of bioactive compounds is influenced by both the properties of the raw material and the processing parameters deployed, suggesting the need to optimise kneading and drying conditions in order to preserve the nutritional value of the pasta.

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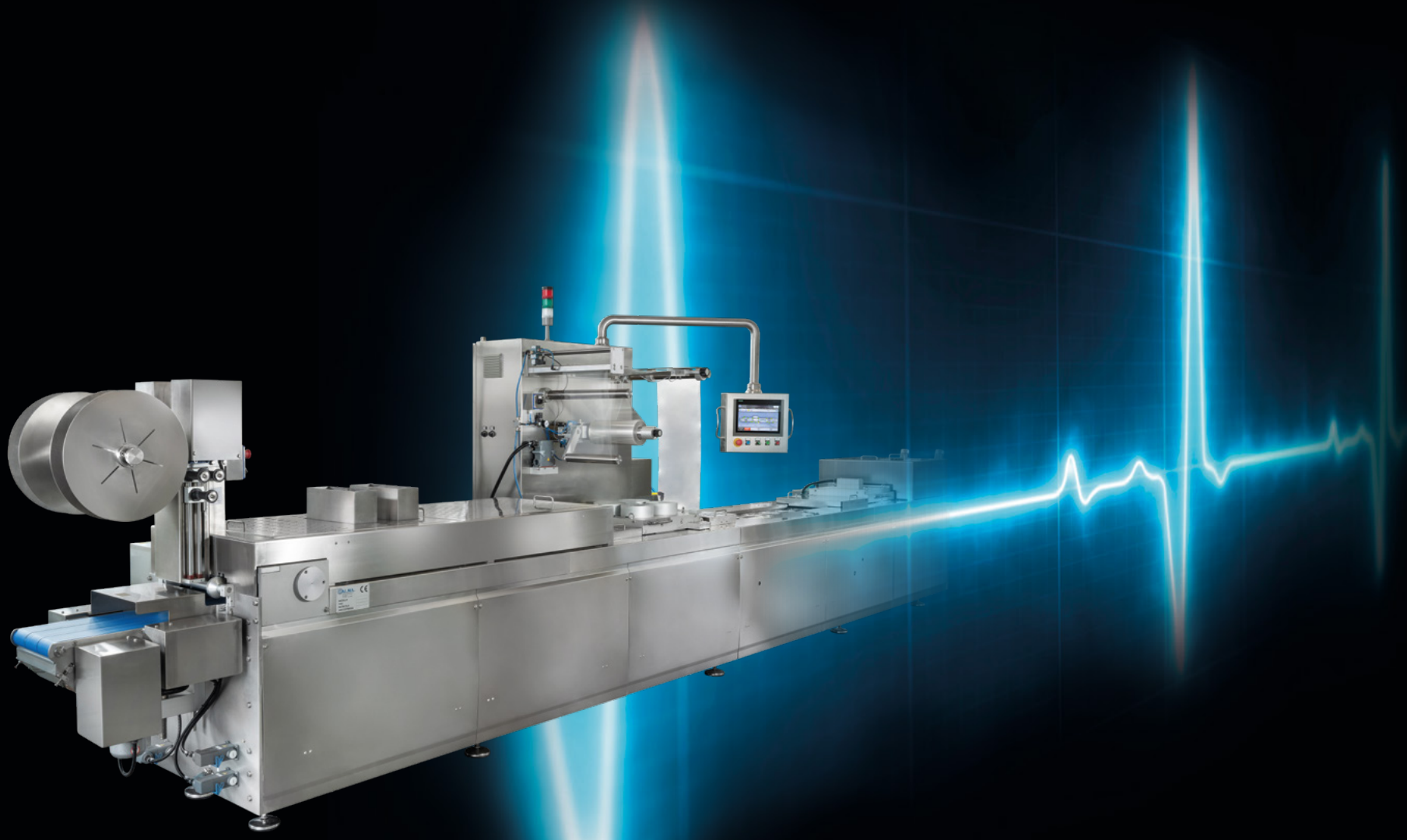
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6

World Pasta Night: a shared celebration of pasta

Editorial team



On June 21, the first edition of the initiative created by Pastaria invited pasta producers, associations, suppliers, restaurateurs and pasta lovers to come together, at the same moment, around a plate of pasta. A debut that lays the foundations for an event set to grow in the years ahead.

