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Review Article

Traditional flat breads spread from the Fertile Crescent: Production process and history of baking systems



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ABSTRACT

The “flat” breads include a multitude of bread types different from each other but are always relatively thin, ranging from a few millimeters to a few centimeters in thickness. These breads, whose origin is very ancient, fit well into the context of a subsistence economy: i) they can be obtained from cereals other than wheat, such as pseudocereals or legumes, allowing the use of sustainable local productions from marginal lands; ii) they do not necessarily require an oven to be baked; iii) they can serve as a dish and as a spoon/fork; iv) they can be dehydrated by a second baking process, preventing the growth of molds and extending the shelf life; v) they are transported with little encumbrance. These strong points make flat breads very popular, traditionally in Near East and Central Asia and also in some Mediterranean areas, in the Arabian Peninsula, and in the Indian subcontinent. By a multidisciplinary approach, this review gives an insight into the variety of traditional flat breads from the Fertile Crescent and related regions, classifying them on the basis of their production process. Moreover, the baking systems adopted to prepare flat breads are reviewed, such as vertical ovens (*tannur* and *tabun*) and griddles (*saj*), whose structure, origin, history, and values are described in detail. This overview shows that these breads have survived until today because of their versatility. In fact, flat breads can be produced both in the same way as they were made thousands of years ago and in modern fully automatic industrial lines, allowing tradition to meet innovation.

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1. Introduction

The “flat” breads include a multitude of bread types different from each other but are always relatively thin, ranging from a few millimeters to a few centimeters in thickness. These breads, whose origin is very ancient, as demonstrated by the findings from Mesopotamia, ancient Egypt, and the Indus civilization, were probably the first processed foods [1].

Flat breads present numerous advantages over “high” and voluminous bread loaves in the context of a subsistence economy, when every resource has to be rationalized. For example, they can be obtained from cereals other than wheat, pseudocereals or legumes, allowing the use of sustainable local productions from marginal lands. They do not necessarily require an oven to be baked as they can be cooked simply by covering by sand and embers or by laying down on a metal or a terracotta plate placed on the fire. In addition, flat breads can serve as a dish, containing food

inside them, and as a spoon/fork because with a piece of flat bread, it is possible to take portions of food out from a container [2].

Flat breads can be dehydrated by a second baking process, which prevents the growth of molds and considerably extends shelf life. Moreover, these breads are transported with little encumbrance by stacking them on top of each other, as done by the Sardinian shepherds in the past when they brought the Italian flat bread *carasau* with them, during the transhumance [3]. All these strong points explain the success of flat breads also in the geographic areas where nomadic life, necessarily based on the transport of a few essential things, was – or still is – predominant [2]. Although flat breads originated in a rural society, quite different from the currently prevailing situation even in developing countries, their strong points make them still very popular, even beyond the areas of origin.

This article, based on a multidisciplinary approach, reviews scientific literature in the fields of food technology, history, and ethnography to give an insight into the traditional flat breads from the Fertile Crescent and related regions, including the processing conditions and baking systems traditionally adopted to prepare them. In fact, flat breads are becoming increasingly appreciated in

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Western countries also where, however, these products are not well known, are generally perceived as a single category, and often are wrongly considered as only unleavened. The aim of the work, therefore, was to shed light on the high diversification degree of these products and highlight the peculiarity of their traditional baking methods to make flat breads better known, along with the cultural richness behind them.

2. Geographical distribution of flat breads

The agricultural practices of the world have different centers of origin, i.e., they arose independently in several geographical areas: the Fertile Crescent, sub-Saharan, Ethiopia, China, New Guinea, Mesoamerica, Amazonia, Andes, and eastern United States [4,5]. Focusing on Eurasia, hunter–gatherers of the Fertile Crescent domesticated wild wheat and barley, beginning around 8500 BC and becoming the world's first farmers [5–7]. This wheat–barley agriculture spread westward around the Mediterranean, across North Africa and southern Europe, northward across the Balkans to Eastern Europe, and eastward to India (Harlan, 1998). Archaeological evidence indicates an extensive introduction of crops from the Fertile Crescent into central and southern Asia [6,8,9] although genetic studies suggest an independent domestication of barley also to east of the Fertile Crescent [10]. Isolated wild barley populations across central Asia as far as Tibet have been reported [8].

Meanwhile, an independent agriculture was evolving in Africa: an array of crops, including sorghum, pearl millet, cowpea, and African rice, were domesticated in sub-Saharan, with no obvious center from the Atlantic to the Indian Ocean, whereas Ethiopia, having the characteristics of a center of origin, contributed some indigenous crops, including teff [4]. Moreover, a form of tetraploid wheat (*Triticum turgidum* L.), differing from durum wheat (*Triticum turgidum* L. ssp. *turgidum* var. *durum*) by the presence of brownish and larger kernels, could have been introduced into Yemen from

Ethiopia, which is considered a center of secondary diversity of tetraploid wheat [11].

