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Colophon

Pastaria International DE
2/2022
March



PUBLISHER

Kinski Editori S.r.l.

registered office

Via Possioncella 1/1 • 42016 Guastalla

operational headquarters

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ROC no. 23238

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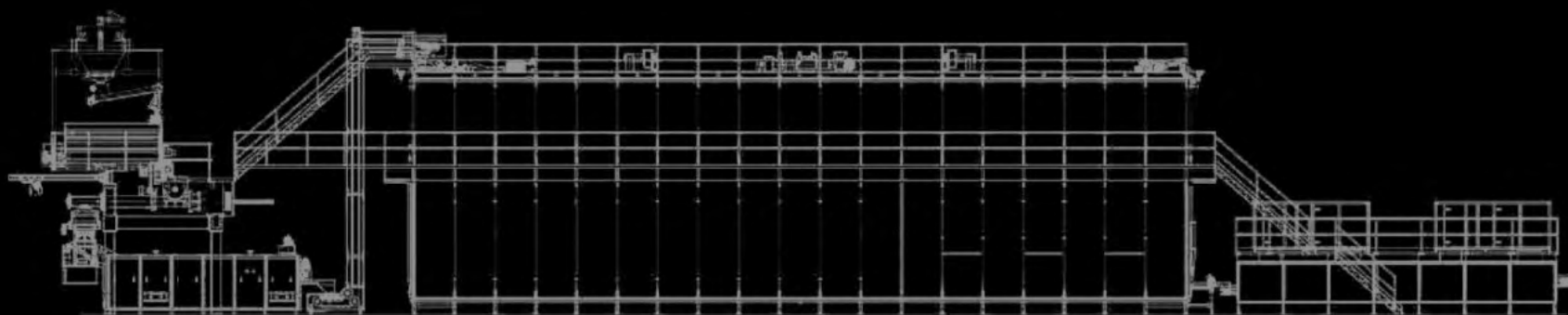
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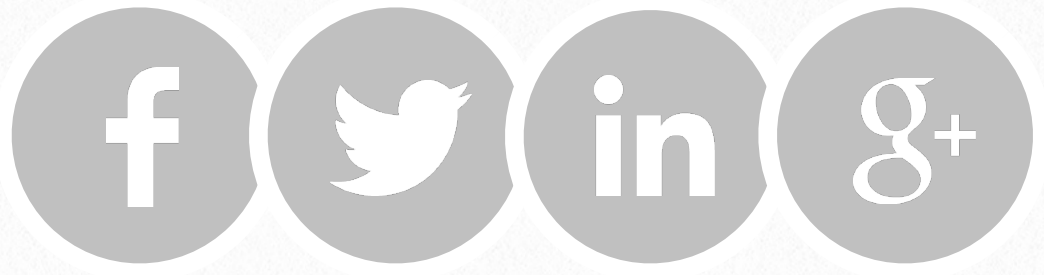


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1



Protein extracts from insects to produce “high protein content” pasta

Gabriella Pasini

Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE),
University of Padua



A summary of Gabriella Pasini’s presentation at the *Dried pasta: innovation and sustainability* conference held as part of the Pastaria Festival 2021.

Eating insects is a common practice in many countries around the world, and particularly in Africa, Latin America and Asia where hundreds of species represent an important food source of macro- and micronutrients (Belluco et al., 2013). The practice has never been customary in Europe. Regulation 2283/2015, however, introduces edible insects as a category of “novel foods”, defined in Article 3 as: “any food that was not used for human consumption to a significant degree within the Union before 15 May 1997”. Naturally, placing such foods on the market requires authorisation. Last year, *Tenebrio molitor* larvae was authorised (Reg. EU 882/2021) in various forms (dried larvae to be used as whole insects, as a snack, as an ingredient in a series of food products) while in August, the EFSA delivered a positive opinion on the consumption of *Acheta domesticus* (<https://doi.org/10.2903/j.efsa.2021.6779>), in anticipation of a proposed implementing regulation to govern its placement on the market in the following forms: frozen, dried, ground and as an ingredient in a series of food products.

Based on the foregoing, it will also be possible to use these ingredients to produce “fortified pasta”, i.e. with added micro- and/or macronutrients, for the purposes of addressing dietary deficiencies or meeting specific consumer demands.

The bibliography contains a large number of studies conducted on “fortified pasta”, as well as a recent review of such studies (Dziki et al., 2021), describing the nutritional/health effect of enrichment but also the factors that affect acceptability to the consumer. For example, the addition of fruit or vegetable powders/purées can increase antioxidant activity based on the quantity and quality of polyphenols in the end product, but also negatively affect the consistency of the cooked product.

Nevertheless, one of the most common trends involves using protein to make protein pasta. To this end, plant-based proteins, derived from pulses in particular, are the main source used to make many types of pasta on the market. Scientific research also recommends the use of animal proteins such as fish powders (pangasius, cod, salmon), while the use of insects – consisting, on average, of 50% protein – is currently only referred to in two



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Table 1 QUALITY PARAMETERS OF THE CONTROL PASTA (CP), PASTA ENRICHED WITH *ACHETA DOMESTICUS* (AD) OR *TENEBRIO MOLITOR* (TM) PROTEIN EXTRACT (average \pm sd)

Cooked pasta	CP	AD	TM
Water absorption (%)	148 \pm 2.9 ^b	1187 \pm 7.7 ^a	150 \pm 2.1 ^b
Optimal cooking time (min)	11.5 \pm 0.5 ^c	12.5 \pm 0.5 ^b	14.0 \pm 0.5 ^a
Cooking losses (%)	4.1 \pm 0.06 ^b	8.4 \pm 0.1 ^a	8.1 \pm 0.3 ^a
Texture (N)	12.4 \pm 0.10 ^b	13.7 \pm 0.08 ^a	13.8 \pm 0.02 ^a
Adhesiveness (N)	-0.01 \pm 0.002	-0.01 \pm 0.002	-0.008 \pm 0.001

The values followed by various letters are significantly different for $p \leq 0.05$

scientific works, recently published (Duda et al., 2019; B. Çabuk and B. Yılmaz, 2020).

In the first study, researchers from a university in Poland tested cricket powder at various concentrations. They found that, while there was an increase in nutritional values, concentrations above 5% were also associated with a deterioration in the sensory and technological characteristics of the end product. Additionally, 5% enrichment would not qualify for the “high in protein” claim. The second study, meanwhile, assessed the nutritional, sensory and technological characteristics of fresh egg pasta enriched with 15% *Tenebrio molitor* and *Locusta migratoria* flour. In this case too, despite a benefit in terms of nutritional properties, critical issues were identified, above all in terms of sensory characteristics, likely due to the

high fat content in the insect powders added. In particular, the smell of the pasta was found to be the most critical sensory parameter.

Returning to the subject of this presentation, i.e. insect protein extracts rather than insect powders per se, such extracts were used to make pasta enriched with a quantity of protein sufficient to make up at least 20% of the energy value of the pasta, the lower limit to qualify for the “high in protein” claim. The experiment involved starting with powdered dried *Tenebrio molitor* (larvae) and *Acheta domesticus* (adult form) species of insects, and performing a defatting process using hexane to remove some of the fat and increase the protein extraction yield. Subsequently, the samples were placed in a saline solution to solubilise the proteins that, in freeze-dried



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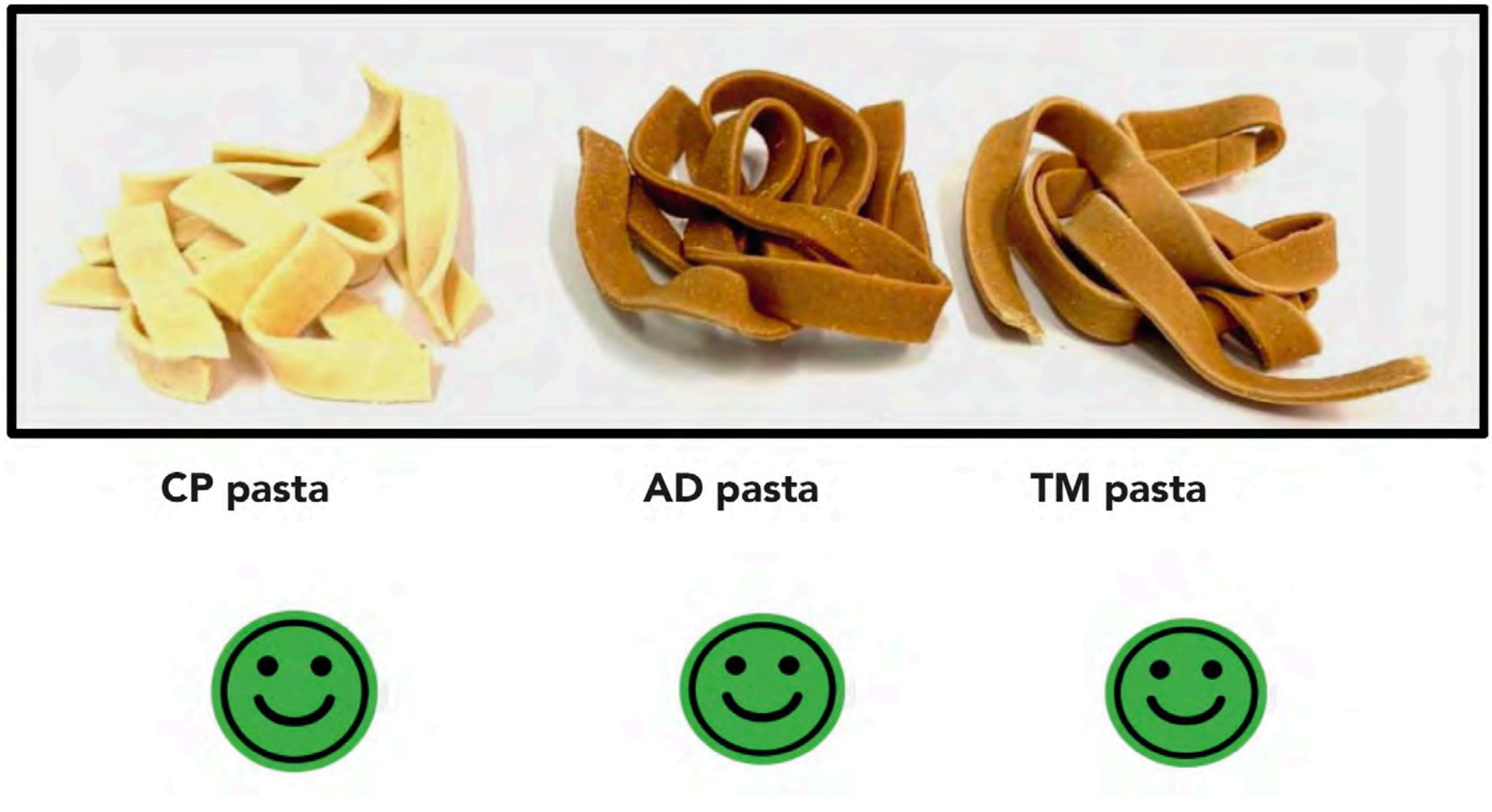
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Figure 1 PERCEPTION OF COLOUR. CONTROL PASTA (CP), PASTA ENRICHED WITH *ACHETA DOMESTICUS* (AD) OR *TENEBRIO MOLITOR* (TM)