One night. One plate of pasta. One simple gesture capable of bringing together people, cultures and countries.
With this spirit, on June 21 the first edition of *World Pasta Night* took place, the international initiative created by Pastaria to celebrate pasta through a shared moment experienced simultaneously around the world.
From its very first edition, *World Pasta Night* demonstrated that it speaks to a genuine desire: gathering around a food that, perhaps more than any other, represents a universal language. Pasta producers, industry associations, suppliers, restaurateurs and pasta lovers embraced the initiative, creating a spontaneous and widespread celebration that crossed continents, cultures and time zones.
The images and messages shared throughout the evening told many different stories, all united by the same theme: pasta as a symbol of togetherness, conviviality and friendship. From family dinners to company gatherings, from initiatives promoted by associations to social media posts shared by individuals, *World Pasta Night* came to life thanks to everyone who chose to take part.
For a first edition, the greatest achievement was not the number of participants, but having laid the foundations for a new international occasion. An open, inclusive celebration without borders, designed to grow year after year through the contribution of everyone who believes in the cultural and social value of pasta.
Pastaria would like to thank all the associations, pasta producers, companies, partners and individuals who embraced this invitation and helped turn a simple idea into a shared global experience.
The next appointment is already set: June 21, 2027. Another night, with even more tables, more encounters and more stories to share. Because *World Pasta Night* has only just begun.

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7

The technology of Veneto Bigoli: back to the roots

Editorial team



Thanks to fresh archival materials, the origins of Veneto Bigoli pasta have been retraced, from the original idea to the administrative procedure and the “privilege” granted between 1602 and 1604 to Bartolomeo Veronese. Here we have one of the oldest documentary records relating to the mechanical production of pasta in northern Italy.

A recent archival research is helping to fill in the gaps about the history of pasta in the Veneto region. Previously unpublished documents relating to the privileges granted between 1602 and 1604 have given us a fresh perspective about the birth of mechanical pasta production in the Domini di Terraferma (literally the mainland domains, or “Stato da Tera” in the Venetian vernacular) area. We talked about this discovery with Paolo Caratossidis, author of the desk research, which might also make a significant contribution to the scientific dossier being compiled for the recognition of Veneto Bigoli as a Protected Geographical Indication (PGI) product.

What are the scientific reasons, and the objectives from a methodological point of view, behind the systematic study of Bigoli and the fresh pasta supply chain in the Veneto region?

This research is not just about food traditions and folklore, it also looks at the history of the economy, technological progress, and industrial heritage of the Veneto area. The aim was to reach beyond anecdotal evidence, and to analyze, through the historical-critical method and examination of primary sources, the transition from domestic, manual pasta production to the first standardized manufacturing models.

The study of fresh pasta-making is directly connected to the history of food technology and the evolution of mechanical extrusion processes. The four pasta formats that we have specific information on are: “*Bigoli*”, “*Menadei*” (or “*Menadelli*”), “*Lasagne*” and “*Maccaroni*”. So when we go back to their origins, we need to study cereal supply flows, the introduction of the first machine dies and the regulations drawn up by the Republic of Venice through the industrial property rights system.

This approach is also of institutional value, offering documentation that can be added to the scientific dossier aimed at obtaining the Protected Geographical Indication (PGI) label for the Veneto Bigoli and helping to document the product’s historical links with the territory.

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Paolo Caratossidis

From a historiographical viewpoint, some stages of the history of pasta production were considered to be firmly established. What new elements emerged from this archival investigation?

The study helped us to pinpoint time frames and the geographical framework of technological innovation for extruded pasta in northern Italy. Much of the existing historiography had focused on resolutions passed by the Venetian Senate. By extending the research to peripheral archives, we uncovered papers of particular interest, namely at the Bertoliana Civic Library of Vicenza, in the Torre Archive Fund (envelope 866, papers 517-518).

The documentation in question relates to the administrative and technical applications filed from late 1602 onwards by Bartolomeo Veronese, indicated in the records as “Bortolo Veronese, also known as Abbondantia”. These documents from Vicenza refer to the procedure that would result in the “privilege” granted to the city of Padua on 26 January 1604.

The most interesting point is that we have identified the documentary link between the “conceptual” phase and institutional recognition of the product. This shows the existence of a veritable territorial system of