The diffusion of flat breads substantially followed the same path of cereals, starting from the Fertile Crescent. From there, flat breads spread to the Mediterranean area (North Africa, Sardinia island, and coastal Spain), the Arabian peninsula, the Indian subcontinent, and the Anatolian peninsula, then to the Balkan area and the Caucasian region, up to Xinjiang (Fig. 1). These diffusive paths followed predominantly an east–west axis, according to the theory that moving along the same latitude requires less evolutionary change or adaptation than between different latitudes [5].

In spite of their ancient origin, nowadays, these very traditional breads are still produced and appreciated in the same areas and are further spread to other countries after modern migrations of people.

3. Production process and classification of flat breads

The production steps of flat breads are not different from those of more voluminous breads: kneading of ingredients (flour, water, salt, sometimes little amounts of fatty ingredients, with or without yeast according to the specific bread type); leavening (which may be absent); shaping (by pouring the batter on a griddle or by sheeting and eventually punching the dough); and baking.

Depending on the gluten content of the starting flour, flat breads can be obtained from either compact and elastic dough, which requires strong and extensible gluten, or from a semi-fluid batter, which, on the contrary, can be obtained from an array of gluten-free flours. Consistent dough, usually wheat based, can be spread into sheets with a rolling pin, whereas the semi-fluid batters are directly poured onto the cooking surface, resulting in “pancake-like” flat breads. These variations allow obtaining an array of flat breads, which are characteristic of different geographical areas (Fig. 2).

The various types of flat breads can be schematically classified according to the consistency of the dough, the presence or absence of a leavening phase, the baking system used, and the thickness and



Fig. 1. Diffusive pathway of flat breads. Flat breads substantially followed the same path of cereals (wheat and barley), starting from the Fertile Crescent. From there, flat breads spread westward around the Mediterranean, across North Africa and southern Europe, northward across the Anatolian peninsula to the Balkans and to Central Asia, and eastward to India. Interlinks with another agricultural center of origin in Ethiopia, contributing some indigenous crops including sorghum, teff, and pigmented tetraploid wheat, are found across the Arabian Peninsula.



Fig. 2. A map of the most representative flat breads and corresponding countries where they are produced. Flat breads are very popular in the Middle East and in the Indian subcontinent. In the Mediterranean area, they are especially consumed in North Africa. Several peculiar flat bread types can be found also in Italy, but they coexist with the prevailing “western-style” voluminous bread loaves.

structure of the finished product. Based on these factors, flat breads can be categorized as i) pancake-like breads, obtained from batters; ii) flat breads with consistent dough, unleavened; iii) flat breads with consistent dough, leavened, shaped as a thick sheet and eventually punched (single layered); iv) flat breads with consistent dough, leavened, and shaped as a thin sheet (double layered).

3.1. Pancake-like breads

The production process of pancake-like flat breads involves the preparation of a batter and, usually, its fermentation. The batter is typically, but not exclusively, obtained from cereals other than wheat or from legumes, usually due to the scarce availability of wheat in the production areas.

Examples of pancake-like flat breads are i) the Ethiopian *injera*, made of teff flour [12]; ii) the Somali *anjero* (or *canjeero*, *canjeelo*), made of sorghum or maize flour [13]; iii) the Yemeni *lahoh* (or *laxox*) based on sorghum flour [14]; iv) the Sudanese *kisra* (or *kissra*, also called *kisra rhaheefa*), also made of sorghum [15]; v) the wheat-

based *goraasa* (or *gorraassa*, *gerasa*, *qurasah*), again from Sudan; vi) the Indian bread *pitha*, obtained from a mixture of local rice flour and black beans; vii) the Indian *dosa*, obtained from a mixture of local rice flour and black beans [16]; viii) the *ruqaq* (or *raqaq*, *roqaq*, *rogag*) produced from wheat flour in the Arabian peninsula, in Egypt, and in northern Iraq (Fig. 3); ix) the *baghrir*, obtained from durum wheat semolina in the Maghreb region, from Maroq to Tunisia (where is named *ghrayef*); x) the Italian *borlengo*, obtained from wheat flour; xi) the Italian *testarolo pontremolese*, obtained from wheat flour; xii) the Italian *panigaccio*, obtained from wheat flour; xiii) the Italian *neccio*, which is made of chestnut flour.