form, were then added to the wheat semolina to produce two types of enriched pasta (TM pasta and AD pasta), which were compared with a control pasta (CP pasta) made using just wheat semolina. The standard qualitative parameters at optimal cooking time were then assessed, i.e. water absorption, loss of solid substances in cooking water, consistency and stickiness using the dynamometer ([Table 1](#)). In terms of sensory properties, meanwhile, the colour of the uncooked pasta ([Figure 1](#)) and smell of the cooked pasta ([Figure 2](#)) were assessed.

The quantity of water absorbed by the AD pasta was significantly higher than that absorbed by the other two types, probably due to its amino acid composition, which is rich in hydrophilic amino acids that can form a structured gel during cooking. The consistency observed for the AD and TM pasta types was significantly greater than that observed for the CP pasta, in keeping with the data obtained by Duda and collaborators (2019). Nevertheless, the increased consistency does not appear to limit the loss of substances during cooking, which was found to be higher in the AD and TM pasta types than in the

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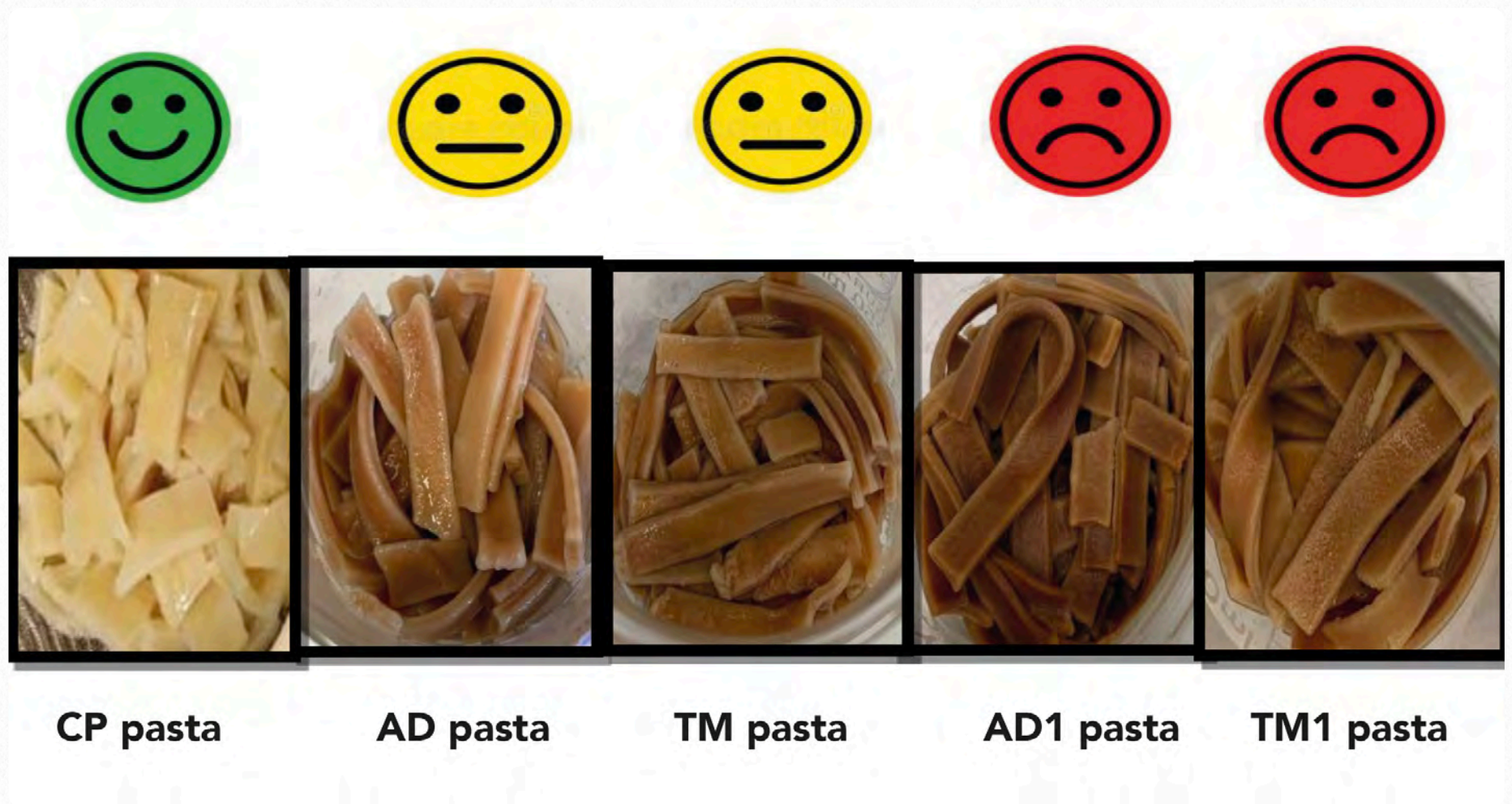
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Figure 2 PERCEPTION OF SMELL. CONTROL PASTA (CP), PASTA ENRICHED WITH *ACHETA DOMESTICUS* (AD) OR *TENEBRIO MOLITOR* (TM) PROTEIN EXTRACT, PASTA ENRICHED WITH INSECT FLOURS PER SE (AD1 OR TM1)



control pasta (CP). This behaviour, previously observed when using plant-based protein additives (Kaur et al., 2013) may be correlated with the weakening of the protein matrix, associated with the gluten network, dilution of which leads to greater loss during cooking, despite the similar levels of stickiness observed across all samples, without significant differences. Finally, the subjective colour analysis found a high level of acceptability among the panel of assessors. They associated it with the colour of whole wheat pasta, and

therefore did not regard it as better or worse than the control, but simply different. As regards perception of the smell, the pasta types enriched with protein extract were found to be less acceptable than the control pasta, but also less unappealing than pasta enriched with insect flours per se, suggesting a potential margin for improvement as regards the organoleptic properties, found to be critical in the studies listed in the bibliography. To conclude, the new regulation on novel foods opens up a new market in which

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Europe is showing increasing interest, in light also of the potential nutritional benefits of insects and their low environmental impact. Numerous studies show that the sensation of disgust that may be evoked in consumers can be overcome by using the insects as ingredients, and grain-based foods such as pasta and bread are best suited to this (Beatriz A. Acosta-Estrada et al., 2021).

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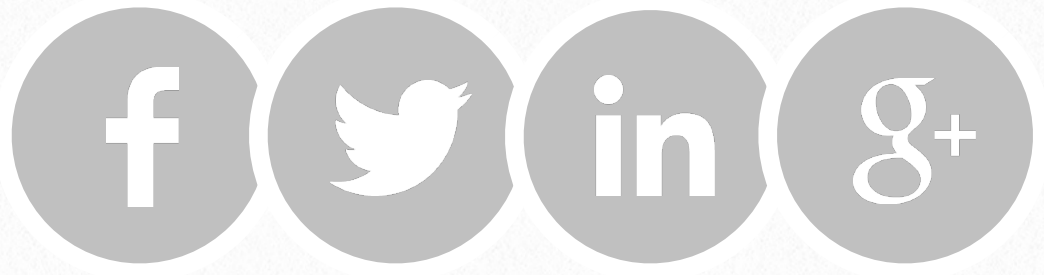
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2



Pastaria webinars to get under way: first session to cover commodity price increases and energy shock

Editorial staff



Shock energetico e stagflazione: le insidie dietro il caro-commodity e gli scenari per chi produce pasta [Energy shock and stagflation: the negative driving forces behind commodity price increases and scenarios for pasta producers] is the title of the opening session of Pastaria's spring webinar series, taking place on 13 April. The webinars are free of charge and reserved for operators in the sector.

Pastaria's spring webinar series

A new tool is added to Pastaria's set of specialist information resources. As well as magazines (digital and hard copy), portals (www.pastaria.it and www.pastariahub.com), the app, social media channels and the Pastaria Festival, Pastaria is now offering webinars. The first session of the Pastaria spring webinar series will be held on 13 April, via Zoom. With contributions from authoritative experts, these sessions are intended to provide opportunities to delve deeper into highly topical issues and those of particular interest.

Energy shock and stagflation: the negative driving forces behind commodity price increases and scenarios for pasta producers is the topic of the first Pastaria spring webinar.

