

REVIEW ARTICLE

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Traditional Italian flatbreads: cultural diversity, processing technology and future perspectives

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Abstract

Flatbreads are particularly prevalent in the Mediterranean region, including Italy, where each community has its unique traditional recipe, preparation method, and baking system. This traditional narrative review provides an overview of the Italian flatbreads that have achieved national or international quality recognitions. The aims of this study are, firstly, to scientifically evaluate these flatbreads and establishing a catalog that includes both technical and cultural information, which are currently missing in the international scientific literature and, secondly, to conduct a comparative analysis of the technical and cultural diversity of traditional Italian flatbreads, outlining areas for future research development. The examined flatbreads were found to be characterized by considerable diversity, reflecting the Italian region's diverse culinary heritage. The formulation is generally simple and includes flour, water, possibly yeast, and salt. Additional ingredients are region dependent, reflecting local availability, and include fats of animal origin, or ham, mostly found in flatbreads from Northern Italy, while olive oil or EVOO is common in flatbreads of Tuscany, Liguria, and Sardinia. The types of flour also differ regionally: Besides soft wheat flour, durum wheat semolina is used in southern Italy and Sardinia, chestnut flour in Tuscany, rye flour in Alto Adige, chickpea flour in Liguria, and corn flour in central Italy. Historically, high-extraction flour and sourdough were largely used but have been replaced by refined flour and commercial baker's yeast over time. Flash baking (short time, high temperature) is generally adopted, and some flatbreads, typical of Sardinia, are baked twice, resulting in complete dryness and long shelf-life. In contrast, quickly prepared unleavened bread is a staple in the Tuscan-Emilian Apennines, Lunigiana, and the Po Valley. Overall, these results suggest encouraging the revival of the ancient baking tradition of using high-extraction flours and sourdough fermentation, which today are almost lost. Reintroducing these methods could increase the fiber, mineral and, vitamin content and ensure a rich sensory profile. Further research could focus on improving the nutritional quality, particularly, through salt reduction, acrylamide levels mitigation, and protein content increase. The lack of historical information highlights the need to perform historical research to gain a deeper understanding of origins, evolution and characteristics of Italian flatbreads.

Keywords Italy, Alternative flours, Quality schemes, Typicality, Regional food, Gastronomy, *Piadina*, *Pane carasau*, *Testo*, *Tigella*

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Graphical Abstract



Introduction

The earliest type of bread attested in history is unleavened and flat dating back to 14,400 BCE [1], even before the Neolithic age and the advent of agriculture. It was not until 1300–1500 BCE that leavened bread was produced by Ancient Egyptians [2]. Flatbread remained in the traditional cuisine of many cultures around the world serving as a staple food [3–6], with a global market valued at \$41.17 billion in 2019 and expected to reach \$62.8 billion in 2026 [7].

Flatbread typically consists of a few basic ingredients, flour, water, salt, and, depending on whether it is leavened or unleavened, yeast. Optional ingredients can be added by incorporating them into the dough or as toppings, making the flatbread a perfect food carrier [8]. Flatbreads are the basis for the preparation of popular fast-food products around the world, including take-out *pizza*, *focaccia*, pancakes, and crepes [9]. In addition to being used as a spoon for grabbing food, they can be covered by food as an “edible plate” (*focaccia* and *pizza*), rolled around food as a “food wrap,” or stuffed and folded as sandwiches [9, 10].

Particularly prevalent in the Mediterranean region, flatbread accompanies almost every meal, and each community has its unique traditional recipe [11], preparation method, and baking system [12]. The latter is often

a portable tool (such as a metal griddle or plate to be placed in the fireplace) rather than a regular oven, reflecting the restriction on the use of ovens in the past. In the Middle Ages, the construction and operation of ovens were restricted to the baker and upper-class families [13], while the lower classes had to bake bread in the communal oven, paying for its use. Clergymen could be exempt from paying the communal oven tax, as prescribed in the city of Altamura (Italy) by an edict of 1420 [14].

According to EU Regulation no. 1151/2012, foods that are part of the cultural heritage of the communities living in a specific geographical area are “typical” as their qualitative characteristics strictly depend on the local microflora, the composition of the soil and water, and the specific processing techniques [15]. The European recognitions granted to these foods are “Protected Designation of Origin” (PDO), “Protected Geographical Indication” (PGI), and “Traditional Specialties Guaranteed” (TSG) [15], depending on the strength of the link with the place where foods are made. Italy also established national quality schemes for protecting local specialties, such as the “*Prodotto Agroalimentare Tradizionale*” (PAT) or “Traditional Agri-food Product” [16], not to forget the “Slow Food Presidium” (SFP) recognized by the Slow Food Foundation for Biodiversity [17]. Italy is the European country with the highest number of foods

recognized as typical, numbering 326 in 2023 excluding wines: 173 PDO, 149 PGI, and 4 TSG products [18]. Within this vast range of specialties, many are flatbreads.

The precious value of traditional Italian flatbread is due to the distinctive handcrafting techniques and methods of preparation and baking, which have been passed down through generations. The transmission of knowledge to master the art of breadmaking, partly oral and partly based on the replication of traditional gestural behaviors, was operated in the past by older women to girls of the same family [19]. This empirical knowledge, survived thanks to the efforts of passionate local scholars who recorded the testimonies of elders, is preserved thanks to protection consortia, by national and European legislation [15, 16]. Italy is a long country with a very diverse orography and microclimate, historically composed of numerous duchies, small kingdoms, and states that merged into a national unity only in 1861. So, rather than a unified culture, Italy is characterized by great regional diversity and a strong local identity, called “*campanilismo*” (localism), which are most evidently manifested in the richness of the gastronomic landscape and culinary culture [20]. In addition, bread characteristics are primarily influenced by factors such as the grain used, flour type class, leavening and baking conditions, shape and size, along with the salt quantity and even the type of water used. Such diversification has given rise to what can be described as a “geography of bread,” with more than 200 regional bread varieties having artisanal character [21, 22]. In 2021, sales of artisanal bread totaled more than 1,400,000 tons, reaching 84.1% of the total bread sold in Italy, while industrial bread reached only 15.9% [23].

Traditional Italian flatbreads originated from a predominantly agricultural society that was very much alive until recent decades, but no longer exists today because of hard work in the fields. In the past, except for the nobility, most people could rarely afford “white bread,” that is, bread made from refined flour [24], as well described by the Italian writer Giovanni Verga (1840–1922). In his 1882 novel “*Pane nero*” (literally “black bread,” i.e., wholemeal bread, darker and denser than “white” bread), set in the Sicilian countryside of the late nineteenth century, Verga describes the constant struggle of peasants to obtain at least some black bread [25]. Also in the rest of the country, flatbreads prepared with little wholemeal flour mixed with chestnut, corn, or rye flour, or even, in times of famine, with ground tree bark, were a sign of food scarcity and poverty [26]. These flatbreads, prepared with inexpensive flours and mostly baked in the fireplace without the aid of an oven, were linked to everyday life. On

the contrary, “white,” thus “pure” and noble versions of the same flatbreads were prepared with refined wheat flour for festive and religious events. Decorated with flowers, hearts, crosses, doves, or solar symbols, these ritual breads were associated with weddings, Easter, All Saints’ Day, New Year’s Eve, and celebrations of patron saints (St. Rita, St. Restituta, St. Palmerio, St. Anthony) [19, 27–29]. Ritual flatbreads were entrusted with the task of conveying auspicious or propitiatory messages for the new year or season, which could protect a couple (wedding breads) or a community (devotional breads) from the threats of natural events that could disrupt agricultural activities [27]. The preparation of breads for All Saints’ Day in Nuoro, Sardinia, is described as a key event in the late 19th-century novel “*La Via del Male*” (“The Way of Evil”) by the Italian writer Grazia Deledda (1871–1936) [30]. Nonetheless, especially when viewed from the perspective of today’s economic well-being and under the leveling effect of globalization, also the “poor” flatbreads have a story to tell, and knowing it means recovering the memory of one’s origins, not to mention their fundamental importance for the identity of Italian communities abroad [31]. The traditional food of a community is a cultural medium because it is a sign of continuity of ethnic identity between past and present, with no other food having acquired such an important and pervasive symbolic force over the millennia as bread [32].

Despite the cultural and economic importance of traditional Italian flatbreads, most of them have never been the subject of scientific studies published in international journals, so knowledge remains local and there is almost no international bibliography to refer to. Furthermore, a comprehensive compendium of Italian artisanal flatbreads is completely missing, which would instead represent a starting point for coordinated valorization actions and for improving the production technology, as well as for prompting scientific research.

Therefore, this review aimed to systematically evaluate traditional Italian flatbreads from a scientific perspective making a comparative analysis of their technical and cultural diversity and outlining areas for future research development. To the best of our knowledge, this is the first article on this subject, providing a complete overview and comparison of Italian flatbreads. To accomplish this objective, all available information, retrieved especially from literature in the Italian language, was gathered to create a proper synthetic catalog describing the technical characteristics, ingredients, and cultural aspects of each traditional Italian flatbread. Subsequently, the catalog, served as the basis for a critical analysis presented in this article.

Methodology and structure of the review

Databases and search terms

A traditional narrative review approach was adopted. The study was carried out in two primary phases: (i) the identification of the Italian flatbreads officially awarded quality recognitions and (ii) a comprehensive literature search about the identified breads.

In the initial phase, a search was performed for the category “Bakery and pastry products” in the two institutional databases of the Italian Ministry of Agriculture, Food Sovereignty and Forestry: “List of Italian designations entered in the Register of Protected Designations of Origin, Protected Geographical Indications and Traditional Specialties Guaranteed—Updated November 2023” [18] and “National List of Traditional Food Products—23rd Edition—2023” [33], as well as by entering “Italy” as country and “Bread and baked goods” as category in the “Slow Food Presidia” global database [34]. The screening process included retaining only flatbreads and led to the identification of a set of 23 items, namely two PGI, twenty PAT, and one SFP, reported in Table 1.

In the second phase, the selected flatbreads were the subject of a literature search, imposing no temporal restrictions. Each flatbread name was entered in Scopus and Google Scholar databases the latter provided a more helpful source due to the need to consider also books and articles in Italian language. The main difficulty encountered in this study lies in the fact that most Italian flatbreads had never been studied by the international scientific community, so information was local and very fragmented.

Finally, supplementary searches were carried out on specific themes that emerged in the literature, such as innovative techniques for quality control, safety issues, salt reduction, and the use of innovative ingredients.