3.2. Flat breads with consistent dough

3.2.1. Unleavened

After preparing the dough, the production process of flat bread can include a leavening phase or not. Without leavening, bread is easier to chew if the dough is spread to a very thin layer. Examples of very thin unleavened flat breads are i) the Turkish *yufka* [17,18];



Fig. 3. Loaves of Egyptian breads. (A) Puffing of the Egyptian *aesh baladi* bread in a domed oven. Puffing is the visible inflation occurring in the oven when dough discs, sheeted to a few millimeters, optimally leavened, and not punched, are baked. The inflation is due to the thermal expansion of gases and produces the so-called “double-layered flat breads”. Optimal puffing requires a horizontal support; therefore, a domed oven is preferably used. (B) Loaves of Egyptian *roqaq* bread. This bread is baked until dry; therefore, it has relatively long shelf life, and usually, it is rehydrated before eating.

ii) the Iranian *taftoon* (or *taftun*), whose name is derived from the Persian word *tafan*, meaning “heating”, “burning,” or “kindling” [19]; iii) the *lavash*, produced in Armenia, Iran, Turkey, and India [19,20]; iv) the Indian and Pakistani *chapati* (or *chapatti*); v) the Indian and Pakistani *bhakri*; vi) the Indian and Pakistani *roti* (also named *rumali roti* or *roomali roti*, where *rumali* means “handkerchief” in many north Indian languages because this bread is so thin that it can be folded like a handkerchief) [18,20,21]; vii) the Lebanese *marquq* (or *markouk*, known as *mashrooh* or *mafrood* in Saudi Arabia, United Arab Emirates, and Oman), widespread also in Syria, Palestine, and Jordan, which similar to the *rumali roti* is also named “handkerchief bread” [22]; viii) the Italian *piadina* (Fig. 4); ix) the Algerian and Tunisian *kesra rakhsis* or simply *kesra* [14,23].

Related to these very thin flat breads is a kind of baked phyllo: the Tunisian *malsouqa* (or *malsouka*). The *malsouka* is normally consumed after filling and frying to prepare a savory food called *brik*.

3.2.2. Leavened—thick (single-layered flat breads)

In their more traditional version, flat breads are naturally leavened by sourdough, i.e., by using a portion of the dough of the previous processing, but nowadays, leavening is most frequently carried out using brewer's yeast. With the alveolation conferred by leavening, which renders bread softer, dough thickness can be increased up to 3–4 cm.

Before baking, the dough discs have to be pressed with fingertips or punched to prevent excessive expansion in the oven [19]. Punching can also serve a decorative function and helps identifying the baker, such as in the Uzbek *non* (Fig. 5), in central Asian breads *chorek* and *lepushka*, and in the Saudi *tamees*. The punches are called *chekich* in Uzbekistan, where they are used together with bread stamps called *bosma*. In Turkmenistan and in the Xinjiang Chinese region, mostly Uyghur, these punches are named *durtlik*.

Examples of leavened and relatively thick flat breads are i) the Algerian, Tunisian and Moroccan *matlouh* (also called *kesra matlouha*, *matloua*, *makla*, or *agroum*) [23]; ii) the Moroccan *tachnift*; iii) the Turkish *pide*; iv) the Turkish *bazlama* [18,24]; v) the Armenian *matnakash*; vi) the Iranian *barbari* (Fig. 6); vii) the Iranian *khoshk* [19,20]; viii) the Iranian *jow*, named from the Persian word for barley because it is prepared from barley flour [19]; ix) the Turkmen *chorek*; x) the Uzbek and Kazakh *lepushka*; xi) the Uzbek and Kazakh *patyr*; xii) the Indian and Pakistani *naan* [25]; xiii) the

Indian and Pakistani *kulcha*; xiv) the Indian and Pakistani *khameeri roti* (a risen *roti*, from *khameer* = yeast); xv) the Afghan and Saudi *tamees* [26]; xvi) the Yemeni *malooga*; xvii) the Somali *muufo*, which in Kenya is named *mkate wa mofa* (meaning “*mofa* bread”, from “*mofa*”, which is the name of the oven used to prepare it); xviii) the *khobz el dar* (or *khobz eddar*) widespread in Morocco, Algeria, and Tunisia, whose name means “home bread”; xix) the Italian *scacciuni* (from Sicily); xx) the Italian *pitta* (or *pita*, from Calabria, Sicily, and Apulian Salento); xxi) the Italian *spianata di Ozieri* (from Sardinia);xxii) the Italian *crescenta* or *crescentina* (from Romagna).

All these types of flat breads can be classified as “single-layered breads” to distinguish them from the “double-layered” ones, where the two layers correspond to the upper and lower surfaces of a dough disc which is allowed to puff up during baking.

In Italy, other very popular flat bakery products, such as the numerous types of *pizza* and *focaccia*, are similar to flat breads but cannot be fully included in the flat bread category. In fact, the numerous *pizza* and *focaccia* types are not staple foods, being usually garnished with many additional ingredients. For a detailed description of Italian *focaccia* types, whose formulation includes also relevant amounts of oil (see Pasqualone et al) [27].