Price tensions in relation to raw materials and energy price increases: the topic of the first webinar

The extraordinary challenges currently facing businesses operating in the agrifood sector, in the context of exceptional increases in the prices of raw materials and the energy shock, are leading to serious financial instability and a drastic reduction in companies' operating margins. At the beginning of 2022, the

situation is further exacerbated by the conflict in Ukraine, which has taken the entire Black Sea area out of play: this area is of strategic significance in terms of supplies of cereals and other agricultural products. With the aim of shedding light on the current tensions, the Pastaria Centre for Economic Research has organised a webinar entitled *Shock energetico e stagflazione: le insidie dietro il caro-commodity e gli scenari per chi produce pasta* [Energy shock and stagflation: the negative driving forces behind commodity price increases and scenarios for pasta producers]. Scheduled for Wednesday 13 April 2022 at 11:00 a.m., it will be an opportunity to delve deeper and reflect on the dynamics that are currently defining world trade. Elements will be identified that are useful to assessing potential medium-term scenarios, in an extremely volatile market, the developments of which, by now, bear almost no relationship to traditional metrics and are subject to pressing interference from speculative demand.

Taking part

Attendance is free and reserved for operators in the sector, with mandatory registration until all places are filled. Users registered with pastaria.it will receive a dedicated newsletter with details of how to take part. The webinar will be in Italian.

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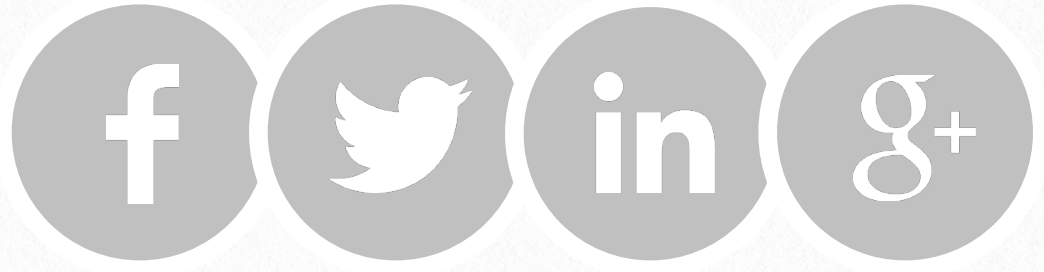
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3



Durum wheat, staples good for 2022/23, but geopolitical developments remain uncertain

Pastaria Centre for
Economic Research



Still in shock over the massive increases in wheat prices, traders are wondering how much longer the tension on world cereal markets will persist. And above all, whether the next season will be characterised yet again by prices that are “light years” away from the historical average, in a scenario characterised by a general imbalance in market dynamics.

Durum wheat, the main users of which are pasta factories, has long been hovering well above the 500 euros per tonne mark. How much longer is it going to stay above this threshold? Or can a situation of gradual normalisation be expected?

To evaluate the situation from an objective standpoint, we have to look at three factors: the climatic factor, which for the time being seems, on the whole, to be under control, at least in Europe and in the North American rural areas; the speculative factor, which is difficult to determine and is closely dependent on the evolution of the conflict in Ukraine; and, of course, the factor associated with the prices of staples.

So it would not be wrong to start from the latter, given that the balance between supply and demand is what, under normal circumstances, defines price levels on world markets, which have long since become globalised. It is important to note that if prices have deviated from their usual trajectory this year, experiencing a break in trend under the alarmed gaze of traders and users, this was due to the combined effect of demand shored up by the economic recovery, especially among western countries, and an exceptionally low supply, following the poor performance of the Canadian harvests, decimated last summer by drought.

This is the starting point for an informed assessment of possible price trends. On this front, the premises are more than positive. As already mentioned, Canadian producers do not appear to be particularly worried about the weather component this year. Neither do producers in Europe where operating conditions and crop development appear to be proceeding according to plan.

In short, if the prices of staples alone were to be taken into account, cautious optimism would be more than justified and, even more important, there would be the prospect of a gradual mitigation in tension as regards



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prices, which would, nonetheless, remain at historically high levels.

All the necessary conditions exist, if we look at the forecasts currently circulating on the 2022 harvests. Reassuring indications are already emerging from Ottawa – the main reason for apprehension among traders and markets last year – starting with the 2022 durum wheat sowing figures which Statistics Canada analysts expect to increase by

9%. It is worth remembering that last year it was the drop in yields for the season – and not the fall in investment, which was, generally speaking, limited (-2.8%) – that led to the very poor production balance, with a 2021 output of only 2.65 million tonnes, a drop of more than half compared to the 6.57 million of the previous year (around -60%).

This year, analysts estimate, sowing should bounce back to 2.45 million

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hectares from 2.24 million a year ago. Yields should return to “normal” values of 2.30 tonnes – as opposed to 1.23 tonnes – per hectare, and the harvest is expected to top 5.52 million tonnes, i.e. more than double. With an initial stock of half a million tonnes, Canada will have more than 6 million tonnes of durum wheat at its disposal in the 2022/23 season, a volume that is increasing year on year but is still 5% below the average of the last five seasons.

According to the analysts, under more favourable operating conditions, Canada should be able to export 4.3 million tonnes. This is over 80% more than the estimate for the entire 2021/22 season. As already mentioned, the outlook is also favourable in Europe, while in North Africa, where water shortages could seriously affect yields, harvests will not be as generous, at least according to current estimates, in a year that may also be impacted, on the supply side, by a shortage of old stocks.

On balance, but with all the uncertainties justified by the drastic global geopolitical emergency, taking into account also global supply chain difficulties and the evolution of the pandemic this autumn, the forecasts are optimistic that there will not be a further escalation of prices, which, on the contrary, are likely, after the summer, to be

adjusted downwards, albeit to a limited degree.

Due to greater global and particularly Canadian supplies, the price of CWAD No 1 with 13 protein points (North American benchmark) is likely to settle at \$400 per tonne, on average, for the 2022/23 season. This, at the moment, is what the experts are predicting. So not a “normal” market level. Although a reverse under current conditions would be no small matter in itself, considering that the average spot price for Canada Western *Amber Durum* wheat with the same characteristics is currently around \$600/tonne. Looking ahead, this would mean a fall of more than 30%, based purely on a reading of the staples alone. Two aleatory factors remain, as mentioned above: the conflict in Ukraine and how it may develop throughout the Black Sea area, and the climate component. But in this case, uncertainty reigns supreme.

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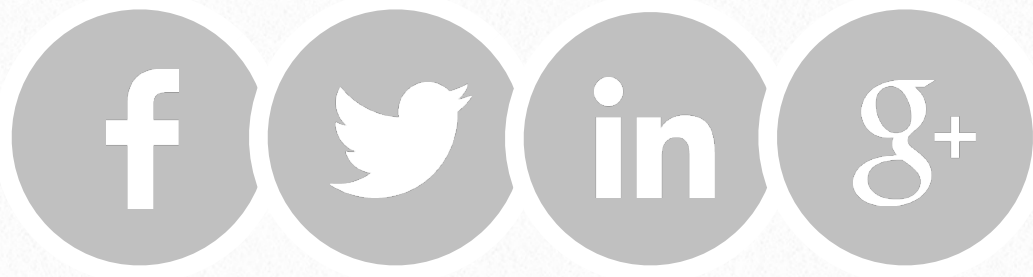
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4



Veronica Gallo

The impact of formulation on the microstructural properties and *in vitro* digestibility of starch in samples of commercially available pasta



The impact of formulation on the microstructural properties and *in vitro* digestibility of starch in three types of commercially available spaghetti was investigated in Veronica Gallo's doctoral thesis, summarised in the following pages. The thesis, entitled *Modellazione della digestione in vitro di prodotti adatti a specifiche popolazioni di consumatori* (Modelling *in vitro* digestion as strategy in developing tailored food for specific consumer population) was among the winners of the Pastaria Awards 2021.

Being so popular, easy to cook and therefore largely consumed worldwide, pasta represents an ideal matrix for the enrichment with a wide range of ingredients.

Traditionally, pasta is made with durum wheat (*Triticum turgidum*, subsp. *Durum*) semolina and water by a multi-stage process that strongly affects the end-product quality.

Besides, in modern industry, pasta enrichment with unconventional ingredients such as whole durum wheat semolina and legumes flour are becoming a strategy to develop highly nutritious food products able to attract new classes of consumers.

Pasta made with whole durum wheat semolina contains larger number of vitamins, minerals, and fibre than durum wheat pasta, since these substances are mainly contained in the bran and germ which are mostly removed during milling (Vignola, Bustos, & Pérez, 2018). In addition, increasing the dietary fibres content in food products represents an effective approach to overcome health problems such as hypertension, diabetes, colon cancer and coronary heart diseases (Brand-Miller et al., 2009; Wen et al., 2017) and it is considered a valuable way to reduce the glycemic index (GI) of high digestible products. Among the legumes flour, the one from lentil (*Lens culinaris* Medik.) is gaining popularity due to its excellent and balanced nutritional composition. In fact, lentil flour represents a great source of nutritional components essential for good human health and thus it is increasingly used in bakery (bread, cake, crackers), extruded (pasta, snacks) and other products (dressings, soups, dairy, and meat products). Specifically, lentil flour is quite rich in high-quality proteins (~23%) containing all the essential amino acids, dietary fibres (~9%), minerals, vitamins (mainly vitamin B9/folate) and antioxidant compounds. In addition, the amino acid profile of lentil flour complements the one of wheat flour, since lysine, leucine, aspartic acid, glutamic acid, and arginine are quite high in lentil flour whereas sulphur amino acids are abundant in wheat flour. This implies that the combined use of lentil flour with wheat flour represents an efficient way to provide a well-balanced amino acid profile. The addition of