Review structure

This review is structured to initially provide information on each individual flatbread in the same order as shown in Table 1 (that is PGI, then PAT and finally SFP flatbreads), allowing the reader to become acquainted with these food products, most of which remain largely unknown beyond their restricted area of origin despite being recognized by international institutions such as the European Commission. Successively, the review presents a critical comparative analysis of these flatbreads for their ingredients, processing steps (dough formation and shaping, leavening, and baking), and cultural aspects.

PGI Italian flatbreads

Piadina romagnola

Piadina romagnola, or *Piada romagnola*, is a traditional bread of the Emilia Romagna region, recognized as PGI in 2014 [35]. It is prepared with refined wheat flour, water, *strutto*, olive oil or EVOO, and salt. Sodium bicarbonate may be added as a fermentation agent [36]. Regarding the ingredient “*strutto*,” it is important to clarify that in Italy, a country with a long pork butchery tradition, there is specific terminology for different types of pork fat. *Lardo* (lard) identifies the fat layer located just below the rind; *sugna* (suet) is the fat of the adrenal and interstitial area; while *strutto* is the product of the fusion of all the fatty

Table 1 Italian flatbreads with national or international quality recognitions

Quality scheme	Region of origin	Flatbreads
PGI	Emilia Romagna	<i>Piadina romagnola</i>
	Trentino-Alto Adige	<i>Schüttelbrot</i>
PAT	Tuscany	<i>Panigaccio di Podenzana; Neccio</i>
	Tuscany and Liguria	<i>Farinata</i>
	Tuscany, Lombardia and Umbria	<i>Schiacciata</i>
	Umbria	<i>Torta al testo</i>
	Emilia Romagna	<i>Borlengo; Gnocco fritto; Gnocco ingrassato; Crescenta; Crescenta frita; Crescentina</i>
	Emilia Romagna and Marche	<i>Crostolo</i>
	Marche	<i>Crescia sfogliata</i>
	Basilicata	<i>Carchiola</i>
SFP	Puglia	<i>Puccia</i>
	Sardinia	<i>Pane carasau; Pane guttiau; Spianata; Pistoccu; Zichi</i>
	Tuscany	<i>Testarolo pontremolese*</i>

PGI Protected Geographical Indication; PAT *Prodotto Agroalimentare Tradizionale*; SFP Slow Food Presidium

*The *Testarolo pontremolese* also holds the PAT designation

parts of a pig. The fatty ingredient most commonly used in traditional Italian flatbreads is *strutto* [26].

Piadina romagnola is a circular flatbread with a diameter of 15–25 cm, 4–8 mm thick (Fig. 1). A larger, thinner, and more flexible variant (23–30 cm in diameter, 3 mm thick) is prepared in the Rimini area, named “*Piadina romagnola alla Riminese*.”

In the past, *Piadina romagnola* was cooked exclusively on stone slabs or on clay pans named “*testo*,” “*teggia*” or “*teglia*,” produced only in the area of Montetiffi, a small village in the mountains of Romagna. Today, such pans are still produced in Montetiffi according to the same tradition and with the same clay, but in most cases *Piadina romagnola* is cooked on metal cooking plates or metal pans, at 200–250 °C for a few minutes [36]. In the past, *Piadina romagnola* was commonly made of cornmeal and was thus identified as “the bread of poverty,” as stated by the Italian writer Giovanni Pascoli (1855–1912) in the poem entitled “*La piada*,” dedicated to this flatbread. Pascoli further defined *Piadina romagnola* as “the bread of freedom, which the venal oven disdains” because it was baked in the fireplace without paying the fee required for using an oven [37]. So, *Piadina romagnola* was a cheap alternative to regular loaf bread. Today, *Piadina romagnola*, perfect to be folded and eaten as a sandwich, is a typical street food sold in traditional kiosks, known as “*piadinerie*,” widespread in the Emilia Romagna region. Tastings of *Piadina romagnola* stuffed with local soft cheeses and charcuterie are organized during the *Piadina Days*, within the Emilia Romagna Wine Food Festival [36]. One of the most traditional fillings is a combination of *Squacquerone di Romagna* PDO, *Prosciutto di Parma*



Fig. 1 An example of unleavened flatbread: *Piadina romagnola*. Today *Piadina romagnola* is made from wheat flour, while in the past it was commonly made from the cheaper cornmeal and was therefore identified as “the bread of poverty,” as stated by the Italian writer Giovanni Pascoli (1855–1912) in the poem entitled “*La piada*.” Photo credit: Pino Marzulli

PDO, and arugula salad, as reported by the Italian writer Mario Soldati (1906–1999) in the novel “*Viaggio in Emilia Romagna*.” Considered “a secular bible of good eating and drinking,” the novel describes the author’s journey through Emilia Romagna in search of food with genuine flavors, from the late 1950s to the early 1970s [38].

Recognition of the PGI, along with consumers’ considerable appreciation of the product, has increased the production volumes of *Piadina romagnola* and raised the need to improve its shelf-life [39, 40]. Since it is forbidden to add preservatives [36], the shelf-life of *Piadina romagnola* is extended by packaging under a modified atmosphere. On a nutritional level, the variants where saturated fat from *strutto* is replaced by EVOO should be preferred [41]. *Piadina romagnola* enriched with selenium is effective in increasing dietary intake of this element [42].

Schüttelbrot

Schüttelbrot is a PGI from the Trentino-Alto Adige region [43]. It is a sourdough-leavened flatbread made by mixing rye and wheat flours (the latter < 10%) with water, and salt [29]. This bread is flavored with fennel seeds and sometimes wild cumin, coriander, or aniseed [21]. After leavening, the dough is flattened by shaking with a circular motion (hence the name *Schüttelbrot*, which in German means “shaken bread”) to obtain a thin disk (10–35 cm large, 0.3–1.5 cm thick), with a few central irregular holes [29]. *Schüttelbrot* is slightly sour and very dry, resulting in a long shelf-life [29, 44].

PAT Italian flatbreads

Panigaccio di Podenzana

Panigaccio di Podenzana is a Tuscan PAT flatbread [33, 45] made by mixing wheat flour with water and salt to obtain a dense batter [21, 29], which is then baked on a red-hot small terracotta plate (around 15 cm diameter) named *testo* [12], homonymous but different from the metallic two-piece *testo* used for baking the *Testarolo pontremolese*. A small amount of the batter is poured onto the preheated terracotta *testo*, then another hot *testo* is placed on top and so on, resulting in a stack of about 10–12 plates [11]. The baking process is rapid, lasting only 1–2 min.

Neccio

Neccio, a PAT flatbread that originated in Tuscany [33, 45], is a gluten-free crêpe-like bread with a diameter of 25 cm, produced from a dense batter of PDO *Garfagnana* chestnut flour [46], water and salt. Chestnut flour imparts dark brown color and marked flavor and its use in breadmaking has recently been reevaluated for its vitamin, mineral, and fiber content [47, 48]. *Neccio*

was traditionally baked in the fireplace between red hot refractory stone plates named “*testo*” [11], similar to the way also *Panigaccio di Ponzanica* is baked. Then, several *testo* were stacked and held together by a tool called *testaiola*. Chestnut leaves were used to line the *testo*, preventing the dough from sticking to it [21]. Today, *Neccio* is mostly cooked by pouring the batter onto the bottom of a two-piece cast-iron pan placed over the fire and pressing it down with the top.

Farinata

Farinata is a gluten-free pancake-like flatbread made of chickpea flour, water, EVOO, and salt, prepared in three neighboring regions (Liguria, Tuscany, and Piedmont) and recognized as PAT in each of them [33, 45]. A wheat-based variant is *Farinata Bianca* or *Farinata Savonese*, named after the city where it originated, Savona. *Farinata* is a cousin bread of *Socca*, from Nice, in the neighboring French region of Provence. After mixing all the ingredients, the dough is poured into a large (about 1 m in diameter) circular pan made of tin-plated copper, left to rest for three hours, then baked in a wood-fired oven for about 15 min [29]. Chickpea flour is rich in proteins, total dietary fiber, unsaturated lipids, minerals, and bioactive compounds with antioxidant activity [49], so considerable interest has recently arisen in the use of this flour in breadmaking [50–52].

Schiacciata

Schiacciata, meaning “squashed,” refers to the action of pressing the dough with the fingers to flatten it, without a rolling pin. This flatbread originated in Tuscany and Lombardia [33, 45], with slightly different ingredients and names. In Tuscany, this flatbread is named *Schiacciata alla Fiorentina*, *Schiaccia Grossetana*, or *Schiaccia pizzicata di Montiano* and is prepared with wheat flour, water, and yeast, then seasoned with abundant EVOO [21]. In Lombardia, it is named *Schiacciatina* or *Chisolina* and incorporates *strutto* instead of EVOO, not typical of the area. Both are baked on the *testo* or under hot ash and charcoals [21].

Torta al testo

Torta al testo, a PAT from the Umbria region [33, 45], is also called *Pizza sotto il fuoco* or *Torta sul panaro* [21, 53]. The dough is prepared by mixing wheat flour, water, lard or EVOO, baking soda, and salt [54]. Originally, farmers used to prepare the *Torta al testo* with cornmeal and bake it on a “*panaro*” or “*testo*.” The latter evolved from being a large flat stone to a clay plate, and eventually to a cast-iron plate [21]. After placing the dough on the preheated *testo*, it is pierced with a fork and, when a crust forms, it is turned over and covered with hot ash and

charcoal until baked. This baking method contributes to the distinctive flavor of *Torta al testo* [53].

Borlengo

Borlengo (or *Burláng*, *Burleng*) is PAT from the Emilia Romagna region [33, 45], specifically from the cities of Modena and Guiglia [55], made of wheat flour, water, salt, and occasionally eggs [22, 56]. It is prepared from a very light batter called “*colla*” (5 L of water per 1 kg of flour) [56]. The high degree of dilution allowed to save flour, as needed in times of scarcity. Furthermore, in case of wheat unavailability, chestnut or corn flours were used [22]. The main characteristic of *Borlengo* is its extreme thinness (0.5–0.7 mm), and crispiness. Since the Medieval period, *Borlengo* was associated with Carnival because it was so thin that it seemed made as a joke (“*burla*” in Italian), not like real bread [55].

Borlengo is baked on a large (45 cm diameter) tinned copper rimless pan with a very long handle, named “*sole*” (or *sól*), greased with pork rinds [22, 26]. It is traditionally seasoned with grated *Parmigiano Reggiano* PDO cheese and a typical sauce called “*Cunza*,” prepared from bacon and/or lard, garlic, and rosemary [22, 38, 56].