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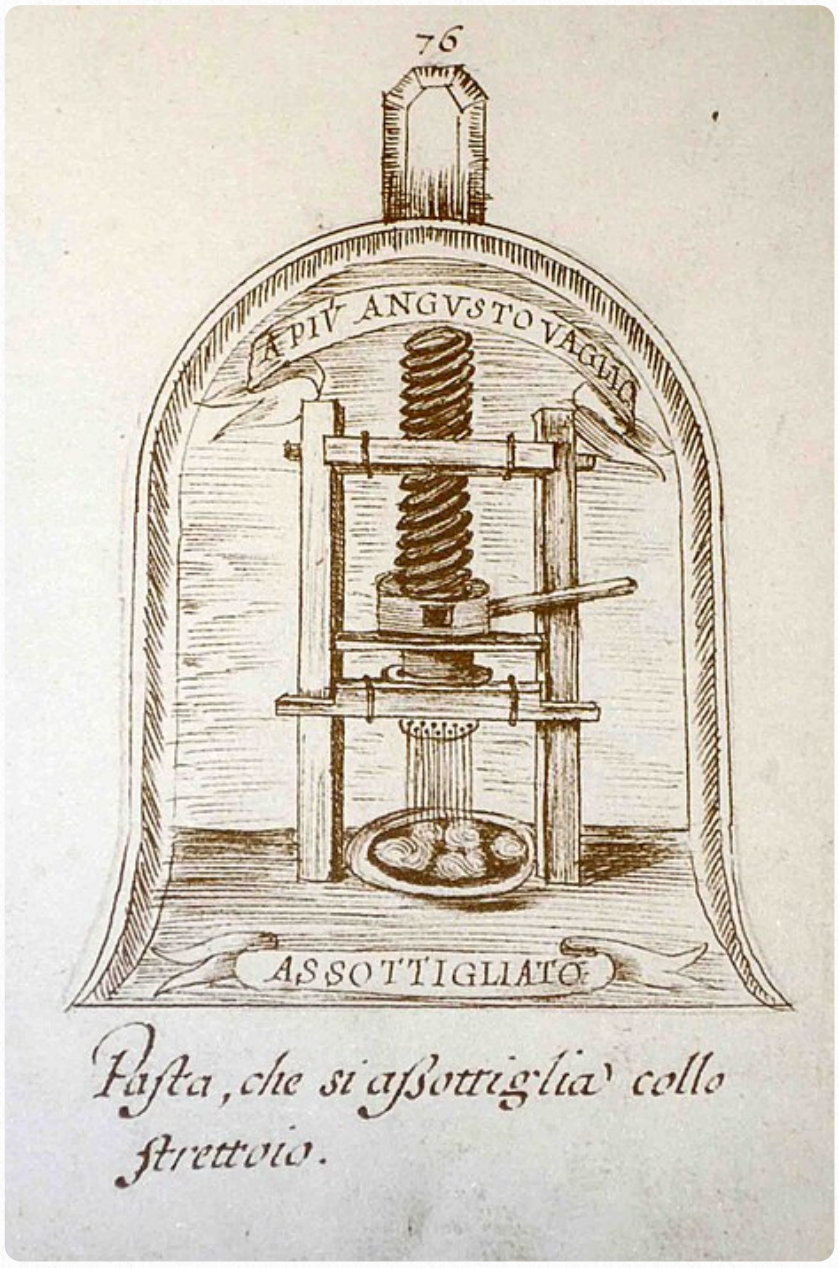
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innovation, developed between Vicenza and Padua, aimed in part at reducing dependence on pasta imports from the "Apulia" region through the development of local production technologies.

For what scientific, economic and legal reasons does this discovery take on such significance for the history of the food industry?
The value of this discovery lies in the actual documentation of the transition from simple manual kneading of the dough to a production system based on an "*edificio*", literally a building or edifice, a term used at the time to indicate a complex machine or mechanical system. The application filed by Bartolomeo Veronese describes a device intended for the production of pasta having characteristics such as to increase productivity, reduce labour requirements and reduce processing costs. With the new system, a single machine operator