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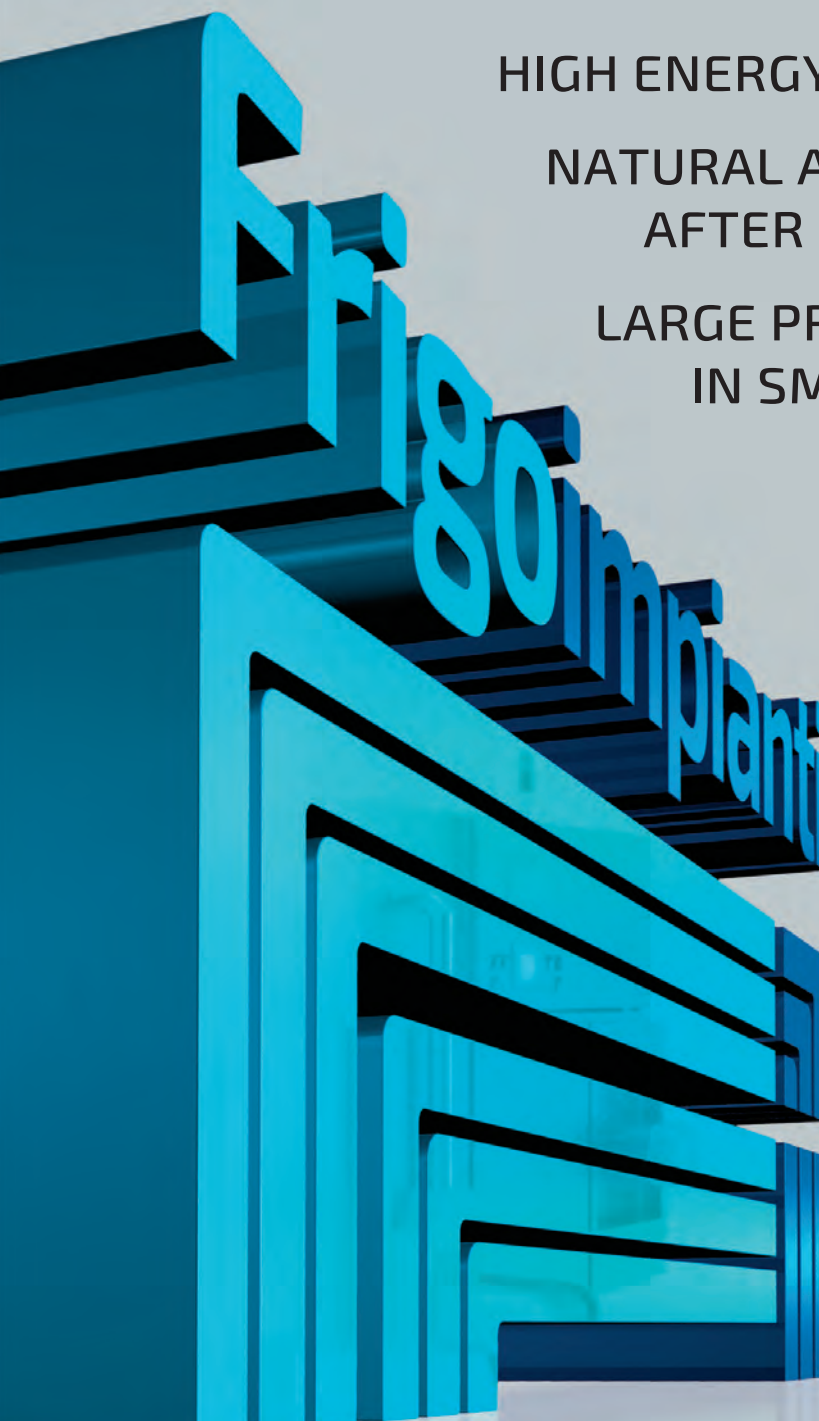
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lentil flour to wheat-based products such as pasta may also lead to a reduction in the GI. This achievement can be mainly related to its peculiar chemical composition such as a lower starch content (~50%) and a higher amylose/amylopectin ratio and soluble fibre content than wheat flour. Lastly, lentil flour is gluten-free, and it is marked by a reduced fat (~2%) and caloric content (~340 kcal/100g).

However, the introduction of fibre and non-gluten proteins can affect the structure of pasta matrix, e.g., compromising the formation of a cohesive gluten network, water absorption (Foschia et al., 2013) and starch granules accessibility.

Moreover, during cooking pasta undergoes to multiple heat- and water-mediated transitions (including starch gelatinization and gluten denaturation) resulting in microstructural modifications of the pasta matrix which could have important repercussions on its quality and nutritional properties (Carini et al., 2014).

Taking into consideration all of the above, one of the study cases treated within this Ph.D. project concerned the evaluation of the impact of pasta formulation on the microstructural properties and thus on the *in vitro* starch digestibility of three types of commercial spaghetti.

Materials and methods

Materials

All the experimental tests have been performed using three types of commercial spaghetti: durum wheat spaghetti (S), whole durum wheat spaghetti (WS) and red lentil spaghetti (LS).

The nutritional composition (% w/w) of spaghetti samples can be reassumed as follows: S – carbohydrates 70.2, proteins 13.5, fat 2.0, fibre 3.0, salt 0.013; WS – carbohydrates 65.7, proteins 13.0, fat 2.5, fibre 6.5, salt 0.013; LS – carbohydrates 47.4, proteins 25.0, fat 2.4, fibre 12.0, salt 0.003.

Sample preparation

S, WS and LS samples were cooked in boiling distilled water (1:10 w/v) at the Optimal Cooking Time (OCT, min) which was 9 min for S and 8 min for WS and LS. The uncooked samples (cooking time = 0 min) were used as control. After boiling, pasta samples were immersed in cold distilled water ($T = 4^{\circ}\text{C}$) for a few second to prevent overcooking. Samples were collected and stored in polyethylene bags at 4°C until used for analysis.

Microstructural analysis

Scanning Electron Microscopy (SEM, LEO EVO 40, Zeiss, Germany) was used to



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examine the microstructure of transverse cross-sections of S, WS and LS samples. Raw and cooked samples were observed by SEM with a 20 kV acceleration voltage and a x 70 and x 1500 magnification according to Romano et al. (2018). The cross-section area (mm²) of samples was quantified using a method based on image analysis protocol of SEM micrographs. Three micrographs were selected and processed per sample by Image Pro Plus 6.1 for Windows[®] (Media Cybernetics Inc.).

***In vitro* starch digestibility**

Measurement of non-resistant starch (solubilised, Non-RS) were performed using an enzymatic assay kit (Resistant Starch Assay Kit, Megazyme International Ireland) by AACC method (number 32–40.01, AACC International Approved Methods of Analysis, 2009) with minor modifications according to Romano et al. (2016). Rapidly digestible starch (RDS) and slowly digestible starch (SDS) were measured after 30 and 120 min of incubation in a shaking water bath (200 strokes/min, horizontal agitation) at 37°C, respectively. The digestion kinetics were described by means of a non-linear model following the equation suggested by Goñi, Garcia-Alonso, & Saura-Calixto (1997):

$$C = C_{\infty} (1 - e^{-kt})$$

where C was the hydrolysis degree at each time, C_∞ was the maximum hydrolysis extent and k was the kinetic constant. The hydrolysis index (HI) given as percentage was calculated by comparing the area under the hydrolysis curve (0–180 min) of each sample and that of white bread used as reference food. From HI the expected Glycemic Index (eGI) was calculated using the equation proposed by Goñi et al. (1997):

$$eGI = 39.71 + 0.549HI$$

Statistical analysis

All experimental results are reported as means and standard deviation of at least three independent experiments. Statistical analysis was performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). One way ANOVA with Duncan's multiple comparison test at the 95% confidence level (P < 0.05) were performed in order to evaluate the effect of cooking time on parameters of each spaghetti type (S, WS and LS).

Results and discussion

Microstructural characteristics

SEM was used to examine the impact of pasta formulation on the microstructure of spaghetti samples (S, WS and LS) before

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Pasta Long Kg-HR	660	590	525	475	430	410	365	340

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and after cooking. The cross-section of the uncooked S and WS appeared as a homogeneous structure where not gelatinized starch granules were deeply incorporated in a protein matrix. Therefore, the presence of fibre in WS samples did not promote significant microstructural differences between the uncooked S and WS samples whose structure is mainly due to the high pressure applied to the pasta dough during the extrusion process.

Regarding instead the microstructural properties of LS, appreciable differences compared to the other samples could be observed, especially at x 1500 magnification. In fact, LS samples exhibited a corrugated surface and starch granules incorporated in a web-like protein matrix were clearly visible. However, after cooking at the OCT, structural differences between the three spaghetti samples emerged. As shown in [Figure 1a](#), at the OCT, one can observe three different zones: 1) outer zone; 2) intermediate zone; 3) central zone, which were characterized by various degrees of starch gelatinization and protein coagulation.

Overall, LS samples showed the most heterogeneous microstructure probably because of a non-homogeneous water distribution among the three zones.

In the outer zone of S and WS spaghetti samples ([Figure 1d, e](#)), starch granules and

protein matrix were practically indistinguishable because of the high degree of protein coagulation and starch gelatinization, in agreement with the strong impact of the cooking process on the outer pasta surface reported by Diantom et al. (2019).

SEM micrographs of LS spaghetti suggested a prevalence of proteins hydration on starch swelling and consequently the predominance of protein network formation on starch gelatinization. In addition, the protein network was more evident and thicker than those of wheat pasta, in accordance with the higher protein content of LS samples.

Between the outer and the central zone, there was an intermediate zone characterized by swollen starch granules embedded in a coagulated but dense protein network ([Figure 1g – i](#)).