Gnocco fritto

Gnocco fritto, named *pinzino* in the city of Ferrara [29], is a PAT from the Emilia Romagna region [33, 45]. This fried flatbread is prepared with wheat flour, water, *strutto*, baking soda, and salt. The dough is finely sheeted, then cut into 5–15 cm long rectangles and fried in hot *strutto* [29]. During the frying process, the dough delaminates due to heat. Historically, *gnocco fritto* was prepared as a large pancake, 25 cm in diameter and 0.5 cm thick, featuring a central hole (referred to as “*umbreghel*” or belly button), made to allow perfect frying even in the center [26] (Fig. 2). *Gnocco fritto* is a very fatty food, aligning with the lifestyle of the past where manual labor outdoors, especially in the cold season, was prevalent. Today, it is consumed occasionally as a snack [29].

Gnocco ingrassato

Gnocco ingrassato or *Gnocco cott al fouren* (where “*cott al fouren*” means “baked in the oven” to distinguish it from the fried *gnocco*) is a PAT from the Emilia Romagna region [33, 45] prepared by kneading wheat flour, water, lard, diced ham, yeast, and salt. The dough is flattened to 2–3 cm thickness, placed in a rectangular pan, and baked in the oven for 30–40 min at around 180 °C [21, 57]. Originally from Reggio Emilia, it is known as *Spianata* in Modena and *Crescenta* in Ferrara [21]. A variant made with similar ingredients, but baked in a fireplace, by covering it with a sheet of damp paper and then embers, is known as *Gnocco sotto le braci*, or *Gnòch sott'al bràsi*.



Fig. 2 An example of fried flatbread: *Gnocco fritto*. This double-layer flatbread from the Emilia Romagna region of Italy is leavened with baking soda and is typically fried in hot *strutto* (pork fat). The picture shows the most traditional shape of *gnocco fritto*, that is a large circular pancake featuring a central hole. Photo credit: Pino Marzulli



Fig. 3 An example of leavened single-layer flatbread: *Crescentina*. Always present at all local festivals and fairs in the Emilia Romagna region of Italy, *Crescentina* is generally stuffed with soft cheese and cured meats. Photo credit: Pino Marzulli

Crescenta

Crescenta is traditionally prepared in the city of Bologna, in the Emilia Romagna region, as well as in Tuscany, where is named *Carscenta della Lunigiana* [33, 45]. Instead, *Crescia*, *Crescia fogliata*, *Cresciolina* and *Crescia sotto la cenere* are all PAT of Marche [33, 45]. These specialties share similarities and are closely related to *Gnocco ingrassato*. *Crescenta* is made with flour, water, lard, diced ham and bacon, yeast, and salt [21]. In Bologna, *Crescenta* is an emblematic food that gives the colloquial name “*Crescentone*” to the raised pedestrian platform located in the city’s main square, Piazza Maggiore [58].

Crescenta fritta

Crescenta fritta is a flatbread from the Emilia Romagna region [33, 45]. In the city of Bologna, it is referred to as *Crescentina* or *Crescentina fritta* [21]. The method of preparation is similar to that of the *Gnocco fritto*, but the ingredients are slightly different: flour, milk, *strutto*, baking soda, and salt. The dough is shaped into diamond forms and then fried in *strutto*, resulting in high fat content [21, 57].

Crescentina

Crescentina (or *Chersèinta sotto le braci*, *Chersèint ind-el tigèli*, *Crescentina di Modena*) is traditionally prepared in the Emilia Romagna [33, 45] (Fig. 3).

Originally from Modena, it is also called *Tigella Modenese* or *Tigèla Modenese*. However, these latter names refer to the traditional baking tool used to bake it, named *tigella*, rather than the flatbread itself [26]. *Tigella* is a circular terracotta plate, 15 cm in diameter and 1.5 cm thick [59] named from the Latin word “*tegere*,” meaning “to cover,” because the dough was baked by

placing it on a red-hot *tigella*, previously greased with *strutto*, then covering it with another *tigella*. A stack was then made in the fireplace [26]. *Tigella* usually has a decoration in relief, which remains imprinted on the dough’s surface as it bakes. These decorations generally depict a star, a solar disk, or a six-petalled flower (“*rosa comacina*”), all emblems of life and regeneration, just as bread is a symbol of life and fertility, which is born from the earth, matures with the heat of the sun and then becomes nourishment through the heat of fire [26]. Today the traditional terracotta *tigella*, often displayed in traditional restaurants or ethnographical museums, is no longer used. Instead, cast-iron molds called *cottole*, decorated in the same way as the old ones, have become the commonly used baking tool [26].

Crescentina is made with wheat flour, water, salt, and occasionally lard and milk [59]. Originally unleavened, today *Crescentina* is generally leavened with either bakers’ yeast or sodium bicarbonate [21, 59]. Attention must be paid to homonyms because in the province of Bologna the name “*Crescentina*” identifies a different flatbread, which is fried [21].

Crostolo

Crostolo is a flatbread from the Montefeltro area, between the Emilia Romagna and Marche regions [33, 45], prepared also in the city of Urbania, in the same region [60]. *Crostolo* is made by kneading wheat flour with eggs, milk, salt, and, as a key ingredient, black pepper, a valuable spice consumed in the past only by wealthy people. Dough sheets are then greased with *strutto* and rolled up into cylinders (“*bigoli*”) used to make narrow spirals. The latter are flattened with a rolling pin to obtain thin disks of puff pastry, ready to be baked for a few minutes on a

metal grill placed over an open fire. The grill forms dark parallel stripes on the surface of the *Crostolo*, which characterize its appearance [29]. The *Crostolo* is considered a very nutritive bread, owing to its eggs and milk content. This flatbread is a key product in any festival promoting the local traditional cuisine of the region, including the “*Sagra del Crostolo*,” a yearly competition that awards the best *Crostolo* [60].

Crescia sfogliata

Originating from an area neighboring the one from which the *Crostolo* comes, hence often confused with the latter, the *Crescia sfogliata* is recognized as PAT in the Marche region [33, 45], made of wheat flour, water, eggs, *strutto*, salt, and black pepper, without the addition of milk (used, instead, in the preparation of *Crostolo*) [22]. *Crescia sfogliata* is baked on a cast-iron pan, named “*panaro*,” so its surface is free of the dark streaks of the *Crostolo* [29]. Typically made in Urbino, the *Crescia sfogliata* is sometimes referred to as “*Piadina di Urbino*” because of its similar appearance to *Piadina romagnola*, but is a very different product, with much more nutritious ingredients.

Carchiola

Carchiola is a flatbread from the Basilicata region [33, 45], also included in the Slow Food “Ark of Taste” [61]. Originating in the town of Avigliano, it was prepared with cornmeal by the poor, who could not afford wheat flour, and was typically baked in the fireplace, to avoid

paying for the use of communal ovens. The preparation of *Carchiola* involves kneading corn flour, water, and salt, sheeting the dough to 2 cm thickness, and baking it on a metal grill equipped with a rotating mechanism, named *r'ticula* and unique to *Carchiola* bread, placed in the fireplace [11]. The rotating grill allows the *Carchiola* to be flipped over when the first side has been cooked. *Carchiola* has a hard consistency and is softened in legumes and vegetable soups [61].

Puccia

Puccia (or *Uliata*, or *Pane di semola*, or *Pane di orzo*) is a PAT of the Apulia region [33, 45], made with durum wheat semolina (or sometimes barley), sourdough, water, EVOO, and salt [29, 62]. After leavening, the dough disks (20 cm large) are baked on refractory stone at 350 °C for 1–2 min [62]. The addition of *L. plantarum* ITM21B fermentation product and 15% chickpea flour allowed the production of salt-reduced *Puccia* with improved nutritional and sensory properties [63]. Also, liquid sourdough made of selected strains of *Leuconostoc citreum* and *Weissella confusa* isolated from semolina was used for making *Puccia* without added salt, retaining taste and aroma. This approach was applied also at the industrial level [62, 64]. *Puccia* is traditionally eaten by stuffing its “pocket” with meat and vegetables (Fig. 4).

Pane carasau

Pane carasau (or *Pana carasatu*, *Carta da musica*, *Pane de fresa*) is a Sardinian PAT [33, 45]. The preparation

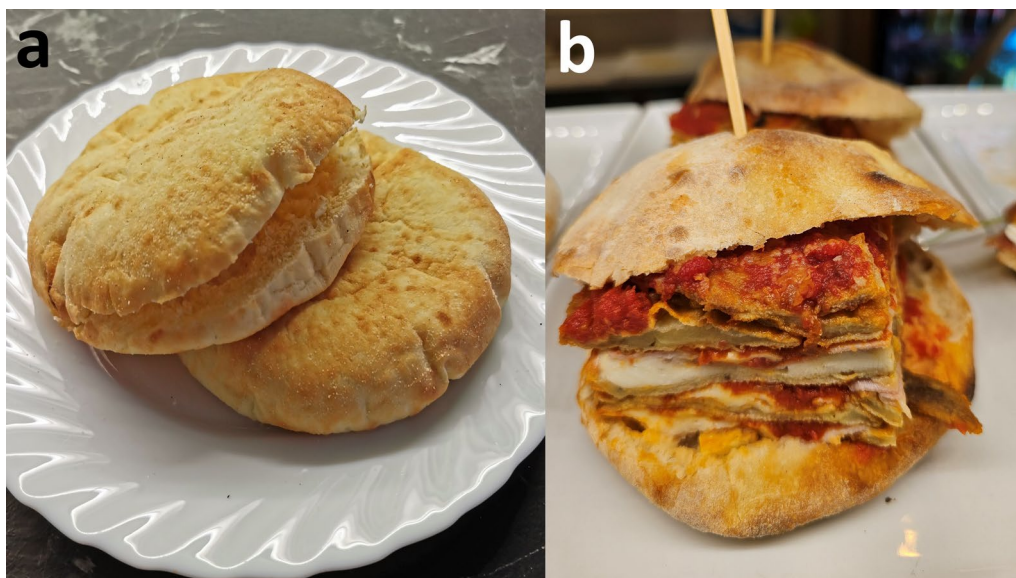


Fig. 4 An example of leavened double-layer flatbread: *Puccia*. **A** Plain *Puccia*, a traditional flatbread from the Apulia region of Italy. This flatbread is made of durum wheat semolina and is leavened with sourdough. **B** *Puccia* stuffed with grilled vegetables, meat and tomato sauce. Photo credit: Pino Marzulli

of this sourdough-leavened flatbread, made of semolina (typically, in the past, a high-extraction rate one, named *semolato*), water, and salt, typically involves two baking rounds, the second of which (*carasatura*) after layer separation (*fresatura*), made to obtain a very thin (1–2 mm) and crisp product [65–67]. Its dryness allows for a long shelf-life and wide commercialization throughout Italy and abroad. The sensory and nutritional quality of *Pane carasau* improves by using liquid sourdough [65], able to enhance crispiness and lower the rapidly digestible starch while increasing the slow and inaccessible starch. The organic acids of sourdough, indeed, induce starch-gluten interactions making the starch less digestible and decreasing the postprandial glucose response [68]. Dough elasticity, instead, improves with leavening time [69]. Sourdough-leavened *Pane carasau* was found to positively influence gut microbiota in rats by inducing metabolic dormancy of *Clostridium* spp. [70].