3.2.3. Leavened—thin (double-layered flat breads)

When the dough is sheeted to a few millimeters and is not punched, it inflates visibly in the oven (puffing up) and forms a “balloon” due to the thermal expansion of gases such as carbon dioxide developed during fermentation, dough humidity, and air entrapped during kneading (Fig. 3). The expansion in volume is optimal if the flour used has good viscoelastic properties; therefore, good-quality gluten-containing flour is needed. After baking, the balloon deflates due to cooling, giving a soft and flexible bread, with a characteristic inner cavity, or “pocket”, that can be stuffed with meat and/or vegetables. This kind of flat bread is the most widespread also in Western countries, where it is known as “Arabic bread” or “*pita* bread”. Alternatively, the two layers can be separated by cutting the loaf along the edges and can be baked for a second time to dry them, as in the case of the Italian *carasau* and *pistoccu*.

Regarding the name “*pita*” attributed to this kind of bread, it is worth mentioning that it is not a classic Arabic word (Arabic even lacks the phoneme “*p*”). Its roots are, instead, in the Illyric word “*pita*” (meaning both “food” and “bread”) and/or in the Aramaic word “*pitta*” (“the bread”), which, in turn, influenced several words, all indicating flat bread or flat bakery products: the Greek *pita*, the Albanian *pite*, the Turkish *pide*, the Bulgarian *pitka*, and the Italian *pizza* [28]. The word *pita* is also used to indicate “bread” in the spoken Levantine Arabic, i.e., in Lebanon, Syria, Jordan, and Palestine, but not in the Maghreb.

Examples of double-layered flat breads are i) the Lebanese and Syrian *khobz* (the Arabic word for “bread”) or *pita*; i) the Egyptian *baladi* bread [20,29] also named *aesh baladi* or *aysh baladi*, meaning “national bread”, where *aesh* in addition to “bread” also means “life” in Egyptian Arabic (Fig. 3); ii) the Moroccan *batbout*; iii) the Iraqi *samoon*.

4. Baking the flat breads

The major difference between flat breads and voluminous breads is the way they are baked. Given the reduced thickness and mass, all flat breads are cooked very quickly (a few minutes) and remain in a rather pale color, with almost no crust. On the contrary, voluminous and heavy bread loaves develop the typical brown crust because they are baked longer (up to 60 minutes for breads reaching 15–20 cm in thickness and weighing approximately 1 kg), so as to cook perfectly the inner part of the loaf as well. Therefore,



Fig. 4. Loaves of Italian *piadina*, unleavened flat bread made of flour, lard or olive oil, salt, and water, baked on a terracotta fire plate. *Piadina* is particularly appreciated in the Romagna territory (northern Italy), i.e., the area surrounding the towns of Forlì, Cesena, Ravenna, and Rimini.



Fig. 5. Decoratively punched dough, ready to be baked to prepare the Uzbek *non*. The decorative punches are named *chekich* and are used in combination with the bread stamps named *bosma*.



Fig. 6. Iranian breads, allowed to cool on a net. (A) *Barbari* bread. (B) *Sangak* bread. The surface of *barbari* is punched by knuckles, whereas the surface of *sangak* shows the imprints of the pebbles on which it is traditionally baked.

voluminous and heavy breads require a stable support and, above all, a prolonged heat surround such as in the baking chamber of an oven, which is not necessarily needed to bake flat breads.

The simplest baking methods of flat breads have remained almost unchanged since ancient times. For example, a technique still used today in the nomadic communities of Sinai, southern Tunisia, and Algeria consists in baking bread under a layer of sand, embers, and ash (*pain de sable* or “ash-baked bread”), without the need for baking tools [30,31]. A step forward is the use of the fire plates, whereas a more structured system is represented by the vertical ovens, where bread baking is a sort of “side effect” of meat cooking. The technical choice depends, among other practical and

cultural factors, also on the baking properties of bread ingredients (gluten-free batters can be baked only on a griddle).

With reference to their structure, the traditional wood-fired ovens can be classified into two categories: horizontal domed ovens and vertical cylindrical ovens. Domed ovens, derived from the ancient Greek oven *ipnos* [32], are medium to big-sized stable masonry structures where bread is put on a horizontal floor. Vertical ovens, smaller and either stably fixed or portable, are cylindrical clay structures where bread is baked stuck onto the vertical inner walls.

Most flat breads are traditionally baked on fire plates or in vertical ovens. However, there are some exceptions. For example,

all the double-layered flat breads, which require a horizontal support to puff optimally, are baked in domed ovens similar to those used for western-style voluminous and heavy breads.