The central zone (core) of the S samples ([Figure 1l](#)) showed a homogeneous structure in which the protein network was still continuous and dense, and the degree of starch gelatinization was limited since the reduced water absorption in this region allowed starch granules to preserve their structure (Cunin et al., 1995). On the other hand, the central zone of WS samples ([Figure 1m](#)) had a more irregular structure in which there were a small number of still intact and therefore non-gelatinized starch

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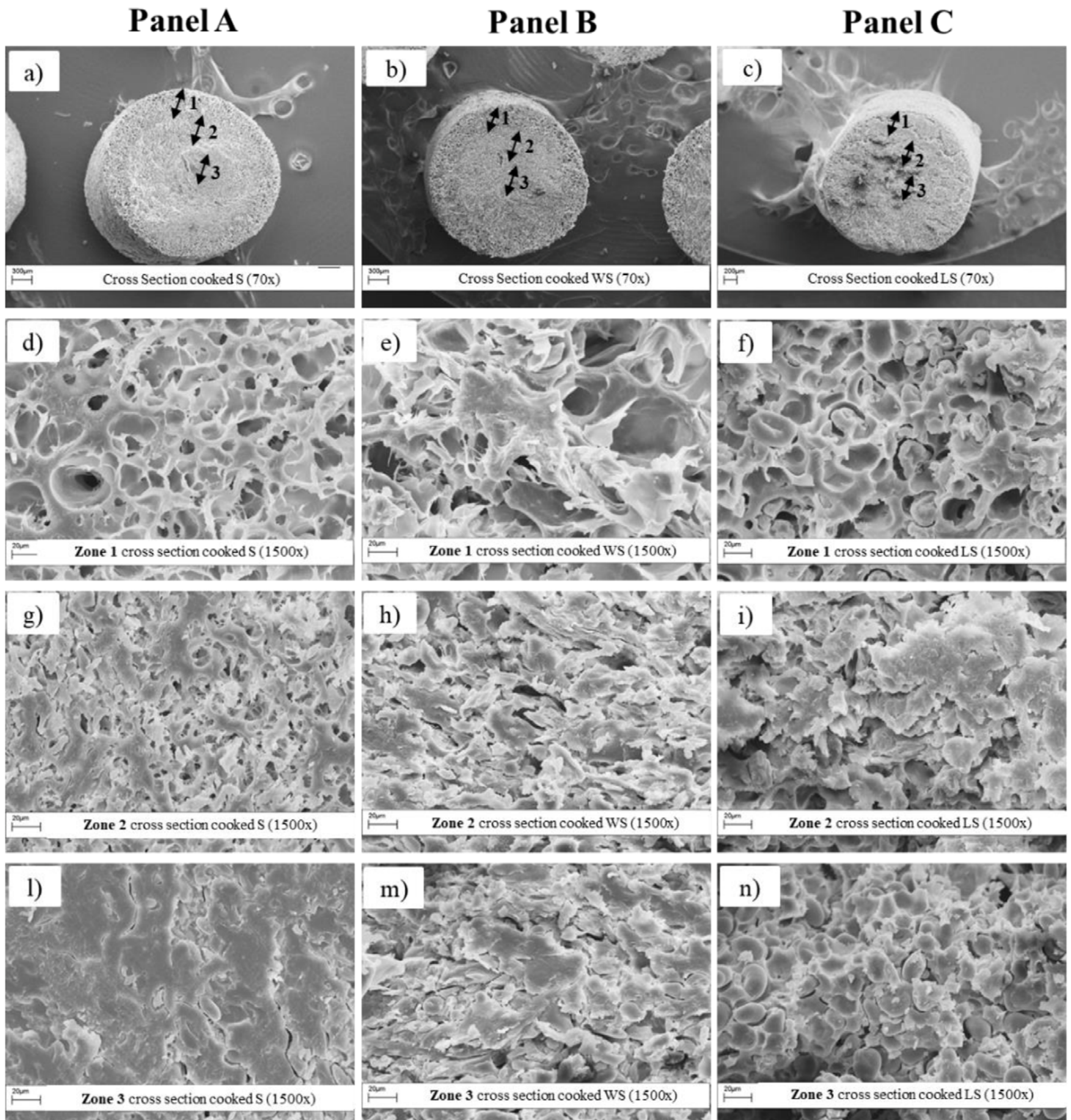
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Figure 1 REPRESENTATIVE SEM MICROGRAPHS OF SPAGHETTI COOKED UNTIL THE OPTIMAL COOKING TIME (OCT). PANEL A: DURUM WHEAT SPAGHETTI (S) A) CROSS SECTION; D) ZONE 1 – OUTER LAYER; G) ZONE 2 – INTERMEDIATE LAYER; L) ZONE 3 – CENTRAL LAYER. PANEL B: WHOLE DURUM WHEAT SPAGHETTI (WS) B) CROSS SECTION; E) ZONE 1 – OUTER LAYER); H) ZONE 2 – INTERMEDIATE LAYER; M) ZONE 3 – CENTRAL LAYER. PANEL C: RED LENTIL SPAGHETTI (LS) C) CROSS SECTION; F) ZONE 1 – OUTER LAYER); I) ZONE 2 – INTERMEDIATE LAYER; N) ZONE 3 – CENTRAL LAYER.



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granules compared to the durum wheat spaghetti (Figure 1l). As reported by Manthey & Schorno (2002), in whole-wheat pasta the dietary fibres may interfere with a proper gluten development. This results in a highly porous structure in which starch granules are more accessible to water molecules.

Lastly, several intact starch granules could be clearly visible in the central zone of LS (Figure 1n). This might be linked to a slower water penetration during cooking which hindered starch swelling and gelatinization.

***In vitro* starch digestibility and expected Glycemic Index**

The *in vitro* starch digestibility was investigated by measuring the released glucose content during starch digestion using an enzymatic method with minor modifications (Romano et al., 2016) and the hydrolysis curves of uncooked and cooked spaghetti samples were compared with those performed by white bread used as control (reference food). S, WS and LS spaghetti showed a different hydrolysis kinetics either in the dry state (uncooked) and at their OCT. After cooking at the OCT, WS was characterized by a rapid increase of starch hydrolysis within the first 30 min, and then the percentage of digested starch increased gradually for the

additional 150 min. By contrast, the slowest starch hydrolysis kinetics was observed for LS followed by S samples. As expected, The RDS and SDS fractions were significantly lower ($P < 0.05$) in the uncooked samples than the cooked ones. Regarding instead the eGI values of the uncooked samples, the lower eGI of S ($46.17 \pm 0.03\%$) compared with WS ($48.51 \pm 0.03\%$) and LS ($49.21 \pm 0.24\%$), may be explained in terms of the different firmness of the gluten network of the three kind of pasta which reflects on the starch granules accessibility to the amylolytic enzymes. Cooking at the OCT led to significant changes in RDS, SDS and eGI and thus in the *in vitro* starch digestibility. In particular, RDS and eGI reached the highest values ($P < 0.05$) in WS samples and the lowest in LS. S samples had intermediate RDS and eGI values and the lowest SDS content ($11.24 \pm 0.6\%$). The different compactness of pasta structure after cooking at the OCT can also explain the different accessibility of the enzyme to the starch granules. An additional evidence is the fact that at the OCT, sample S and even more LS samples were characterized by a central core in which proteins were not coagulated and starch granules were not gelatinized. The same was not true for sample WS that at the OCT appeared to be completely cooked and no microstructural differences



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between the intermediate and the central zones could be observed.

Our findings are in good agreement with the achievements of Vignola et al. (2018), who demonstrated that the use of whole durum wheat semolina in pasta formulation led to the presence of a weaker gluten network which promoted the starch amylolysis and thus increased the amount of RDS. The lower RDS content ($29.15 \pm 0.2\%$) of the cooked LS samples than the cooked S ($44.26 \pm 0.3\%$) and WS ($46.61 \pm 0.5\%$) may be due both to a different microstructure and to the high total flavanol index of red lentils as reported in the literature. In fact, as stated by Lu et al. (2018) phenolic compounds, and, in particular, the flavanols, are known to be the major contributors to the α -glucosidase inhibitory activity which implies reduced starch digestibility.

Conclusions

Food structure may strongly affect the bioaccessibility and thus the digestibility of the nutrients they contain. Thus, understanding how food structure can influence kinetics of nutrients release and hydrolysis by the digestive enzymes, may provide more-effective ways to keep a healthy diet.

Two main points emerged from this study. First, the presence of high amount of dietary fibres and non-gluten proteins significantly affects the microstructure of both the uncooked and cooked samples. As regard the latter, fibre interferes with gluten-starch matrix in WS samples, while the higher protein content of LS samples resulted in a strong protein matrix which limited starch gelatinization.

Second, the *in vitro* starch digestibility method revealed that the presence of fibre had a negative impact on pasta nutritional properties, causing an undesirable increase in the RDS and eGI values of WS compared with the S and in particular LS which featured the lowest starch digestibility.

All together, these results may help to better understand to what extent raw materials influence pasta microstructure and nutritional properties, giving the scientific community useful tools for controlling (promoting/hindering) nutrients bioaccessibility and digestibility according to the needs.

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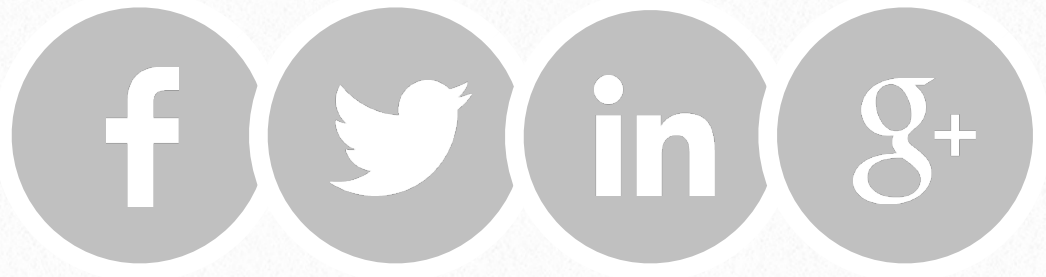
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5



Pasta: trend reversal for Italian exports in 2021, but consumption remains above pre-Covid levels

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Italian pasta exports closed with a minus sign in 2021. Such are the preliminary findings of ISTAT (at the time of writing, the most recent updates refer to November 2021), which estimate foreign sales for the entire year at around 2.95 billion euros, corresponding to a year-on-year drop of 4.5%.

This is, of course, a negative figure, but one that should be interpreted in the light of certain facts that will enable us to improve our understanding of the phenomena currently in progress.