Pane guttiau

Pane guttiau is a PAT from the Sardinia region [33, 45] and is an EVOO-seasoned version of *Pane carasau*. The term “*guttiau*” in Sardinian means “dripped” or “sprinkled.” This name originates from the practice of sprinkling EVOO over the two separate layers of *Pane carasau* after its first baking. The two layers, seasoned, are then briefly baked again to achieve dryness, and then salted [71]. *Pane guttiau* has a crunchy texture and is usually eaten as a snack, alone or paired with cold cuts or cheese [72].

Spianata

Spianata (or *Ispianada*, *Pane modde*, *Pane poddine*, *Pane fine*) is a traditional flatbread from the Sardinia region [33, 45]. It is a sourdough-leavened flatbread made with durum wheat semolina (today refined, while in the past a high-extraction rate semolina was most used), water, and salt. After sheeting, the fermented dough is baked in a wood-fired oven. Circular in shape, 20–30 cm large, and one cm thick, *Spianata* has a minimal crumb [29].

Ritual variants of this flatbread are prepared to celebrate religious events, such as the festival in honour of Our Lady of Gonare, in the towns of Orani and Sarule, and other patronal festivals [19, 28, 29]. For this ritual variant only refined semolina is used. The ritual *Spianata* is stamped with hearts, crosses, and other symbols and, in the ultimate phase of baking, is sprinkled with water (*imbridadura*) to induce starch gelatinization and obtain a shiny surface [21, 29]. On New Year’s Eve (*Candelaira*) a special *Spianata* is prepared that, in addition to being decorated, is enriched with lard. The ritual breads are then given to children [28]. The custom of decorating bread in Sardinia dates back to antiquity. A circular



Fig. 5 Reproduction of an ancient *pintadera*. Scholars interpreted the circular terracotta stamp with geometric patterns in relief, named *pintadera*, as a tool for decorating bread in Sardinia during the Nuragic civilization, since bronze figurines offering loaves decorated with similar motifs have been found in archeological excavations in the area. The Nuragic culture lasted in the Sardinia island, Italy, from the Middle Bronze Age up to the Roman colonization in 238 BC. Photo credit: Pino Marzulli

terracotta stamp with geometric patterns in relief, named *pintadera* (Fig. 5), has been interpreted by scholars as a tool for decorating bread in Nuragic times, being bronze figurines offering loaves decorated with similar motifs found in archeological excavations [73].

Pistoccu

Pistoccu (meaning “baked twice”) is traditionally prepared in Sardinia [33, 45]. It is an elongated crisp bread slightly thicker than *Pane carasau* (3–4 mm) prepared with semolina (refined or, as in the past, high-extraction rate), water, bakers’ yeast, and salt [28]. After kneading, the dough is left to rest for an hour, then rolled out and baked. Wood-fired ovens were used in the past, while today *Pistoccu* is mainly baked in steam ovens at 200 °C for 20 min. Once baked, each loaf is cut into two halves and baked again to achieve dryness in fan-assisted “rotor” ovens, to extend the shelf-life up to several months [21, 29].

Zichi

Zichi is a Sardinian sourdough-leavened PAT flatbread [33, 45] made from durum wheat semolina (refined or high-extraction rate, which was more widely used in the past), water, and salt. The dough is flattened using a wooden rolling pin to obtain 0.5 cm thick disks, 35–40 cm large, which were traditionally stamped with wooden stamps, named “*sa marca*,” for identification [73]. *Zichi* is baked in a wood-fired oven at 400–500 °C for a few minutes. When, a few days after baking, the

bread hardens, it is cut into small pieces and softened in sheep's broth [21]. Decorated *Zichi* breads are prepared for weddings (“*su pane'e iscadda*”) or for religious events (Fig. 6), similarly to *Spianata*, using only refined semolina [73].

SFP Italian flatbread

Testarolo pontremolese

Testarolo pontremolese is a Tuscan SFP bread [33, 45] also recognized as PAT [74]. It is a pancake-like bread round in shape, 40–45 cm in diameter, very thin and highly porous, prepared from a smooth batter of wheat flour, water, and salt [21]. Traditionally, *Testarolo pontremolese* is baked in the fireplace in a two-piece cast-iron pan, named “*testo*” [21] (Fig. 7). When the bottom piece of *testo*, a disk plate called “*sottano*,” reaches the desired temperature, the batter is poured and covered with the top piece, a dome-shaped lid called “*soprano*.” This ancient cooking method, native to the *Lunigiana* area, is unique. However, today *Testarolo pontremolese* is also produced industrially, cooking it on a hot steel plate without any cover. This flatbread is not eaten as it is. Cut into diamond shapes and soaked in hot water, is dressed with a fresh pesto made of basil, *Parmigiano Reggiano* PDO cheese, and EVOO [21].

Comparative analysis of Italian flatbreads

Flatbreads can be broadly categorized as unleavened and leavened, the latter subdivided further into double-layer and single-layer varieties (Fig. 8) [11, 12].



Fig. 7 The special baking system used to cook *Testarolo pontremolese*: *Testo*. This baking system is made of cast iron and is composed of two pieces: a base, basically a pan, called *sottano*, and a lid, called *soprano*. Placed in the fireplace and made red-hot, this *testo* is exclusively used to bake *Testarolo pontremolese*. Photo credit: Lumachelli Pietro e Figli srl

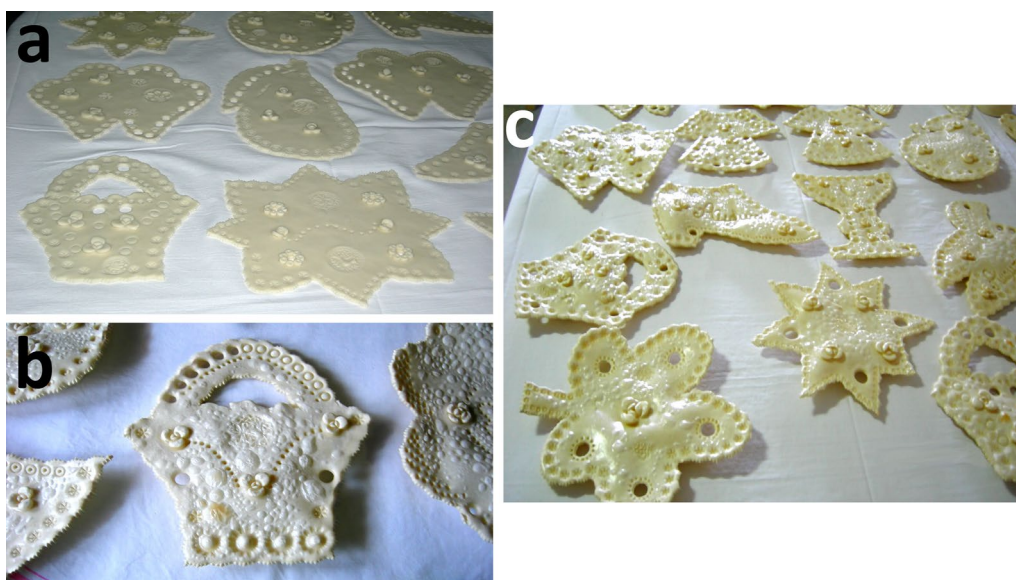


Fig. 6 Ritual flatbread. **A** Uncooked *Zichi* flatbread decorated for wedding (*su pane'e iscadda*). These ritual flatbreads convey auspicious messages to protect the couple. **B** Detail of a handbag-shaped decorated *Zichi* flatbread. **C** Decorated *Zichi* flatbread after baking. It is visible the shiny surface, due to starch gelatinization. Photo credit: Angelo Morittu

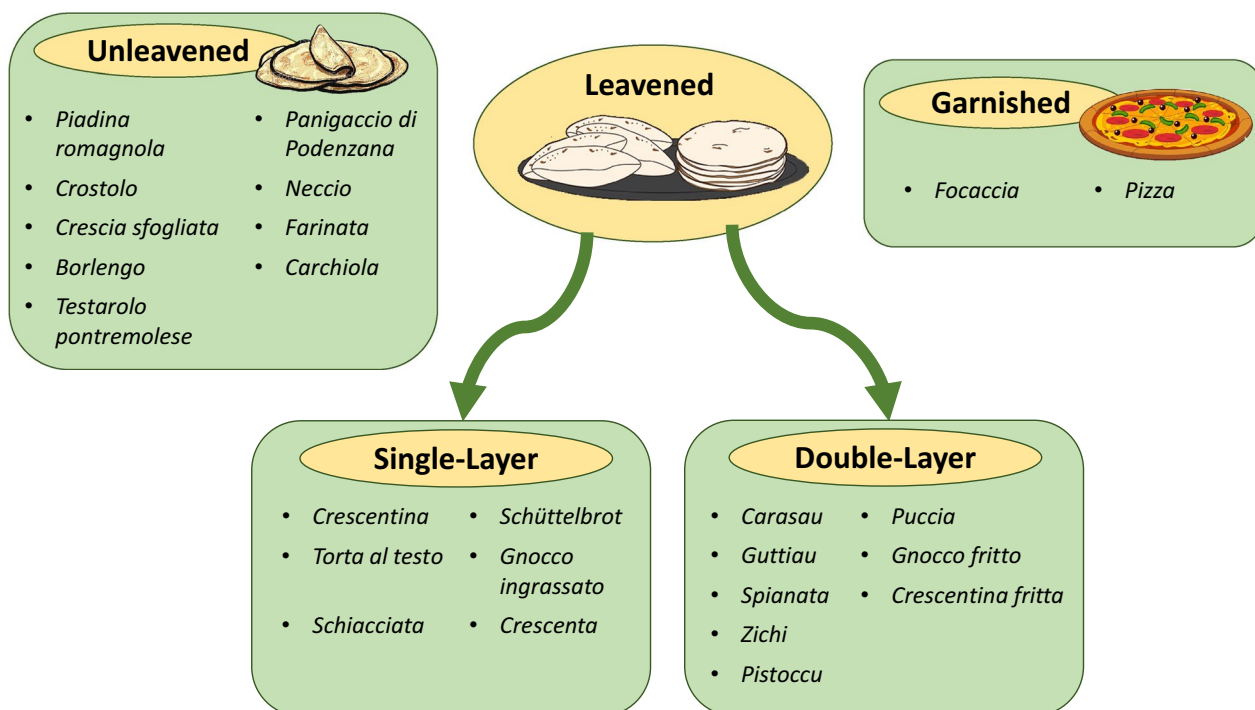


Fig. 8 Classification of Italian flatbreads. Flatbreads are broadly classified into three categories: unleavened; leavened (subdivided further into single-layer and double-layer varieties); garnished. From the nutritional point of view the latter represent a complete meal due to their rich garnishments, which may include cheese, meat or vegetables