Other flat breads requiring domed ovens are the ones baked on a layer of red-hot pebbles put on a horizontal floor, such as the Berber *tafarnout*, consumed in Morocco, and the Iranian *non-e sangak* [20,33,34], where *non* (transliterated also “*nan*” or “*naan*”) means “bread” and *sangak* “pebbles” in Farsi [19] (Fig. 6). The reason for baking on hot pebbles was originally to keep bread separated from the soil and to confer it a desirable rough surface and texture.

Besides, in certain geographical areas, such as Sardinia and Sicily, where in ancient times, Phoenician settlements and Islamic domination were established (the latter in Sicily only), several flat breads are still produced, but they are baked in the horizontal domed oven, the vertical ovens being practically unknown in Italy nowadays.

4.1. Fire plates

A baking plate placed directly on the embers, which can be a flat stone slab or a clay griddle, can be used to bake flat breads [35]. Round clay griddles named *doka* and *mogogo* in Tigrinya or *metad* in Amharic were used in the past to bake sorghum flat bread in Sudan and Ethiopia, respectively [14]. These clay griddles are now nearly replaced with iron ones, which in Sudan are named *sadj* [14]. In Palestine, Jordan, Lebanon, Syria, and Iraq, a similar griddle is named *saj* (Fig. 7), whereas in Turkey, it is named *saç*. The large dimensions of these metal griddles, which however remain portable, allow cooking flat breads of large diameter, up to 40 cm. In the Balkans, especially in Bosnia, the name *saç* is given to the metal griddle which covers the *crepulja*, a container used to cook bread or other foods on the charcoals [32].

In northern India and Pakistan, the *chapatti*, the *roti*, and the *bhakri* breads are cooked on the *tava* (or *tawa*) [36], a convex metal griddle that is used also in the Arabian peninsula for the preparation of the *ruqaq*. The *tava* is named *daawo* in Yemen, where it is used for the production of *lahoh*.

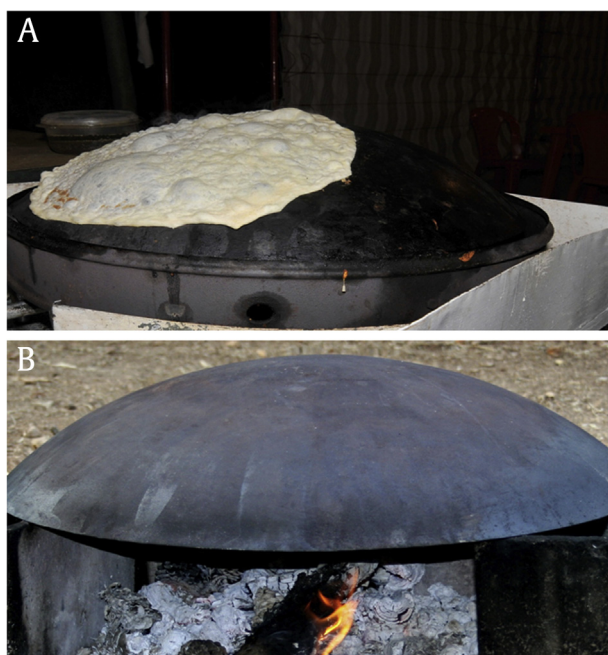


Fig. 7. Metal griddles. (A) A gas-fueled metal griddle for baking flat bread. (B) A wood-fired metal griddle for baking flat bread. These metal griddles are named *saj* in Palestine, Jordan, Lebanon, Syria, and Iraq, *sadj* in Sudan and Ethiopia, and *saç* in Turkey.

The Italian *testo*, a cast iron baking tool composed of a conical cover and a round flat support, is very similar to the ancient Roman *testum* [37,38]. The *testo* is made red-hot by putting on the charcoals before pouring a flour pastel on it. The Italian *testarolo pontremolese* is baked on a cast iron *testo* in the Lunigiana area (between Tuscany and Liguria), whereas clay versions of *testo*, more similar to the ancient *testum*, are used to prepare the *panigaccio* of Podenzana (Tuscany), the *piadina*, and the *crescentina* (both from Romagna, the latter baked on the *tigella*).

4.2. Vertical ovens: structure and way of use

The single-layer flat breads are traditionally baked in vertical ovens, i.e., in cylindrical or truncated-cone-shaped clay ovens with an opening at the top (Fig. 8) which replaces the front one of the domed ovens [39]. The truncated-cone ovens may have curved walls, thus resembling the shape of a dome with the top cut away, and are also called “beehive ovens”. Both the truncated-cone and the beehive-shaped ovens have the larger part at the bottom.

The circular opening at the top, or “mouth”, allows both the introduction of the loaves and the exit of smoke, whereas a side hole in the lower part, or “eye”, is used to facilitate air inlet from outside and to remove ash after use [40]. At the beginning, the lower hole is kept open to favor air flow and wood burning needed to preheat the oven. The vertical ovens, like all wood-burning ovens, reach very high temperatures, exceeding 300°C.