Let's take a closer look. First and foremost, the statistical comparison is between 2020 and 2021, two years which were heavily affected – in terms of consumption and export trends – by the Coronavirus emergency.

As we all know, at the time of the first lockdown in spring 2020, enforced due to the pandemic, both domestic purchases and foreign sales of Italian pasta showed an exceptional upward trend.

Suffice it to say that in March alone, the sector's exports soared to a level that was almost 40% higher than that of March 2019. And that also in the months that followed, from April to July, there were out-of-range variations, technically classed as outliers, with year-on-year increases constantly in double digits.

Such a phenomenon had never been

encountered before, so that by the end of 2020 forecasts for export revenues had reached a record figure of more than 3 billion euros, with an impressive growth of 16% over the previous year.

In the light of these factors, it is clear that the retracement of over 4% in 2021 takes on a different meaning, being largely the result of a comparison with twelve months marked by movements unprecedented in history, in terms of the disruptive effects of the pandemic and the panic-buying dictated by the lockdowns decreed in an effort to limit the spread of the virus.

The year 2021 could even be classified as a “technically” positive year, since the minus 4.5% is the result of a statistical effect less obvious than what we might, objectively, have expected. And the 2.95 billion euros estimated through December represents an absolute record – excluding the outlier of 2020 – due to the driving effect of the prices.

Looking at real movements, it emerges that, with just over 2 million tonnes exported from January to November, Italian pasta experienced an 11.8% drop in 2021 (against – 4.9% in currency). A sort of return to normality that puts exported quantities, also including the December estimate, at a level higher than that prior to the pandemic.

The price effect, which was pretty evident



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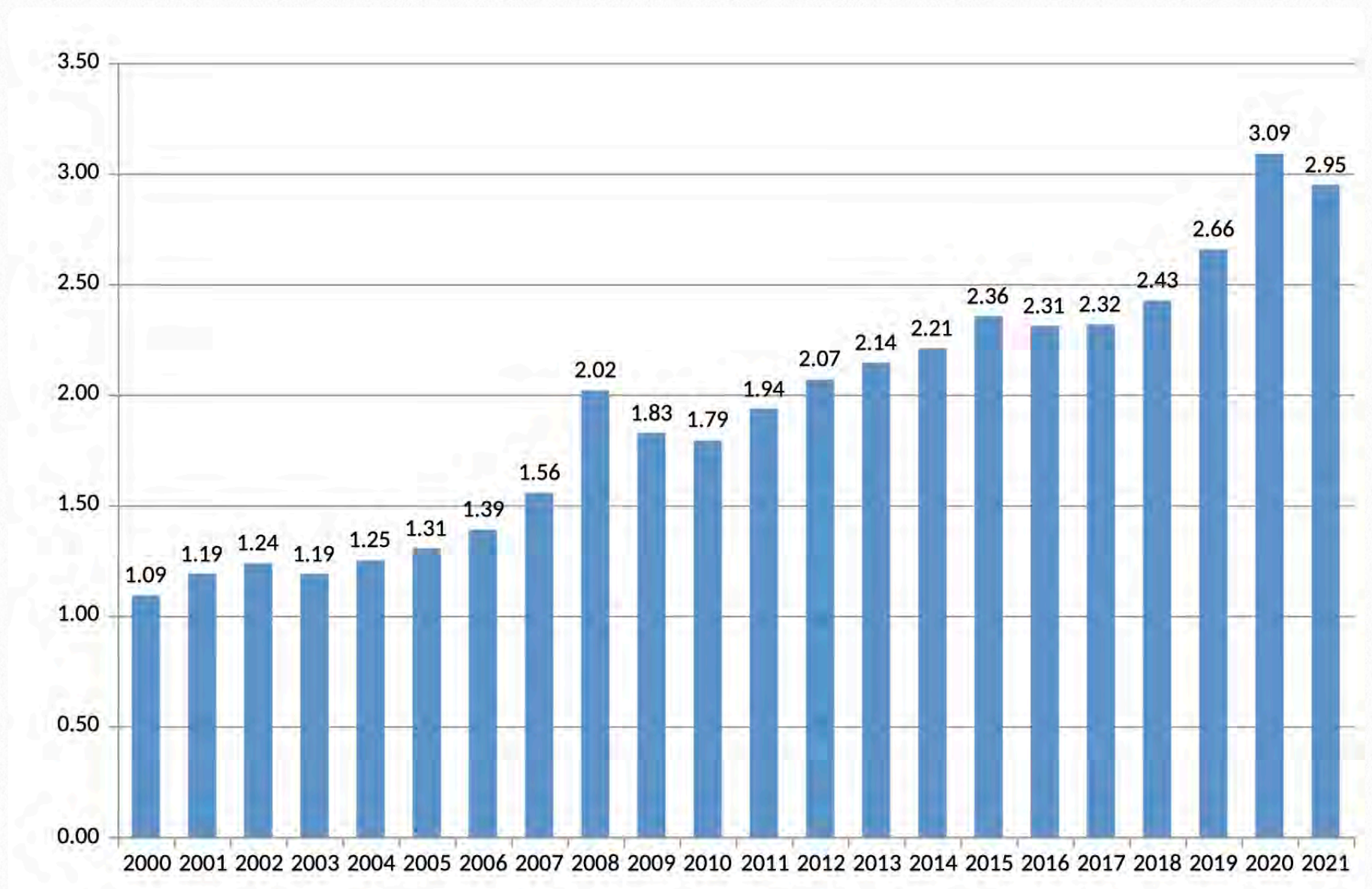


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Chart 1 TRENDS HISTORY FOR ITALIAN PASTA EXPORTS (€BN)



Source: Istat

in 2021 due to steep rises in wheat prices on the world markets (prices reached an all-time high due to poor Canadian harvests), is demonstrated by the wide gap between the dynamics of exports in currency and their respective movements in quantity. The implicit effect is an 8% increase in FOB (Free On Board) prices at ports of embarkation, which soared from an average of 1.21 euros per kilo in 2020 to 1.30 euros last year.

With regard to turnover, ISTAT's preliminary

figures throughout November show a prevalence of minus signs with regard to the different destinations. Within the European Union, turnover even grew, albeit by a paltry 1.3%, but it was too little to compensate for the 10.9% drop in sales experienced in the rest of the world.

In Europe, Italian pasta products performed well in Germany, Spain, the Netherlands and Switzerland, but suffered a setback in France and even more so in the United Kingdom, where the effect of



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Table 1 ITALIAN PASTA EXPORTS (JANUARY-NOVEMBER)

	Thousands of euros			Tons		
	2020	2021	Variation	2020	2021	Variation
D	2,842,577	2,702,621	-4.9%	2,347,988	2,071,095	-11.8%
EU-27	1,390,635	1,409,042	1.3%	1,137,599	1,066,887	-6.2%
Non-EU 27	1,451,942	1,293,579	-10.9%	1,210,390	1,004,208	-17%
Germany	430,671	438,212	1.8%	394,993	373,413	-5.5%
United States	439,669	366,955	-16.5%	285,044	225,045	-21%
France	363,328	350,061	-3.7%	267,139	241,866	-9.5%
United Kingdom	371,217	318,466	-14.2%	329,404	253,688	-23%
Spain	106,284	114,161	7.4%	57,941	60,709	4.8%
Belgium	79,134	76,526	-3.3%	61,658	54,808	-11.1%
The Netherlands	69,151	73,157	5.8%	58,074	54,987	-5.3%
Switzerland	67,749	73,071	7.9%	42,148	41,127	-2.4%
Sweden	71,680	70,743	-1.3%	59,199	57,071	-3.6%
Japan	80,333	70,064	-12.8%	81,116	69,175	-14.7%
Canada	55,500	47,443	-14.5%	35,683	27,771	-22.2%
Austria	47,452	47,424	-0.1%	38,067	36,015	-5.4%
Australia	59,382	44,209	-25.6%	43,382	28,231	-34.9%
Poland	33,996	36,390	7%	31,475	29,701	-5.6%
China	27,931	29,580	5.9%	34,097	33,146	-2.8%
Denmark	28,809	27,719	-3.8%	21,742	20,329	-6.5%
Israel	25,219	25,816	2.4%	30,1	27,436	-8.9%
Russia	25,129	23,892	-4.9%	24,704	19,02	-23%
Brazil	24,698	23,403	-5.2%	21,111	20,4	-3.4%
Czech Republic	18,955	20,409	7.7%	19,734	20,637	4.6%

Source: Istat

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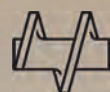
As regards third countries, the negative result of the United Kingdom is also shared by the USA, where exports

plummeted by 16.5%. Double-digit declines were also experienced by Japan, Canada and Australia and although sales in China closed with a rise of over 6%, the Chinese market is still twelve points down on the US market in terms of turnover.



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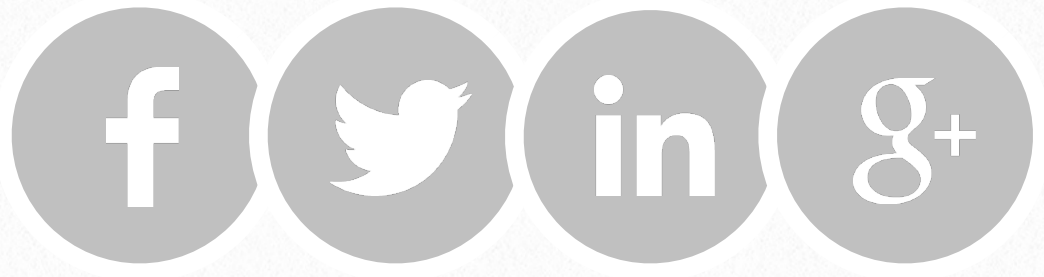


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6



Reviewing the “Farm to Fork” strategy to avoid famine

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Economy, war and famine: reflections for a new agrarian policy.

The global chessboard has been looking pretty troubled over the first few months of this year. The historical triad of misfortunes that strike humanity – plague, war and famine – is joining forces again, following an ancient dynamic but, inevitably, in a contemporary key.