Unleavened flatbreads are: *Piadina romagnola*, *Crostolo*, *Crescia sfogliata*, *Borlengo*, *Testarolo pontremolese*, *Panigaccio di Podenzana*, *Neccio*, *Farinata*, and *Carchiola*. Leavened double-layered flatbreads are *Pane carasau*, *Pane guttiau*, *Spianata*, *Pistoccu*, *Zichi*, *Puccia*, *Gnocco fritto*, and *Crescenta fritta*. Leavened single-layered flatbreads are *Crescentina*, *Gnocco ingrassato*, *Crescenta*, *Torta al testo*, *Schiacciata* and *Schüttelbrot*. It is important to note the existence of another category -garnished flatbreads such as pizza and focaccia- which, although significant, are not considered in the present review.

The overall flowchart of the production process of unleavened and leavened, double- and single-layered, flatbreads is reported in Figs. 9 and 10.

Information on ingredients, dough consistency, leavening, and baking conditions, bread shape and size has been schematically summarized in three tables: unleavened flatbreads are summarized in Table 2, leavened double-layered flatbreads in Table 3, and leavened single-layered flatbreads in Table 4. A comparative analysis of the ingredients and main processing steps (dough formation and shaping, leavening, and baking) of the Italian flatbreads described so far is provided as follows, considering the entire group of flatbreads altogether to allow a complete discussion.

Ingredients

The formulation of Italian flatbreads is generally very simple, being the most common ingredients only flour, water, yeast (in the leavened ones), and salt. Additional ingredients can be oils and fats, and sometimes ham, eggs, and milk. The most used fatty ingredients are *strutto* (a name that stands for fat obtained by fusing all the fatty parts of a pig), and lard. These ingredients have a strong regional variation, being found only in flatbreads (*Piadina romagnola*, *Crostolo*, *Crescia sfogliata*, *Gnocco ingrassato*, *Crescenta*, *Torta al testo*, *Schiacciata*, *Gnocco fritto* and, occasionally, *Crescentina*) prepared in the regions of north-central Italy (Emilia Romagna, Marche, Umbria, and Lombardia), where animal farming is more common than in the south and pigs are usually reared.

Olive oil or EVOO is used less frequently. They are proposed today as a healthier alternative to *strutto* and lard in *Piadina* and *Torta al testo*, or are a typical ingredient of a few flatbreads originally from areas where olive cultivation is common, such as *Farinata* (from Tuscany and Liguria), *Guttiau* (from Sardinia), and the Tuscan version of *Schiacciata*.

Eggs and milk are found in a few flatbreads (*Crostolo*, *Crescia sfogliata*, *Crescenta*, *Crescenta fritta*, and, occasionally, *Borlengo*), usually in combination with *strutto*.

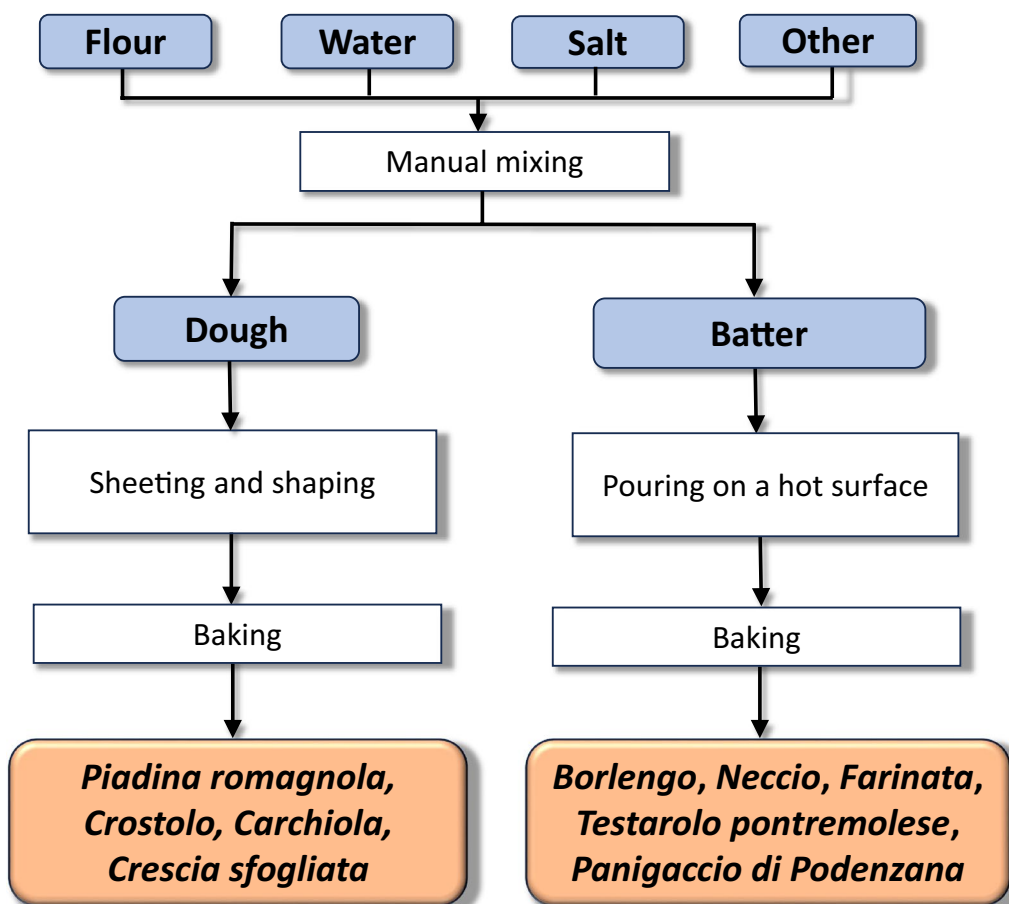


Fig. 9 Flowchart of the production process of unleavened Italian flatbreads. The flowchart details the procedure for preparing the unleavened flatbreads, which can be obtained either by preparing a batter or a dough. The specific names of breads are reported in the orange boxes

Added ingredients especially fat also have nutritional implications depending on whether are rich in unsaturated fatty acids and antioxidants, like EVOO, or whether are saturated, like *strutto* and lard [41]. Generally, flatbreads with added fats of animal origin, or egg and milk, were not intended for daily consumption but only for an occasional one. In the past, they were considered “rich” bread formulations, associated only with festive days, and today, similarly, they are mostly consumed in food festivals and convivial occasions.

Spices occur rarely in the preparation of Italian flatbreads, being black pepper used only in the preparation of *Crostolo* and *Crescia sfogliata*, and fennel seeds (or, occasionally wild cumin, coriander and aniseed) used for preparing the *Schüttelbrot*.

Regarding the type of flour, the history of cereal cultivation in Italy is ancient, dating back to 7000 BP, with the first flatbreads made with emmer (*Triticum turgidum* subsp. *dicoccum*) [75]. Today, Italian flatbreads are mostly made from bread wheat flour (*Triticum turgidum* subsp. *aestivum*) or durum wheat

semolina (*Triticum turgidum* subsp. *durum*), reflecting wheat’s status as the primary cereal crop. Local indigenous wheat cultivars are mostly used, specifically adapted to the area [73]. Durum wheat semolina is used in flatbreads prepared in southern Italy (*Puccia*) and especially in Sardinia (*Pane carasau*, *Pane guttiau*, *Spianata*, *Pistoccu*, and *Zichi*), being durum wheat largely cultivated in these regions and being less common in northern Italy. Carotenoid pigments in the semolina give the product its typical golden color [76].

Flatbreads produced using high-extraction (75–90%) or whole-grain flours are a good source of dietary fiber and minerals [10] and were largely used in the preparation of flatbreads in the past. Refined flour was used almost exclusively by the wealthier social classes or for the preparation of precious ritual breads, the latter being particularly typical in Sardinia (*Spianata* and *Zichi*) [19, 28, 29, 73]. With the general improvement in economic conditions, refined flour has largely replaced high-extraction flour, being preferred to achieve lighter-colored bread [11]. Today the trend shows that