When the oven is ready, the upper part of its hot inner walls is wiped with a moistened cloth to remove any ashes. The sheeted dough discs are then rapidly pressed onto the inner walls (Fig. 8) with the aid of a “bread cushion” or directly by hands [31]. The cushion is used mainly for fairly thin and large dough discs, which cannot be easily supported by hands. Named *makhbaza* in Yemen, the bread cushion has a circular shape and has a cloth or leather surface, where the dough is laid down, and a wooden bottom with a handle.

The adhesion to the vertical walls can be helped by wetting the surface of the dough discs just before slapping them into the oven. After about 1–2 minutes of cooking (at most 6–7 minutes for thicker loaves), breads are taken out by metal tongs.

Usually, women bake bread at home, whereas men bake in the bakeries. In any case, the use of a vertical oven requires a skillful baker to avoid both accidental burns and breads falling into the embers. Moreover, a recent study highlighted high levels of polycyclic aromatic hydrocarbons in the final bread, which are lower if metal griddles are used [36]. Despite this, for a long time, the vertical oven has been the most common baking system used for preparing flat breads and is still very much appreciated, becoming a strong point of many traditional restaurants in European countries and in the USA.

4.3. Vertical oven building and installation

When vertical ovens are small, they can be portable, which is fundamental for nomadic life. In the portable version, used by the communities of nomadic shepherds in the Euphrates region [41], they are simply placed on the ground, otherwise these ovens can be stably fixed either by embedding them in the masonry of the cooking area or in a pit in the ground. In the latter case, the oven rim does not protrude from the ground level, and an underlying conduit conveys outdoor air inside the oven. Sometimes, vertical ovens are placed on the roof to prevent smoke invading the area below. In any case, the prevailing location of wood-fired vertical ovens is outdoors, whereas modern versions, gas fueled, are used indoor.

The construction of these ovens is artisanal and traditionally was entrusted to women. The construction involves a basic spiral



Fig. 8. Details of the mouth of ovens, with one loaf of bread being baked stuck onto the inner walls. (A) A Pakistani *tandoor* vertical oven. (B) A Syrian *tannur* oven. (C) Ignition of a *tannur* in Yemen, almost ready for cooking fish. (D) Ignition of a Syrian *tannur*, placed in a slightly inclined position.

technique by kneading clay with straw, goat hair, and salt to minimize cracking during sun-drying. At the first ignition, necessary to transform clay into terracotta, the flames must be kept high for the first 4 hours and then kept gradually lower for another 10 hours. The oven has to be replaced every 2–3 years because the inner surface tends to crumble with use, hampering bread adhesion [42].

Nowadays, modern plants are also available for the industrial production of both single- and double-layered flat breads. Semi-automated and fully automated bread-making lines automatically knead the ingredients, extrude and sheet the dough, proof, bake in tunnel ovens, and cool and pack the end products [43]. In these mechanized lines, the equipment requirements are relatively few compared with those of pancake-like bread preparation. Flat breads, in fact, are produced directly on the conveyor belts, without the need for baking trays and pans, and a large array of products can be made with an existing production line by slightly modifying ingredient formulation and dough shaping [44]. These automatic flat bread-making lines allow to obtain traditionally looking products, with the high production capacity required by the industry.

4.3.1. Underground vertical ovens

The habit of positioning vertical ovens in a pit in the ground, usually in the backyard [45], is found especially in Central Asia: from Eastern Turkey, Armenia, and Georgia—where cylindrical ovens are used that are approximately 1-m high and 50-cm wide [46]—to Punjab, passing through Azerbaijan, Turkmenistan, Afghanistan, Uzbekistan, and Tajikistan and further north-east to Kazakhstan and the Chinese region of Xinjiang. Underground vertical ovens are often lined inside with fire bricks to allow for long-lasting heating [47].

In this position, the oven mouth being at ground level, it is necessary to kneel to slap dough discs inside the oven. This way of installing the oven reminds the primitive way of sheltering fire in a pit dug into the ground [48], which further evolved to combustion pits coated with clay, suitable for cooking whole animals or large pieces of meat. The combustion pits were used already in the Neolithic [49]. Also today, the vertical ovens are used to cook

skewers of meat and fish inside the oven chamber (Fig. 8), while bread stuck onto the walls is baked.

This cooking system presents similarities to that found even at antipode regions. In fact, combustion ditches dug into the ground were adopted by the Australian aborigines to cook whole animals or large pieces of meat. In Polynesia and in Micronesia, the ancient practice of cooking in an oven excavated in the earth, called *'umu* in the Polynesian dialects [50], is still used to cook starchy tubers along with fish or meat.