Focus on the current state of affairs

The Covid-19 pandemic is still with us after roughly two years, with unpredictable developments, although we are starting to have some preliminary instruments to combat it, rather than simply locking down society in order to prevent the spread of the infection.

Significant progress has been made in an unusually short time frame, bringing about a promising upturn in economic activity that had already started by late 2021 and has continued into 2022.

The escalating conflict in eastern Europe between Russia and Ukraine (the war) is reaching worrying proportions, with the risk of it becoming a world war, the third in about a hundred years. This military confrontation, with extremely heavy consequences, is proceeding inexorably, apparently with no end in sight.

The war, with its direct and indirect costs, is causing a serious economic slowdown

(i.e. famine) just when the economy seemed – consolingly – to be getting back on its feet. Many essential items, such as, but not limited to, food staples, are in short supply, eroding the standard of living. Famine, in the broadest sense of the term, is extending to human and financial aspects, to such an extent that the global GDP could be negatively impacted.

Is the world heading for a global crisis?

The components of the triad of mankind's evils are starting to take on increasingly alarming characteristics. On the one hand, the economic recovery is hampered by elements that slow it down – some of which were expected and others less so – which risk undermining the continuation of the recovery at a time when major financial efforts should be stimulating it. Suffice it to consider the great plans, such as Next Generation EU or those of the USA and Great Britain. Financial efforts are enormous everywhere and require careful monitoring, with an eye to the dynamics of interest rates on the huge debt contracted by the States and not forgetting the costs of combating the pandemic, which is not yet over.

With the sudden outbreak of war between

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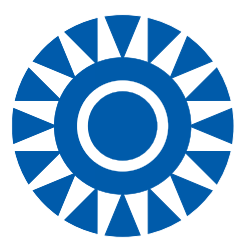
Russia and Ukraine, a latent problem has re-emerged with rare force. A full-scale war in Europe, between countries bound by ancient ties and alternating relations is a phenomenon with potentially disruptive characteristics. Matters for which it is now difficult to find workable solutions.

The economy is suffering, but not just because of inflation

The speed and intensity of the economic recovery driven by the developed economies has “camouflaged” a number of issues that threaten its balanced continuation.

The existence of problems that are

complex and difficult to solve had already come to the fore in the first months of the recovery, with the rise in inflation. Inflation had not been seen for some time in advanced economies; they were, in fact, hoping for an increase of around 2%, considered compatible with growth as a stimulus to recovery. But it has risen far above this threshold: first in the US and then also in other economies, with a year-on-year increase of almost 7% in the US and around 5% in Europe. Initially, this was blamed on the upsurge of energy products, first and foremost oil and gas, due to a higher-than-expected imbalance between demand and supply. Following on from this category, however, came agricultural commodities, some iron ores



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and rare earth elements, and some specific semi-finished products for use in production processes. These imbalances are attributable both to the rise in certain basic commodities and to bottlenecks and disruptions in production chains brought about by the pandemic. The inflation problem is not limited to energy costs, but extends to the entire production system due to the well-known transmission mechanism of inflation. Price variations in Italy show that the largest increases are due to energy products and to some agricultural commodities, while for other products the price increase is “driven” by the dynamics of the categories indicated.

The irruption of the Russia-Ukraine conflict in the world economy

The conflict that began in 2014 revolved around control of Crimea and part of Ukraine’s eastern provinces. After the fall of communism and the dissolution of the USSR, these areas were attributed to Ukraine, even though a large proportion of their population was Russian-speaking. When the acute phase ended with a formula that did, in fact, appease Russian demands, local armed clashes between the two countries continued to break out

right up until the war currently in progress. The dispute is hampered by ancient rights in favour of both sides in addition to the hasty liquidation of the USSR, which has also led to clashes between Russia and the newly independent states in other areas. The end of Soviet communism did not come to grips with a past that was abruptly wiped out. But if the communist component of Russia fell, the same cannot be said for its imperialism, a legacy of both imperial and Soviet Russia. The war set in motion by Putin stems from problems that stretch well beyond a territorial dispute and can be traced back to the Yalta decisions and the demarcation between the spheres of influence determined by the Lübeck-Trieste line, together with the very interpretation of the concept of “sphere of influence” to the West and East of the line itself.

The passage of time has increased the flow of trade between Russia and the Western countries, particularly in terms of energy products and some agricultural commodities such as cereals and oilseeds. Let’s be clear: the war provides motivation for a rise in the prices of certain raw materials that was already shaking up the markets.

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What lies ahead for agricultural markets and specifically for cereals?

The tumultuous economic recovery that led to an increase in the Italian GDP in 2021 initially estimated at 6.1% and now, after the latest calculations, at 6.6% reflects the previous structure of the national manufacturing economy, second only to Germany's in Europe. Italian players are fantastic processors in every field, including the food sector.

In times of peace and increased globalisation, problems are limited, but this is not the case in major emergencies such as the present one. Italy is a net importer of a substantial portion of its energy requirement. Since its domestic resources, mostly consisting of renewable energy (hydro, wind and solar), gas and oil, are insufficient, they need to be supplemented by imports, mainly of Russian gas – accounting for 42% of the country's requirements – and oil. This situation is the result of a series of decisions such as the phasing out of nuclear power, the reduction of gas and oil extraction on national territory, and the limitations set on new installations, even hydroelectric ones. Renewables, however, are difficult to manage due to the irregularity and discontinuity of their

production and the storability of the energy produced.

In many respects, the situation in the agri-food sector is similar. The trade balance of agricultural raw materials in our country tends, traditionally, to be in deficit. Only recently has the “agri-food” trade balance shown a surplus due to the fact that the food component had already been enjoying a surplus for some time, while the agricultural component was in deficit. So export successes have been stemming from the food industry's ability to process increasing quantities of imported commodities into food that is then exported. Wine, however, is the decisive item in terms of profits.

This is the backdrop to the Italian agriculture's recent trend towards a reduction in domestic production for a complex series of reasons, which also includes the constraints put in place by environmental protection regulations. This compels the country to import increasing quantities of raw materials, particularly for large-scale crops such as cereals, especially soft and durum wheat and corn, as well as oilseeds, primarily soya. While, in the 1990s, domestic corn production still made it possible to maintain a low flow of exports, and wheat production made it possible to limit imports to around a third of national



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requirements for durum wheat – which is also used to produce an equivalent quantity of pasta for export – today Italy imports around 50% of its corn requirements, 35% of its durum wheat and 64% of its soft wheat requirements. These cereals are now increasingly imported from the countries of the Danube Basin and the Black Sea. If these trends are not corrected in time, future emergencies, be they due to health, commerce or war issues, could place the Italian agri-food sector in the same powerless condition as the country's energy sector, with consequences that do not bear contemplation.

Today, even if immediately enforceable decisions were taken on the energy-related raw materials that the country is forced to import from the world market due to the sanctions and retaliation caused by the war, their results in terms of production would not be discernible for at least three years, in the case of the simplest measures – which would entail resuming production in abandoned or underused installations – and at least a decade in the case of structural ones.

Time frames and prospects for a production recovery in Italian agriculture are similar – notwithstanding the relative advantage of being able to reorient the

production mix each year – but it has to be borne in mind that a decisive shift to forms of agriculture that will increase productivity must be introduced with all possible haste, reviewing the current approach that informs agricultural policies, from the CAP to its Farm to Fork strategy.

By analogy, if the logical and programmatic framework of the energy transition is reviewed in such a way as to take into account the energy crisis brought about by the war, then it is time to rethink agricultural policies from the perspective of food security, an aspect which – at least until now – has been neglected.

From this perspective, the recent statements of the EU Agriculture Commissioner, Janusz Wojciechowski from Poland, at the end of an emergency meeting of the EU Council of Agriculture Ministers on the need and willingness to review the Farm to Fork strategy, pave the way for a concrete and rapid review of the CAP.

The nations of the EU and the whole world are looking forward to this prospect expectantly, in the hope of avoiding the next global famine.

