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RESEARCH ARTICLE

Some Sociological, Gastronomic and Microbiological Characteristics of Turkish Sourdough Breads

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ABSTRACT

Bread is an indispensable staple food that has been consumed by humans since they settled. Thousands of breads and other products are made around the world with sourdough adventure that started approximately 6000 years ago. Türkiye, which has hosted numerous ancient civilizations (Hatti, Hittites, etc.) and has significant archaeological sites (Çatalhöyük, Göbeklitepe, Karahantepe, etc.), possesses a wide variety of sourdoughs. In this study, the general characteristics of Turkish sourdough breads, their cultural values, and the health and technological effects of sourdough are explained in the light of the information obtained through the document examination method. The stoves or ovens where sourdough breads are baked, fuels, and kitchen utensils used in bread preparation are clarified. In Türkiye, up to 21 types of traditional sourdough-making methods have been find. It's determined that sourdough types are made such as yoghurt water (zembek), ayran (waterry yoghurt), flower, chickpea, potato, onion, ash, grape, dew, tarhana, colostrum, pinecone and date sourdough. The most common microorganisms in Turkish sourdough include Lactobacillus plantarum, L. paraplantarum, L. brevis, L. pentosus, L. curvatus, Lactococcus lactis ssp. lactis, Saccharomyces cerevisiae, Kazachstania servazzii, and K. humilis. Sourdough breads display medium-high to high volumes such as Trabzon Vakfıkebir bread) while others are low-volume breads (such as yufka-phyllo dough, bazlama, pita-pide breads. The majority of these breads are produced using traditional methods and are baked in different wood-fired stoves and stone ovens burnt with kind of woods such as alder, oak, pine, fir, hornbeam, olive, willow, poplar, cherry, apple, plum, peach tree woods, plant and animal wastes. Turkish sourdough breads also have a positive effect on health, and sourdoughs have a technological improvement effect on bread. Turkish sourdough breads have many sociological and gastronomic features.

INTRODUCTION

The advent of bread can be traced back to approximately 10,000 years ago when human beings began farming or harvesting wheat, grinding it into flour, and mixing flour with water to make dough. Sourdough bread is believed to be produced after a piece of dough left for a few days before being fermented on its own. The first sourdough bread was made in ancient Egypt and dates back to 4,000 BC (Civitello, 2019, p.8; Ross et al., 2002, p.4).

With the domestication of grains such as wheat (11,000-12,000 BC) and barley (11,000-10,000 BC) in Mesopotamia, called the Fertile Crescent in Southwest Asia, one of the cradles of civilization

(Larson, et al., 2014, p.6141), bread has been made for approximately 10,000 years (Catzeddu, 2019, p.179; Mondal and Datta, 2008, p.465). According to Arranz-Otaegui et al., (2018), bread-making dates back as far as 14,400 years in northeastern Jordan. The first cultivation of einkorn wheat (T. monococcum ssp. monococcum) was made in 10,000-12,000 BC, in Diyarbakır, Türkiye, on the foothills of Karacadağ (Karakas et al., 2022, p.407). Considering the historical significance of the region, Türkiye is considered one of the places where sourdough bread was first produced.

This study provides a comprehensive review of the traditional sourdough types used in Turkish culture and the sourdough breads derived from them. Additionally, the general characteristics of sourdough bread, its role in Turkish cuisine, and its health and technological effects are described.

Sourdough Types

There are various methods for sourdough production, as shown Figure 1.