4.3.2. Vertical ovens above the ground

Vertical ovens installed above the ground level can be managed while standing and are found mainly in Syria, Lebanon, Iraq, Yemen, and Saudi Arabia. Usually, the beehive-shaped ovens are placed in this way. The traditional wood-fired ovens are still widespread in the rural areas of the Middle East, whereas they disappeared from other areas, such as Egypt, where they were used until the 19th century [51].

Embedded in the masonry, which acts as a workbench to prepare the dough and lay the bread loaves for cooling, the ovens are placed in a slightly inclined position, at an angle of about 25° (Fig. 8), so as to make the top opening more easily accessible [42]. When the ovens are particularly large (similar to those currently used in some bakeries), the inclination is more pronounced, so that they are placed almost horizontally. In this position, they could resemble the domed ovens, but the way of use remains peculiar for the vertical ones: the bread is not placed on the oven floor but is pressed onto the inner side of the oven walls, up to the vault. This almost horizontal position is particularly evident in the Uzbek *tandir* (Fig. 9).

In Tunisia, the oven is a bit different and is used in a slightly different way. It has the usual top opening and up to five secondary small openings at the side in the lower part. After ignition, when the inner walls reach the desirable temperature (they become almost red), the side-openings are closed, and well-cleaned stones (rectangular shape, size: around 10*5*2 cm³) are carefully placed at the bottom between the charcoals (concentrated in the middle) and



Fig. 9. Details of a horizontally placed Uzbek *tandir* vertical oven with several loaves of *non* being baked stuck onto its inner walls. In this position, this oven could resemble a horizontal domed oven, but it is used in the peculiar way of vertical ovens: bread is not placed on the oven floor but is pressed onto the inner oven walls, up to the vault.

the walls. Bread, slightly watered, is then slapped onto the inner walls of the oven, as usual, and the top opening is closed. When one side of the bread is almost done, each loaf is removed from the wall, watered again, and then reinserted into the oven to cook the other side. However, this time, the bread is placed on the bottom stones, positioning it vertically, leaning against the wall, while the top opening is closed again to retain heat. This second baking step is uncommon outside Tunisia.

In Palestine and Jordan, finally, a different kind of oven is used, with an “igloo” shape, which is wider than tall, with an upper opening [52]. This oven is used in a very different way from the classic vertical one because instead of slapping onto the inner walls, the loaves are placed on the oven floor, next to the embers, usually on a layer of hot pebbles [39,41,53–55]. During baking, the top opening of the oven is closed with a metal lid.

5. Origin and history of vertical ovens

In general, baking ovens tend to prevail in the archeological remains from the Near East, whereas cooking pots prevail in those

from central Africa [56]. These findings are a consequence of gluten weakness, or even absence, in the flours used in central Africa (predominantly obtained from tubers, legumes, minor cereals, or pseudocereals), which renders these flours more suitable for porridge than for bread-making.

Vertical ovens are of Semitic origin [57], and their archeological remains are widespread in the Middle East, Central Asia, northern India, and North Africa and along the Mediterranean coasts. In particular, remains of vertical ovens have been found in Tell Sabi Abyad, in Syria (5050 BC) [58]; Jarmo, in Iraq (5000 BC); Tepe Sialk, in Iran (3300 BC); Mohenjo-daro, in the Indus valley, Pakistan (2500 BC); and in Egypt (2000 BC) [59]. Other remains, dating from about 2500 BC, have been excavated in Gilund, in Rajasthan, India [60], in Tell Abu Salabikh, in southern Iraq (3000 BC) [61], and in Tell Barri, in Syria (3000 BC) [62].

Numerous cuneiform tablets found in the archives of the royal palace of Ebla and in those of Mari and Tell Beydar, concerning the conditions of agriculture around 2400 BC, report that the officials received grains, flours, a kind of polenta, and bread [63,64]. Bread was called “*ninda*” in Sumerian and Akkadian, followed by adjectives that defined its quality, seasoning, and type of baking [65,66]. The dough was cooked on a stone slab placed directly on the embers or in terracotta ovens. In addition, owing to the low quality of gluten in the flour used, bread had a reduced volume and appeared low [63].

In Nora, a Sardinian town of Phoenician origin, numerous clay fragments of small vertical ovens have been found, both archaic (VIII and VII century BC) and datable at the beginning of the Punic age (V–II century BC) [67]. These ovens were widely present in the Phoenician and Punic western Mediterranean colonies and consisted of truncated conical structures [67]. The vertical oven was known also in ancient Rome because of the conquests in the Middle East [57]. However, the domed oven (named “*furnus*” in Latin), bigger and with greater production capacity, was preferred because of the prevalence of communal production of bread, ruled by guilds.