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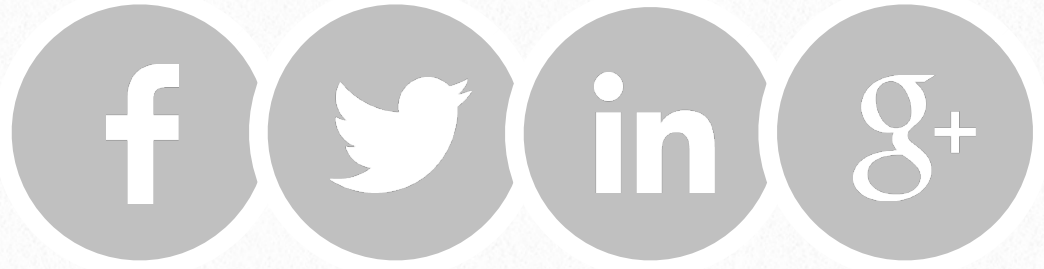
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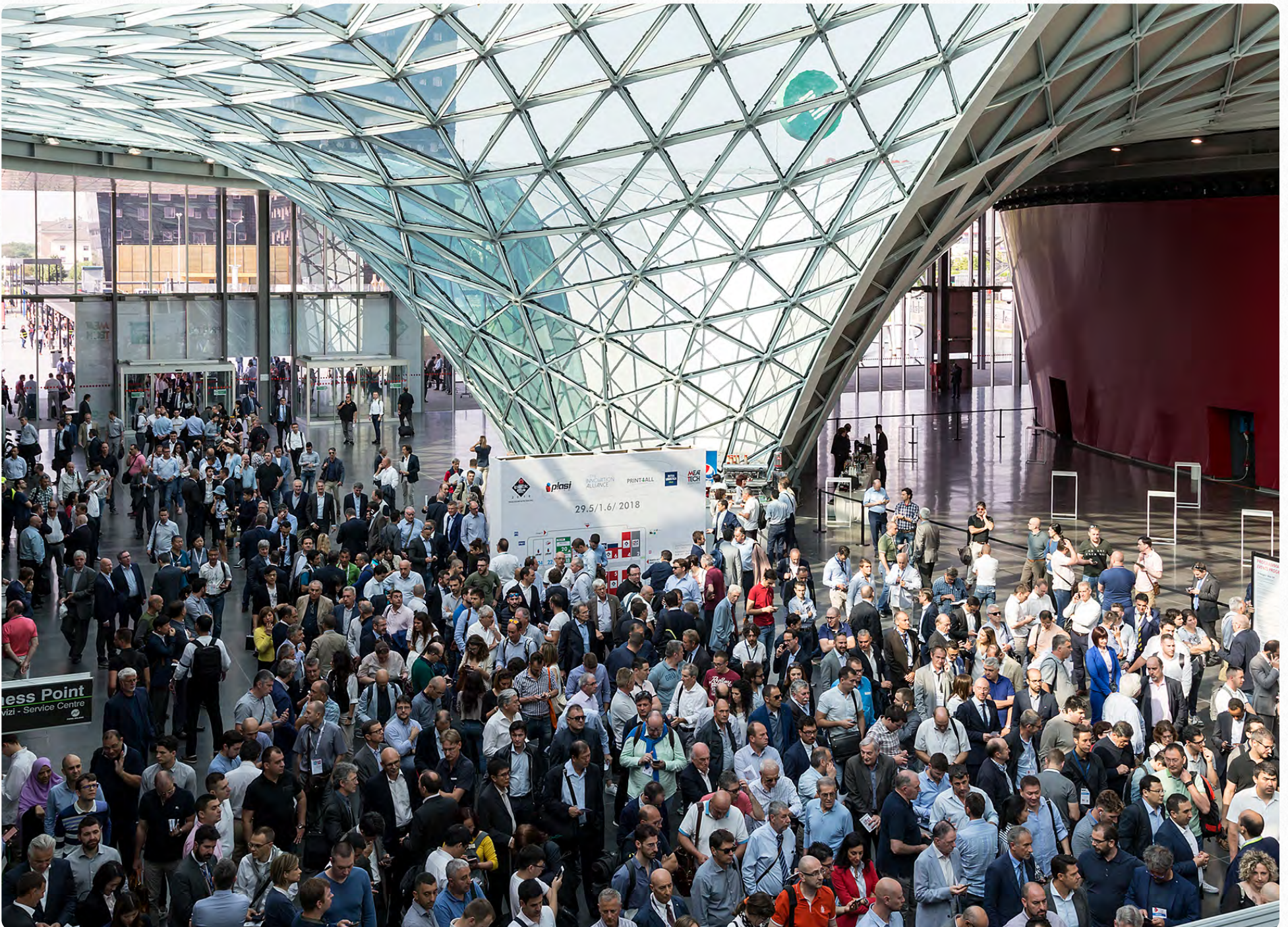


7



Over to Valerio Soli, Ipack-Ima president

Press release



The 2022 edition of Ipack-Ima – the leading international trade fair for pasta production and packaging technologies – will take place from 3 to 6 May at Fiera Milano Rho. Pastaria – the event's media partner – will be in attendance.

The 2022 edition of IPACK-IMA is just around the corner. Taking place in Milan from May 3rd to 6th, the event marks the return to presence for exhibitors and visitors, serving as a meeting point for demand and supply of processing technologies, packaging solutions and materials. Valerio Soli, President of Ipack Ima Srl, tells us about the many meanings of an exhibition that brings together the various stakeholders in a complex production chain.

Four years after the last edition, and after so many changes and developments in the industry's production processes, what will we find more than in the past at IPACK-IMA?

IPACK-IMA will be the most important processing & packaging exhibition to be held in attendance in 2022 after a long time, a truly long-awaited and necessary return for the industry. I can confirm that the packaging industry has never stopped during this period, with a total turnover of € 8,435 million and an 8% increase over 2020 – according to the latest Ucima data – and, even in the most difficult times, it has always been close to its customers. The ability of companies to reorganize themselves in terms of safety and flexibility has made it possible to continue production.

Companies with a vision of the sector based on connectivity, customization, digitalization, automation and remote control have been the ones to benefit most. All this is reflected in the many solutions that will be on show at the exhibition by an industry that has interpreted the new challenges.

In terms of the exhibition offer... Which sectors and markets have you designed this edition for?

IPACK-IMA is an exhibition specializing in processing and packaging technologies for the food and non-food sectors, but food & beverage remains a primary market. Four Business Communities are dedicated to this sector, from pasta and milling – the “core” industry for the show – to liquid food and beverage – to which we will devote an entire pavilion – to fresh food and ready meals and to up to and technologies to meet the



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Valerio Soli, President of Ipack-Ima



needs of the entire confectionary sector. IPACK-IMA will also focus heavily on the non-food sector, covering pharmaceuticals and nutrition, beauty & personal care, chemicals & home care, and industrial & durable goods.

From your point of view, how is the world of packaging changing, a sector

whose speed of reaction to the constraints imposed by the pandemic is emblematic...

2021 was a year of great change for the entire packaging industry. Unprecedented increases in raw material prices and component shortages have created unexpected challenges. However, it was also a year full of opportunities. The ability

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of packaging to preserve the taste, flavor and integrity of products, even over long periods, was rediscovered. Above all, the safety of packaging in preventing contamination during handling was appreciated. Developments related to sustainability are also becoming of primary importance for the industry and primarily for material manufacturers who have

invested heavily in research and development in a green perspective, responding to brand owners' commitments to a circular economy. These are all issues that have become essential when it comes to packaging and that will be fully developed at IPACK-IMA.

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A special focus will be devoted to packaging materials, which are able to meet the requirements of sustainability and rationalization of production: how will they be highlighted at the fair?

We will pay a great deal of attention to packaging materials, which will be strongly represented at the show by over 200 companies active in this segment.

IPACK-Mat is the IPACK-IMA brand that will make it easy to identify these companies, which will offer innovative and eco-friendly materials in a dedicated area located in hall 5. The topic of packaging is constantly confronted with that of product safety and preservation. IPACK-IMA, together with the Italian Packaging Institute will tackle this by discussing research laboratories, certification institutes and centers specialized in FCMs compliance standards in the special area Ipack-Ima Lab. We will also host the “Packaging Speaks Green” international forum, organized by Pack-Media with the support of Ucima, which will focus on sustainability in the packaging supply chain.

PHARMINTECH will take place in conjunction with IPACK-IMA. What will be the added value of this synergy?

A new aspect of the next edition will be IPACK-IMA’s focus on the

chemical-pharmaceutical sector. Our partnership with Pharmintech will allow us to make the most of technologies and solutions for this sector. These two events will thus combine to create a unique exhibition moment, the expression of a synergy built on the demand for processing and packaging technologies, a great added value for both exhibitors and visitors. In 2022, Milan will be the meeting point for the world’s most important players in the Lifescience industries: from pharmaceuticals to parapharmaceuticals, from nutraceuticals to cosmeceuticals, from medical devices to biotechnologies. The layout was conceived to amplify business opportunities for the three communities Pharma & Nutritional, Beauty & Personal Care and Chemicals & Home Care that will be located in Hall 2, with the aim of enhancing Pharmintech’s identity and boosting synergies among the exhibition segments representing IPACK-IMA’s competitive advantage.

IPACK-IMA is not only about packaging. What other product sectors will be represented?

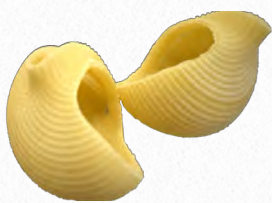
PACK-IMA will not only showcase the most innovative packaging solutions: processing technologies will also play an increasingly important role. Visitors will find the most advanced solutions, from



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What are your expectations, especially in terms of visitors and arrival of foreign buyers? What will be the benefits offered to professionals by the “MYipackima” project, on which you are focusing so much?

We are working on the incoming of carefully profiled buyers from abroad, a theme our platform has always focused on. Therefore, we are very confident, thanks also to an improvement in the global health situation. Our Association, Ucima, is also making a great effort in this direction: thanks to the good relations we have with ITA – Italian Trade Agency, we

will be able to host selected professionals from many target markets interested in our technologies at IPACK-IMA. Moreover, IPACK-IMA offers its professionals new digital networking opportunities, thanks to “MYipackima”, the innovative match making platform that allows exhibitors and buyers to profile themselves and find the right contact person to talk to and develop new business with, before, during and after the show. I can proudly say that to date, with over 1,000 exhibitors, IPACK-IMA offers a truly attractive and complete technological panorama, with innovations and previews of future production trends and a full calendar of specialized events.

How is “The Innovation Alliance”, the format created in 2018 that marked the collaboration between Fiera Milano, the organizers of individual events and trade associations, evolving?

I After a successful debut in the last edition, the great project “The Innovation Alliance” will again include IPACK-IMA in 2022 in conjunction with other exhibitions dedicated to instrumental mechanics: Intralogistica Italia, focused on goods handling and warehouse management, Print4All, dedicated to industrial printing and converting technologies and the first edition of Greenplast, focused on the

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In view of the positive development of the pandemic situation, what measures do you envisage to ensure the success of the event in attendance?

IIPACK-IMA is an event not to be missed by companies wishing to showcase their technological innovations to industries eager to discover, learn and develop new business relations. The in-person presence is guaranteed by protocols that have been extensively tested at various times during the resumption of trade fair activities in

2020 and 2021. In Italy, and at Fiera Milano in particular, it is now standard practice to ensure the safety of exhibitors, journalists and buyers who crowd the pavilions of the exhibition center. Also, government measures in Italy have significantly eased restrictions on visiting international trade fairs.

I conclude with a message to exhibitors and visitors: bring and pursue innovation at the show because IPACK-IMA is the right place and the right time. IPACK-IMA is an incubator of ideas and, above all, a great business connector.



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