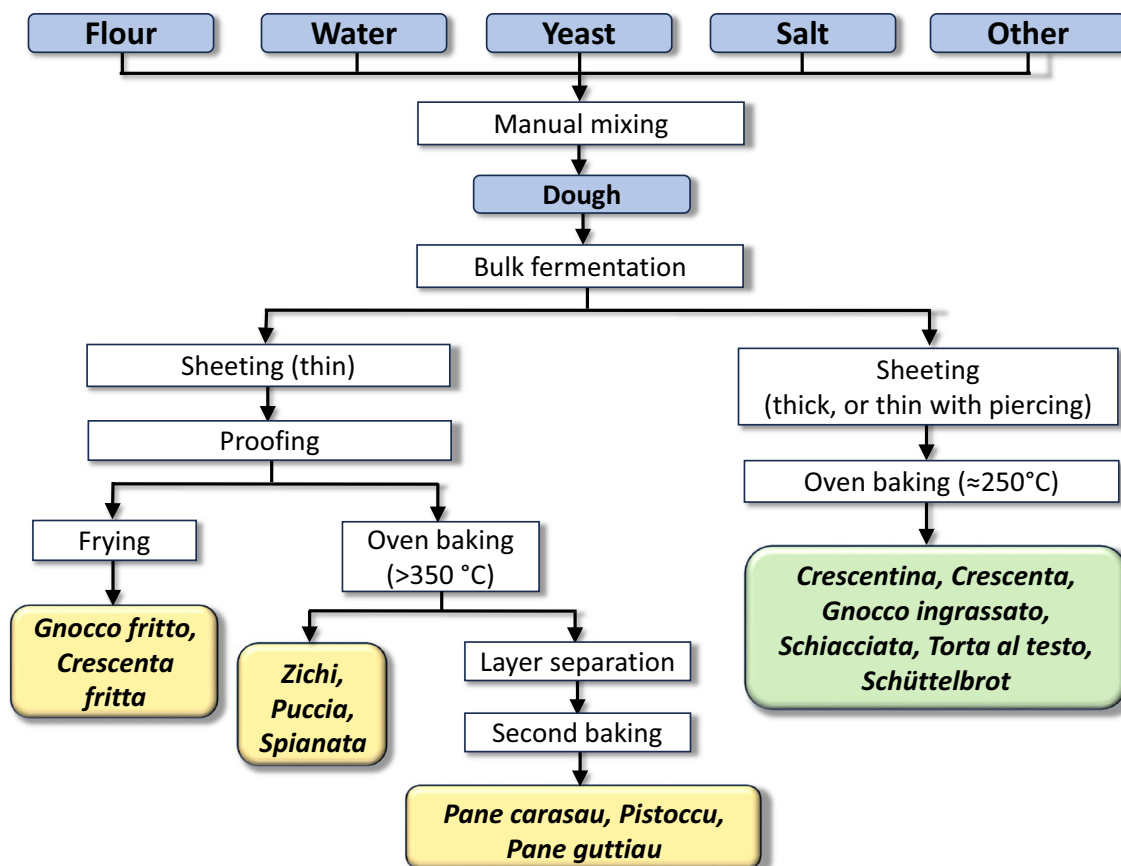


Fig. 10 Flowchart of the production process of leavened double- and single-layered Italian flatbreads. The flowchart highlights the main differences in the production process of double-layered flatbreads (reported in the yellow boxes) and single-layered ones (reported in the green box), consisting in a different thickness of the sheeted dough and different baking temperature. The flowchart also details the procedure for preparing the double-baked flatbreads and the fried flatbreads

people are returning to whole-grain bread for health reasons, but this type of bread is a niche product [77].

One advantage of flatbreads over loaf bread is that they can be easily made with non-wheat flours, also gluten-free, being high volume not required in this product, at least in the unleavened version. Alternative flours used in Italian flatbreads include chestnut flour, used for *Neccio* in Tuscany, rye flour, used for *Schüttelbrot* in Alto Adige, chickpea flour, used for *Farinata di ceci* in Liguria, and corn flour, for *Carchiola* [11]. In addition, the use of cornmeal has been recorded throughout history as a cheap alternative, in case of famine, for the preparation of some breads that, instead, today are made with wheat flour, such as *Piadina romagnola*, *Borlengo*, and *Torta al testo*. Being cheaper, cornbread was a staple food for the lower social classes, leading to the spread of pellagra among the poor in north-central Italy in the late 19th and early twentieth centuries [78].

Dough formation and shaping

The mixing of ingredients, traditionally manual, can be done with automatic kneading machines, but the latter are used only for those breads that have a larger production such as *Piadina romagnola* and *Pane carasau*. The consistency of dough varies from a semi-fluid batter to a thicker batter, to a consistent dough. In any case, regardless of dough consistency, and whether they are leavened or not, flatbreads are generally thin, varying in thickness from a few millimeters to a few centimeters. They are characterized by low specific volume, and high crust-to-crumbs ratio [12].

Batters, ready to be poured onto a hot baking surface (Fig. 9), are typically prepared for the majority of unleavened flatbreads (*Borlengo*, *Testarolo pontremolese*, *Panigaccio di Podenzana*, *Neccio*, and *Farinata*). The result is generally very thin (1–4 mm thickness). All the other Italian flatbreads require a consistent dough which is then sheeted and shaped as a disk of about 1–2 cm thickness.

Table 2 Technical features of unleavened Italian flatbreads prepared according to the old tradition

Bread name	Flour type ⁵	Additional ingredients (other than flour, water, salt)	Dough consistency	Baking time (with old baking system) [∞]	Traditional (old) baking system	Bread shape and size
<i>Piadina romagnola</i> *	Corn flour in the past; wheat flour today	In the past <i>strutto</i> [#] today also olive oil, or extra virgin olive oil	Dough	3–5 min depending on thickness	On clay pans named “testo” or “teghia” or “teglia” made red-hot by being placed in the fireplace	Circular; 4–8 mm thick; diameter 15–25 cm. The <i>Riminese</i> variant is 3 mm thick and has a diameter of 23–30 cm
<i>Crostolo</i>	Wheat flour	Egg, <i>strutto</i> [#] , milk, black pepper	Dough	3–4 min	On a hot metal grill placed over an open fire, which gives the surface of the bread its typical dark striped appearance	Circular; about 5 mm thick; about 25 cm diameter
<i>Crescia sfogliata</i>	Wheat flour	Egg, <i>strutto</i> [#] , black pepper	Dough	4–5 min	In a large (about 50 cm) cast-iron pan named “panaro” placed in the fireplace	Circular; about 1 cm thick; diameter about 50 cm
<i>Borlengo</i>	Wheat flour or, in periods of famine, corn flour or chestnut flour in the past. Today only wheat flour	Occasionally egg	Thin batter	1–2 min	In a large (45–50 cm diameter) tinned copper rimless pan with a very long handle named “sole” placed in the fireplace	Circular; 1 mm thick; around 45 cm diameter
<i>Testarolo pontremolese</i>	Wheat flour	–	Thick batter	1–2 min	In a hot cast-iron pan with a lid, named “testo,” placed in the fireplace	Circular; 2–3 mm thick, 40–45 cm diameter
<i>Panigaccio di Podenzana</i>	Wheat flour	–	Thick batter	1–2 min	Between two small terracotta plates named “testo” (about 15 cm diameter) placed in the fireplace	Circular, 2–3 mm thick; 10–15 cm diameter
<i>Neccio</i>	Chestnut flour	–	Thick batter	2–3 min	Between two medium sized terracotta plates named “testo” (about 25 cm diameter) placed in the fireplace	Circular; about 3–4 mm thick; 25 cm diameter
<i>Farinata</i>	Chickpea flour	Extra virgin olive oil or olive oil	Thick batter	5–6 min	In a very large pan (about 1 m diameter) of tin-plated copper placed in a wood-fired oven	Circular; 4–6 mm thick; up to 1 m diameter
<i>Carchiola</i>	Corn flour	–	Dough	3–4 min	On a metal grill with a rotating mechanism called “ <i>riticula</i> ” placed in the fireplace	Circular; 4–5 mm thick; 25–30 cm diameter

*Originally unleavened, today chemical leavening agents may be added

⁵ High-extraction rate in the past, refined today[#] *Strutto* is an Italian word indicating fat obtained by fusing all the fatty parts of a pig[∞] With the traditional old baking systems, in the fireplace or in wood-fired oven, temperature was between 300 and 400 °C

Table 3 Technical features of leavened Italian flatbreads having a double-layered structure, prepared according to the old tradition

Bread name	Flour type [§]	Additional ingredients (other than flour, water, salt)	Leavening agent	Leavening time and temperature	Baking time (with old baking system) [∞]	Traditional (old) baking system	Bread shape and size
<i>Pane carasau</i>	Durum wheat semolina	–	Sourdough or baker's yeast	Several hours for sourdough, 1 h for bakers' yeast; RT	2–3 min + 1 min; baking is done in two steps, the second step is done after the separation of the two layers and leads to complete dryness	On the slab of a wood-fired oven	Circular; 1–2 mm thick; about 30 cm diameter
<i>Pane guttaiu</i>	Durum wheat semolina	Extra virgin olive oil	Sourdough or baker's yeast	Several hours for sourdough, 1 h for bakers' yeast; RT	2–3 min + 1 min; baking is done in two steps, the second step is done after the separation of the two layers and leads to complete dryness	On the slab of a wood-fired oven	Circular; 1–2 mm thick; about 30 cm diameter
<i>Spianata</i>	Durum wheat semolina	–	Sourdough	Several hours; RT	2–3 min	On the slab of a wood-fired oven	Circular; 1 cm thick; 10–20 cm diameter
<i>Pistoccu</i>	Durum wheat semolina	–	Baker's yeast	1 h; RT	3–4 min + 1 min; baking is done in two steps, the second step is done after the separation of the two layers and leads to complete dryness	On the slab of a wood-fired oven	Small rectangular; 3–4 mm thick
<i>Zichi</i>	Durum wheat semolina	–	Sourdough or baker's yeast	Several hours for sourdough, 1 h for bakers' yeast; RT	2–3 min	On the slab of a wood-fired oven	Circular; 0.5 mm thick; 30–40 cm diameter
<i>Puccia</i>	Durum wheat semolina or barley flour	Extra virgin olive oil	Sourdough	Several hours; RT	3–4 min	On the slab of a wood-fired oven	Circular; 2 cm thick; 20 cm diameter
<i>Gnocco fritto</i>	Wheat flour	<i>Strutto</i> [#]	Baking soda	15 min	Frying in hot <i>strutto</i> for 1–2 min at 250 °C	–	Circular (25 cm diameter) or diamond shaped (5 × 10 cm); 0.3 cm thick
<i>Crescenta fritta</i>	Wheat flour	Milk, <i>strutto</i> [#]	Baking soda	15 min	Frying in hot <i>strutto</i> for 1–2 min at 250 °C	–	Diamond shaped (5 × 10 cm)

[§] High-extraction rate in the past, refined today[#] *Strutto* is an Italian word indicating fat obtained by fusing all the fatty parts of a pig[∞] With the traditional old baking systems, in the fireplace or in wood-fired oven, enough wood should be used to reach at least 350 °C, up to 500 °C

Table 4 Technical features of leavened Italian flatbreads having a single-layered structure, prepared according to the old tradition