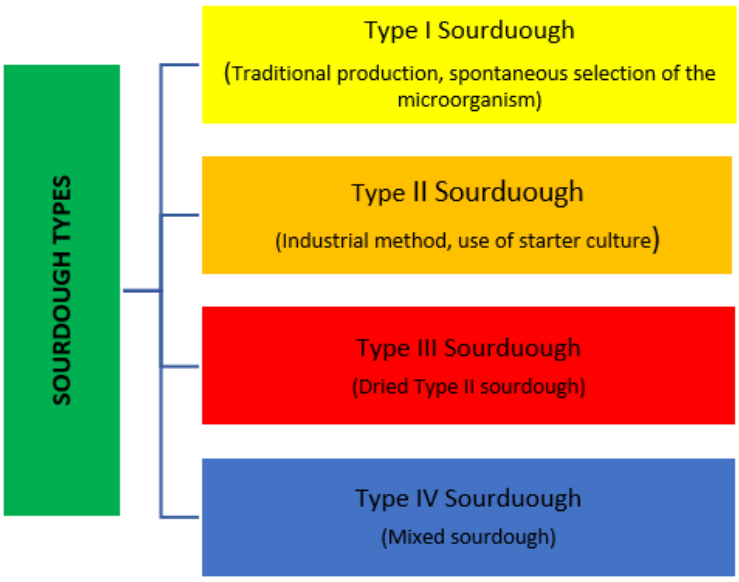

Fig 1 Sourdough production types (Papadimitriou et al., 2019).

Essentially, in the traditional method, sourdough is obtained through the spontaneous growth of microorganisms (Type I), while in industrial production; the production method is differentiated by using starter culture for uniform production of the same quality (Type II, III, IV). There are different types of sourdough traditionally produced in Türkiye. Table 1 presents both the sourdough varieties that are still widely used in Türkiye and the varieties that are now almost forgotten. Sourdoughs made in Türkiye are named according to the raw materials used.

Table 1 Türkiye's traditional sourdough (Badem, 2023)

Name of Sourdough	Contents	City / Region
Vakfıkebir sourdough	flour, water	Trabzon
Trabzon zembek sourdough	flour, whey (zembek)	Trabzon
Gümüşhane / Rize sourdough	flour, water	Gümüşhane, Rize
Rize ayran sourdough	yayık ayranı, flour, salt	Rize
Isparta sourdough	flour, water	Isparta
İstanbul flower sourdough	linden leaf and flower, water	İstanbul
Sweet sourdough / Chickpea sourdough	chickpeas, water	Balıkesir, Acıpayam-Denizli, Bursa, Didim-Aydın, Kapadokya-

		Nevşehir, Mustafapaşa-Nevşehir, Torbalı - Ormanköy, Tire, Ödemiş-İzmir, Tekirdağ
Potato sourdough	boiled potato, flour, water	Afyonkarahisar
Potato sourdough	raw potato juice, flour, water	Akçakoca-Düzce
Beer sourdough	beer, flour, water	-
Onion sourdough	onion juice, flour, water	Kastamonu
Yoghurt sourdough	yoghurt, flour, water	Trabzon
Yoghurt sourdough	yoghurt water (şerat), flour, water	-
Ash sourdough	ash, flour, water	Germiyan-İzmir
Dew soudough	dewdrop, flour, water	-
Grape sourdough	green grapes, flour, water	Niğde-Kemerhisar, Antakya, Trakya
Kıvas	flour, water, salt	Mustafapaşa-Nevşehir
Yer sourdough	flour, water	Kapadokya-Nevşehir
Tarhana sourdough	Tarhana (chickpeas, yoghurt and flour), flour, water	Ayvacık-Çanakkale
Colostrum sourdough	colostrum	-
Pinecone sourdough	pine cone+milk; yoghurt, flour	-
İspirli sourdough	egg white, honey	-
Date sourdough	date, flour, water	-

Microorganisms in Sourdough

Sourdough is formed when microorganisms grow and dominate the environment by using fermentable energy sources. The dominant microorganism flora in sourdough is lactic acid bacteria (LAB) and yeasts (Corsetti and Settanni, 2007, p.540). The most common bacteria are *Lactobacillus* species (Catzeddu, 2019, p.182), and the most common yeast species are *Saccharomyces, Candida, Kazachstania, Torulopsis, Yarrowia, Pichia* species. More than 50 LABs, mostly from *Lactobacillus* genus, and more than 20 yeast species, dominated by *Saccharomyces* and *Candida* species, are isolated in sourdough (De Vuyst and Nesens, 2005, p.43). The most frequently isolated LAB species from sourdough are *L. plantarum, L. brevis* and *L. sanfranciscensis* (Arora et al., 2021, p.74), and Saccharomyces cerevisiae as yeasts (Papadimitriou et al., 2019, p.132; Arora et al., 2021, p.74; Sakandar et al., 2019, p.4). Microorganisms commonly isolated in sourdough are given in Figure 2.