Images: Courtesy of the Accademia della Crusca

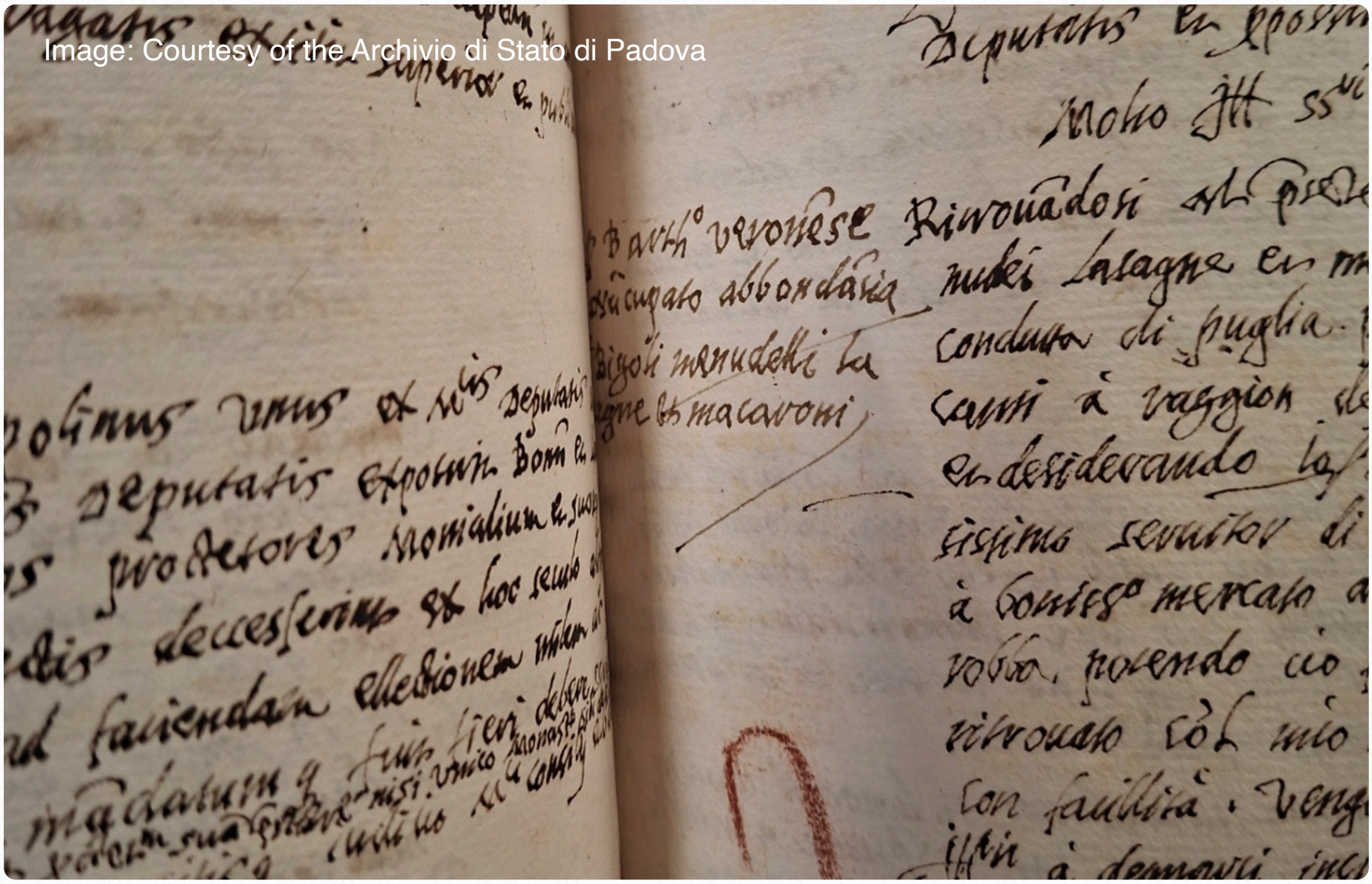
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could carry out a job normally requiring ten men.

From an economic point of view, the introduction of this technology seems to meet the need to foster competitive local production, reduce dependence on imports and make a staple food available at a lower cost.

From a legal point of view, these documents illustrate the operation of the “exclusive privilege”, an incentive granted for a five-year period to foster technological innovation.

Taken together, these documents represent, as far as we know, one of the oldest known testimonies relating to the mechanization of pasta production in northern Italy, and have advanced our knowledge about the history of technological progress in the sector.

In the same place and at the same time, Padua could boast the presence of Galileo Galilei. Are there any elements that might link the scientist to this context, and is it historically right to talk about a “Galilean cuisine”?

The link between Galileo and the material culture of the time can be found in the year 1604, when Galileo Galilei was teaching at the University of Padua. From that year we

also have a copy of the scientist's handwritten shopping list. This document gives us a valuable insight into the eating habits of his family and those around him. The idea of a "Galilean cuisine" is not that of attributing to Galileo the invention of recipes or culinary techniques, it means that in those years, the culture of the time showed a growing interest in mechanics, experimentation and the rationalization of processes.

While Galileo studied the strength of materials, the mechanics of bodies and the functioning of Archimedes' auger, local artisans and builders were applying similar principles to the processing of cereals and construction of production machinery. The fact that the privilege relating to the pasta "edifice" was obtained at the height of Galileo's scientific activity suggests that scientific innovation and technological innovation in the food sector was happening within the same cultural environment.

We are continuing to collect materials, also with the aid of artificial intelligence, in order to better understand this context. I recently had the privilege of talking to astrophysicist and Galilean scholar Alessandro De Angelis, author of a recent guide dedicated to Galileo's Padua. The fact that in those years Galileo was working closely with trusted craftsman Marcantonio Mazzoleni on the construction of his scientific instruments brings up a particularly stimulating question: what was the relationship between the world of scientific mechanics and that of the city's artisan workshops. Some people have raised the hypothesis that some of the scientist's collaborators may also have worked on the construction of Bartolomeo Veronese's press. But this historical conjecture has not yet been backed up by documentation.

It would however come as no surprise.

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