Bread name	Flour type [§]	Additional ingredients (other than flour, water, salt)	Dough shaping modality	Leavening agent	Leavening time and temperature	Baking time (with old baking system) [∞]	Traditional (old) baking system	Bread shape and size
<i>Crescentina</i>	Wheat flour	Occasionally lard and milk	Sheeted using a rolling pin	In the past was unleavened, today baker's yeast or sodium bicarbonate are used	20 min, RT*	2–4 min	Between two small (15 cm diameter) circular terracotta plates called "Tigella" placed in the fireplace	Circular; 1.5 cm thick; 5–15 cm diameter
<i>Gnocco ingrassato</i>	Wheat flour	Lard, diced ham	Sheeted using a rolling pin	In the past sourdough, today baker's yeast	Several hours for sourdough, 1 h for baker's yeast; RT	About 20 min	Rectangular pan in the fireplace	Rectangular (40 × 30 cm), 2.5–3 cm thick
<i>Crescentina</i>	Wheat flour	Lard; ham	Sheeted using a rolling pin	In the past sourdough, today baker's yeast	Several hours for sourdough, 1 h for baker's yeast; RT	About 25 min	Rectangular pan in the fireplace	Rectangular (40 × 30 cm), 4–4.5 cm thick
<i>Torta al testo</i>	Corn flour in the past, today wheat flour	Lard or extra virgin olive oil	Sheeted using a rolling pin and pierced with a fork	Baking soda	1.5 min, RT	About 10 min	In a clay plate or eventually a cast-iron plate called "Pannaro" or "Testo" placed in the fireplace	Circular; 1 cm thick; 25–30 cm diameter
<i>Schiacciata</i>	Wheat flour	Extra virgin olive oil in Tuscany, <i>strutto</i> [#] in Lombardia	Flattened with the pressure of fingertips	In the past sourdough, today baker's yeast	Several hours for sourdough, 1 h for baker's yeast; RT	About 15 min	On stone slabs or on clay pans named "Testo" placed in the fireplace	Circular; 2 cm thick; 25 cm diameter
<i>Schüttelbröt</i>	Mix of rye and wheat flours	Fennel seeds. Occasionally wild cumin, coriander or aniseed	Flattened by vigorously shaking	Sourdough	2 h; 25–40 °C	About 15 min, baked to dryness	On the slab of a wood-fired oven	Circular; 0.3–1.5 cm thick; 30–35 cm diameter

[§] High-extraction rate in the past, refined today

*RT = Room Temperature (about 20 °C)

[∞] With the traditional old baking systems, in the fireplace or in wood-fired oven, temperature was set around 250–300 °C

[#] *Strutto* is an Italian word indicating fat obtained by fusing all the fatty parts of a pig

Usually, sheeting is made manually with the aid of a rolling pin. Alternatively, the dough can be flattened with the pressure of fingertips, as for the *Schiacciata*, or by vigorously shaking, as for the *Schüttelbrot*. At the industrial level, sheeting is done by laminating machines.

Leavening

The leavening phase is skipped for unleavened flatbreads (*Piadina romagnola*, *Crostolo*, *Crescia sfogliata*, *Borlengo*, *Testarolo pontremolese*, *Panigaccio di Podenzana*, *Neccio*, *Farinata* and *Carchiola*), resulting in a rapid procedure. In this case, the bread must be very thin to make it easier to chew. Unleavened flatbreads, commonly referred to as “wraps,” generally come from the Tuscan-Emilian Apennines, Lunigiana, and Po Valley, in north-central Italy (Fig. 11).

For leavened flatbreads, a bulk fermentation of the dough is carried out, followed by shaping. After shaping, a final proofing step is made only when an intense fermentation is crucial for achieving the desired bread structure, as in the case of double-layered flatbreads. Regarding the leavening agent, leavened flatbreads are often prepared with sourdough, a fermentation starter made at first from flour and water, and then from a portion of the previous breadmaking batch [6].

Flatbreads prepared with sourdough are *Gnocco ingrassato*, *Crescenta*, *Schiacciata*, *Schüttelbrot*, *Pane carasau*,

Pane guttiau, *Spianata*, *Zichi*, and *Puccia*. The use of sourdough was predominant, especially in the past, but in the early twentieth century this complex ecosystem composed of yeast and lactic acid bacteria [79] was gradually replaced by commercial baker’s yeast (*Saccharomyces cerevisiae*). The latter accelerates fermentation time, but results in a shorter shelf life and a weaker sensory experience than sourdough [80]. Today, interest in sourdough is growing back again due to its ability to lower the glycemic index, improve protein digestibility, increase nutrient bioavailability [81, 82], and reduce acrylamide content [83]. Liquid sourdoughs made of selected strains have been introduced in response to the need for a shorter and more controllable fermentation process [65, 84].

An alternative to biological fermentation is to use a chemical leavening agent, a mix of sodium bicarbonate or “baking soda” and a weak acid able to release carbon dioxide. The latter then thermally expands with the heat of the oven causing the dough to swell [85]. Chemical leavening agents are used in *Crescentina*, *Torta al testo*, *Gnocco fritto*, and *Crescenta frita*.

Baking and structuring the final bread

Flatbreads are generally characterized by “flash baking,” that is they are baked at very high temperatures (up to 450–500 °C) for a very short time, a maximum of a few minutes [86]. While in the Middle East and Indian



Fig. 11 Map of the Italian flatbreads produced in north-central Italy. The map shows the geographic area of Tuscan-Emilian Apennines, Lunigiana and Po Valley. Unleavened flatbreads are shown in green, single-layer leavened flatbreads in red, and double-layer leavened flatbreads in black

subcontinent baking is made by using a griddle or a hot plate, a *tannur*-style vertical oven [12], or even frying [87], the most traditional baking systems in Italy were terracotta plates placed in the fireplace [11, 12]. The most common name for these old baking plates, made of terracotta or metal and having a diameter ranging from 15 to 25 cm, is *testo*, a name mainly used in Tuscany and Emilia Romagna. A special *testo* is the one used for *Testarolo pontremolese*, consisting of two pieces, a pan and a lid. Placed in the fireplace and made red-hot, it acts as a small portable oven in which only this specific type of flatbread is baked (Fig. 7). Today, domed wood-fired ovens are the most popular baking systems among Italian consumers, complemented by modern electric ovens with refractory stone floors, or metal plates to be placed on the gas stove.

Baking causes the thermal dilation of gases, such as water vapor and eventually carbon dioxide generated by leavening agents, when used. Meanwhile, starch gelatinization and thermal denaturation of proteins confer the bread its final shape and structure. Depending on the presence or absence of gluten in the flour used, and according to the way the precedent processing steps, shaping and leavening, have been done, flatbreads can significantly inflate like a “balloon,” with consequent “delamination,” e.g., separation of the dough sheet into two distinct layers [9, 12, 88]. Also, baking temperature influences in determining delamination, being double-layered flatbreads are generally baked at higher temperatures than single-layered ones. Temperatures between 350 and 550 °C have been reported as required for perfect delamination [88]. After cooling, the bread loaf deflates but the two layers remain separated, resulting in a “pocket,” suitable to be stuffed with meat or vegetable ingredients according to the personal taste.

In unleavened flatbreads, the absence of fermentation, often coupled with the use of gluten-free or poor gluten-containing flours, and the frequent preparation of batters instead of dough, does not allow thermal delamination, explaining why they remain flat and thin.

In the case of leavened flatbreads, fermentation induces significant inflation and a double-layered structure only if a finely sheeted dough has been prepared and wheat flour has been used. Only a properly formed gluten matrix can produce a dough having sufficient viscoelasticity to perfectly delaminate during baking, so all double-layer flatbreads (*Pane carasau*, *Pane guttiau*, *Spianata*, *Pistoccu*, *Zichi*, *Puccia*, *Gnocco fritto*, and *Crescenta fritta*) are made of wheat flour [89]. The majority of them are from Sardinia: *Pane carasau*, *Pane guttiau*, *Spianata*, *Pistoccu*, and *Zichi* [73, 90, 91], while another one, namely *Puccia*, is from Apulia. This category of flatbreads also includes two fried products, namely *Gnocco fritto* and *Crescenta fritta*, very different from others in the same category,

being prepared with baking soda. They delaminate due to the thermal expansion of carbon dioxide and water vapor when immersed in hot frying oil.

Double-layer flatbreads can also be the subject of a double baking. Specifically, *Pane carasau*, *Pane guttiau*, and *Pistoccu* are baked in two steps: the first to achieve dough inflation and delamination, and the second to toast the bread. In detail, after the first baking step, the two layers of each loaf are separated by cutting them off at the edges, obtaining two extremely thin disks. The second baking is then done for a very short time (about 1 min) until each layer is toasted [66, 67, 92]. This double baking procedure results therefore in a very thin, dry, and crispy flatbread with a long shelf-life [90]. In the past, dry flatbreads were the staple food of shepherds, who spent several months away from home, without the opportunity to bake fresh bread [12].

Single-layer flatbreads (*Crescentina*, *Gnocco ingrassato*, *Crescenta*, *Torta al testo*, *Schiacciata*, and *Schüttelbrot*) are fermented ones, but inflation during baking is undesirable. Therefore, the sheeted dough is pierced with a fork (such as in the case of *Torta al testo*) to eliminate most carbon dioxide, thus preventing thermal delamination in two layers. Alternatively, the dough disk is kept relatively thick (2 cm), which also helps prevent delamination. Most single-layer flatbreads come from the area of the Tusco-Emilian Apennines, Lunigiana, and Po Valley. In some cases (such as *Crescentina*, *Crescenta*, and *Gnocco ingrassato*) their names are characterized by the surprisingly high number of linguistic variants (confusing the non-locals) due to dialectal differences among the towns of production, even though these are not far apart.

Cultural diversity and social dimension

Italy is seen as a true “bread cornucopia” being one of the richest countries in terms of bread variety among the European panorama [93]. Some traditional Italian flatbreads are also found in classical Italian literature, such as Sardinian breads, recounted by Grazia Deledda [30] and the *Piadina romagnola*, which inspired Giovanni Pascoli [37] and Mario Soldati [38]. Besides the already discussed occurrence of ritual flatbreads (*Spianata* and *Zichi*) in ceremonial life, i.e., in patronal festivals and weddings, the cultural significance of flatbreads can be further explained in terms of the role they play in Italian cuisine, evidenced by the hundreds of websites and cookbooks that list recipes for various Italian flatbreads both traditional and reinvented, further garnished, filled or wrapped around classic and non-classic ingredients. In Italy, besides environmental and climatic regional differences, historical factors such as the past civilizations and successive occupations by other peoples, also varying among different parts of the country, strongly influenced

gastronomy leading to well-differentiated regional culinary styles. Saying “traditional” in Italy means therefore taking into consideration all the 20 regions composing the country, generating a myriad of food cultures [94]. Similarly, the flatbread landscape is very rich in terms of regional and subregional diversity. This study identified and focused on 23 flatbreads in the Italian context that have received national and international quality awards, many other flatbreads in Italy do not have any quality label despite being equally important locally, not to mention that only plain flatbreads were considered, while there are also many garnished types [11]. The high degree of diversity observed in flatbreads is thus another expression of Italy’s diverse culinary heritage.