The vertical oven spread to the Spanish Andalusia after the Islamic conquest, starting from 711 AD [30]. Ibn al-'Awwām, Sevillian author of the late 12th century, in his treatise on agriculture, mentioned four ways used at the time to bake bread both in Andalusia and in other Islamic areas: i) under the ashes; ii) in the domed oven (diffused in the Middle East probably after the Roman conquests and named in Arabic with the term “*furn*” of Latin derivation); iii) on a fire plate; iv) in the vertical oven [30].

6. Variability in vertical oven denominations

Ibn al-'Awwām named the vertical oven “*tannūr*” and the fire plate “*tābaq*” [30]. The 10th century Arab cookbook “*Kitab al-Tabikh*” by Ibn Sayyar al-Warraq reported six recipes for *khobz* (bread), all based on *tannūr* cooking [68]. The vertical oven was therefore called *tannūr* (popularly transcribed also as “*tannur*” or “*tannour*”, pl. “*tananir*”), a term still in use in Syria, Lebanon, Iraq, and Arabian Peninsula. This word, Arabic but having a non-Arabic origin, shows several variants, “*tenoor*” in Sudanese [69], “*tinaar*” in Somali, “*tandir*” in Turkish [59] and in Uzbek, “*tonir*” in Armenian, “*tanoor*” in Farsi, “*tone*” in Georgian, and “*tandur*” in Hindi (transcribed in English as “*tandoor*”, used in India, Pakistan, and Afghanistan) [70]. The word *tannur* is traced back to the Akkadian “*tinuru*” [65,71] and the ugaritic “*tnr*”, which meant “oven” [72], corroborating the origin of the *tannur* oven in the Syrian–Mesopotamian area.

In Spain, the vertical ovens are not used anymore, indeed the word *tannur* has influenced the term “*atanor*”, via the word “*attannur*” (literally meaning “the *tannur*” in Arabic) [73]. In fact, probably reminding the tubular shape of *tannur*, *atanor* means in

Spanish “a clay pipeline to bring water” [74]. Moreover, the Spanish “*hornillo de atanor*” is the heating part of an alchemic alembic that is used for distillation [30].

In Sicily, where the Phoenicians settled in the 11th century BC and which was under the Islamic rule from 827 AD to 1091 AD, first under the Aghlabid and then under the Fatimid dynasty, there are no traces of vertical ovens, but the word “*tannura*” indicated the hearth until the last century [75,76].

In any case, the word *tannur* and its variants are referred to vertical ovens, usually stably fixed but also portable, cylindrical, or beehive shaped, variable in size but always taller than wide. These ovens are intended to protect the embers and to bake breads stuck onto the inner walls, also in combination with meat or fish cooking.

In Tunisia, a vertical oven similar to the *tannur* is called “*tabouna*”. Ancient vertical ovens from the Punic era have been found in Carthage [30]. The word “*tābūn*” (transcribed also as “*tabun*”, pl. “*tawabin*”), with its variants (“*taboon*”, “*taboun*”, “*tabouna*”), has a likely Arabic root and finds its first attestation in Palestine in the 10th century AD [55]. The relatively recent archaeological attestation suggests that the introduction of the *tabun* oven in the Palestinian area occurred sometime after the Arab conquest [55]. In Palestine and Jordan, in fact, the word *tabun* (or *taboun*) is referred to the traditional wood-fired oven used in that area although its shape is different from that of *tannur* being wider than tall, similar to an “igloo” [52]. Finally, in Morocco and Algeria, *tabun* is a taboo word because it is related to the feminine sex, and instead of the vertical oven, a wood-fired horizontal domed oven, named “*kanoun*”, is commonly used.

Typically in the Arabian peninsula, the term “*mawfa*” (pl. “*muwāfieh*”), with the variants “*mawfe*” in Tihamah, “*mawfi*” in Zabid, and “*mufa*” in Aden, is used, instead, to indicate a clay oven outside the house [77]. Not far from the Arabian Peninsula, this term influences the denomination of the *tannur*-type oven used in Somalia and in Kenya, called *mufa* or “*mofa*” [14].

7. Conclusion

Since the gradual shift from hunting and harvesting to agriculture, the cycle of cereals, from cultivation to transformation into flour and bread, has become a central activity, ruling the rhythms of work and life. The origin of flat breads is very ancient and has its roots in this rural social structure, centered on the hearth as the focal point of the house.

Characterized by several strong points in the frame of a subsistence economy, flat breads are always the result of rational and effective solutions to the problem of how to transform cereals and non-cereals into digestible and tasty foods and have survived until today because of their versatility. In fact, these breads are produced both in the same way as they were prepared thousands of years ago, on cooking plates or in vertical ovens, and in modern fully automated industrial lines, where tradition meets innovation. This is the basis for the increasing appreciation and spread of this variegated family of breads far beyond the area of origin.

Conflicts of interest

The author has no conflicts of interest to declare.

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