However, it is possible to identify some criteria for grouping these flatbreads. Although a limitation of the study is the lack of specific historical information available on Italian flatbreads, it was possible to highlight some regional variations probably rooted in local history, such as the contrast of double-layered flatbreads *versus* single-layered flatbreads. Double-layered flatbreads are prepared almost exclusively in Sardinia. Internationally, the double-layer structure is typical of flatbreads from the Middle East and North Africa [12], areas where first the Phoenicians and then the Carthaginians settled in antiquity and then spread to the coastal areas of the Mediterranean basin, including Sardinia. Therefore, the hypothesis of an ancient cultural influence cannot be ruled out. Similarly, a probable east–west cultural influence of *pide* on *pizza*, indeed, has been theorized by other authors [20]. On the contrary, the majority of single-layered flatbreads, typically prepared in the Tusco-Emilian Apennines, Lunigiana, and Po Valley and cooked on *testo* baking plates, hark back to the ancient Roman baking mode *sub testum* [11, 95]. Bread is one of the most documented foods in primary sources about ancient Romans, and it was generally unleavened [93].

Other regional differences relate to texture and leavening conditions: crispy flatbreads with long shelf-life, fully leavened and double-baked to dryness, are typically made in Sardinia. Shepherding has always been widespread in this region, where shepherds spent months away from home overseeing sheep flocks in little inhabited rural areas and had to carry enough bread for the duration of the transhumance. In contrast, the production of unleavened breads, to be baked quickly as an evening meal upon returning home, consolidated in areas where agriculture was more developed and people worked in the fields all day, like in the Tusco-Emilian Apennines, Lunigiana, and Po Valley. These differences derive from the mutual interaction between peoples and their environments, already established as being the basis of the biocultural diversity in Italy [96].

Finally, most (16 out of 23) of the Italian flatbreads with national or international quality marks come from North-Central Italy, while only 7 are from the south and the islands. These results reflect the gap in socio-economic conditions between the north and south still present in the country, where in the south there is still a lower degree of awareness of quality systems and their opportunities, and there are difficulties in managing bureaucratic procedures and in establishing producer consortia.

Prospect of Italian flatbread development

Traditional foods are generally not suitable for applying processing innovations as they are artisanal by nature, and are appreciated by consumers who are looking for a product that recalls the past. Nonetheless, innovation should not be ruled out. Interest in traditional and ethnic food has grown, and research projects, such as the “FlatBreadMine,” funded within the PRIMA Sect. 1 call [97], are focusing on balancing authenticity, taste, health benefits, and adaptability to new lifestyles, especially in terms of extended shelf-life. The World Health Organization (WHO) recommendations [98] encouraged the food industry to create innovative products with improved nutritional properties e.g., high in fiber and proteins, but low in fat, salt, and sugar while substituting baker’s yeast with sourdough [99]. Given their daily consumption, flatbreads are ideal candidates for reformulation to enhance consumers’ health.

Although the heritage of traditional Italian flatbreads is very rich, only a few of them have been the subject of scientific studies aimed at defining their nutritional properties or improving their quality. Most of the studies have focused on *Pane carasau* and *Piadina romagnola*. These flatbreads have moved out of a strictly local consumption sphere, being produced in large quantities by industrial companies that complement the small-sized artisanal ones, and being marketed throughout Italy and abroad. Indeed, the market for flatbreads has great growth potential, typicality being a recognized purchase driver [77]. However, at the industrial level, it is essential to overcome empirical process regulation and achieve quantitative standardization. To this end, quality monitoring by wireless and microwave-based sensors has been proposed to check the composition of *Pane carasau* doughs through the dielectric signal [66, 92]. These sensors are also able to monitor, during bread production, environmental parameters (temperature, relative humidity), conveyor belt speed, and, through image analysis, the morphological characteristics of the product before baking [66]. Similar monitoring systems could be applied to other flatbreads, with appropriate adaptations. The flatbread baking process

in a home-scale electric oven has been also investigated. By monitoring the temperature distribution within the oven and the evolution of starch gelatinization during baking, a three-dimensional transient numerical model has been developed, helpful for electric oven designers [100].

Given the high temperature typically required for baking flatbreads, another key point is to increase safety by containing the level of acrylamide [101, 102]. To this end, the addition of calcium carbonate is effective in mitigating this toxic compound [103]. Another strategy involved the use of pigmented cereals, rich in anthocyanins having antioxidant activity [104, 105].

Salt reduction is another hot topic. The WHO and FAO have recommended a maximum daily salt intake of 5 g [106], highlighting the need to reduce salt content in staples such as flatbreads [107]. In addition to substitution with potassium chloride [108], other studies proposed a sourdough-based strategy due to the ability of lactic acid bacteria to mask salt reduction by acidification and proteolysis [63, 64].

Some studies have addressed the incorporation of legume flours, either native or dry fractionated, to enrich the nutritional profile of Italian flatbreads, particularly to increase the protein content [50, 109, 110]. Innovative, non-conventional, ingredients have been also proposed to boost the nutritional value of international flatbreads [8]. Microalgae, added at $\leq 3\%$ due to strong marine flavor, enhanced proteins, phenolics, carotenoids, and antioxidant activity of *tortilla* [111]. Whole hempseed flour increased the protein and fiber content of *chapati* [112]. House cricket powder, rich in high-value proteins and polyunsaturated fatty acids, resulted in darker products but with a similar texture to control when added to *chapati roti* at a 5% level [113, 114]. Although these approaches have not yet been applied to Italian flatbreads, the use of non-conventional ingredients could be of interest to broaden commercial offerings. However, it is generally not easy for consumers to accept a new flavor, color, or texture in traditional food products. Increased awareness and communication are essential to facilitate the consumer's acceptance of these new, nutritionally enhanced flatbreads, mitigating food neophobia [115].

Conclusion

This study gives an overview of Italian flatbreads that have received national or international quality recognitions, establishing a catalog with technical and cultural information on each of them. The raw materials and main processing characteristics of flatbread in the Italian context have been critically compared. Key findings include:

- Twenty-three Italian flatbreads have national or international quality recognitions, predominantly originating from North-Central Italy.
- Flatbreads show a high degree of diversity, reflecting the Italian region's diverse culinary heritage.
- The formulation is generally simple and includes flour, water, possibly yeast, and salt. The region-specific ingredients include fats of animal origin, or ham, mostly in flatbreads from Northern Italy, and olive oil or EVOO in flatbreads of Tuscany, Liguria, and Sardinia.
- The type of flour is also region dependent: besides soft wheat flour, durum wheat semolina is used in southern Italy and Sardinia, chestnut flour in Tuscany, rye flour in Alto Adige, chickpea flour in Liguria, and corn flour in central Italy. Historically used, high-extraction flour has been largely replaced by refined flour.
- The consistency of dough varies from a pourable batter for unleavened flatbreads, to a firm dough for rolling or hand-flattening.
- Nine flatbreads are unleavened. For the leavened ones, the use of sourdough, predominant in the past, has been replaced by commercial baker's yeast. Three flatbreads are prepared with baking soda.
- Ancient baking systems consisted of terracotta or metal plates to be placed in the fireplace, today replaced by metal plates used on the gas stove. Domed wood-fired ovens are also popular among Italian consumers, followed by modern electric ovens.
- Flash baking (short time, high temperature) is typical of all flatbreads.
- Flatbread baking leads to delamination and double-layered structure if the flour used has good gluten quality, the dough is fermented, finely sheeted, and correctly proofed, and the baking temperature is very high.
- Among leavened flatbreads, 8 have a double-layered structure and 6 have a single-layered structure.
- Three flatbreads are baked twice, resulting in complete dryness and long shelf-life. These crispy flatbreads are typical of Sardinia, where shepherding has always been widespread.
- Quickly prepared unleavened breads are well established in the Tuscan-Emilian Apennines, Lunigiana, and the Po Valley.
- Some traditional Italian flatbreads (namely *Spianata* and *Zichi*) are associated, as decorated variants, with weddings and patronal festivals, and some are found in classical Italian literature, such as the Sardinian breads and the *Piadina romagnola*.

Overall, these results point out that Italian flatbreads differ regionally in terms of ingredients and preparation methods, and suggest encouraging the revival of the ancient tradition of using high-extraction flours and sourdough fermentation, today almost lost, to increase the fiber, mineral, and vitamin content and to ensure a rich sensory profile. Flatbreads have a fundamental importance in the cultural heritage of Italian gastronomy, and their identity must be recorded and preserved. A limitation of this study was the lack of historical information, highlighting the need to perform historical research to gain a deeper understanding of Italian flatbreads. Furthermore, recommendations for future research and development in traditional Italian flatbreads can be pointed out in the technical field. Regional products, made by traditional processing methods and associated with a specific geographic origin, encompass a greater “emotional quality” than products of less defined origin. In turn, these emotional aspects positively influence consumers’ food choices. In this light, Italian flatbreads are deeply rooted in their origin and linked to traditional practices. Nonetheless, there is room for technical improvement, which is not in contrast with their genuineness. Most of the Italian flatbreads have not been studied in depth from key perspectives, such as shelf-life extension and automatic quality control. More attention and innovations are needed in this area. Future trends and prospects, to attract new market segments, could be the reformulation for nutritional improvement and diversification of sensory characteristics. Further research should also be conducted to provide health benefits, thorough the formulation of functional flatbreads, and to improve the sustainability of the production process.

Acknowledgements

The authors are grateful to Angelo Murittu for providing valuable information and photographs of *Zichi* ritual flatbreads, Pino Marzulli for accurate photographs of the other flatbreads and Lumachelli Pietro e Figli srl for providing the photograph of *testo* used to cook *Testarolo pontremolese*.

Author contributions

MM: literature review, writing—original draft preparation; FV: literature review, visualization; CS: writing—review and editing; AP: conceptualization, literature review, writing—original draft preparation, writing—review and editing. All authors read and approved the final manuscript.

Funding

This paper is supported by the PRIMA program under grant agreement No. 2031, project Flat Bread of Mediterranean area: INnovation & Emerging process & technology (Flat Bread Mine). The PRIMA program is an Art. 185 initiative supported and funded under Horizon 2020, the European Union’s Framework Programme for Research and Innovation. The results and content found on this paper reflects only the author’s view. The PRIMA Foundation is not responsible for any use that may be made of the information it contains.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 28 January 2024 Accepted: 18 May 2024

Published online: 22 July 2024

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