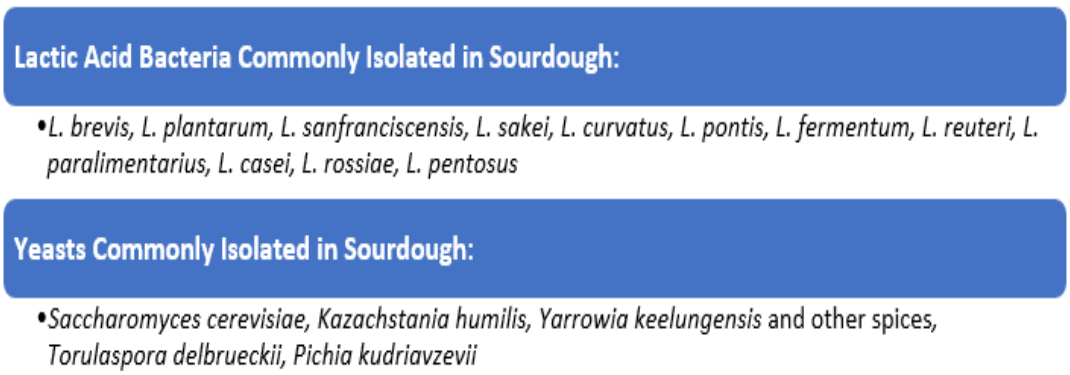

Fig 2 Microorganisms commonly found in sourdough (Arora et al., 2021).

Microorganisms in sourdough produce hydrogen (H_2), carbon dioxide (CO_2) gas, and organic acids such as lactic, acetic, tartaric, phosphoric, formic, succinic, citric, and malic acid (Diowksz and Ambroziak, 2006, p.368; Salim-ur-Rehman et al., 2006, p.559; Hammes and Ganzle, 1998, p.205). Flavor and aroma compounds such as octane, ethyl acetate, ethanol, propanol, butanol,

benzaldehyde, diacetyl, hexane, and heptane are also produced by yeasts and bacteria (Salim-ur-Rehman et al., 2006, pp.558, 559; Chavan and Chavan, 2011, p.178).

MATERIAL AND METHODS

The study used the document review method. The general characteristics of sourdough in Turkish cuisine, sourdough production methods, traditional sourdough breads, geographically indicated breads, fuels and stoves-ovens used in bread production were determined. For this purpose, Google Scholar was searched with the keyword "sourdough" until 15.07.2024, and articles directly about Turkish sourdough and breads were examined. In addition, the Turkish Patent and Trademark Office website and books written in Turkish were reviewed.

Turkish Sourdough Studies

As shown in Table 2, according to the search conducted on Google Scholar with the keyword "sourdough" until July 15, 2024, there are very few microbiological studies on Turkish sourdough bread, other than direct sourdough research. In their studies, Gül et al., 2021, p.34; Gül et al., 2005, p.691) determined the following microflora of Isparta bread LAB species; *Lactobacillus divergens, L. brevis, L. amylophilus, L. sake, L. acetotolerans L. plantarum, Pediococcus pentosaceus, P. acidilactici, P. halophilus*, yeast species; *Saccharomyces cerevisiae, S. delbrueckii, Torulopsis holmii,* and *T. unisporus*. In the study conducted by Gerçekaslan et al. (2012), a total of 113 lactic acid bacteria were detected in Trabzon Vakfıkebir bread. The majority of them (54%) were *L. plantarum*, and also isolated to (13.2%) *Lactococcus lactis ssp. lactis*, (7.9%) *L. brevis*, (5.3%) *L. pentosus*. Yurttaş et al. (2023) determined the number of LAB, Total Aerobic Mesophilic Bacteria and yeast in Trabzon bread sourdough samples were 3.65-8.97 cfu/g, 4.19-7.20 cfu/g, and 4.17-7.52 cfu/g, respectively.

Table 2 The studies on Turkish sourdough.

Sources	Microorganism Types	References
Different flours (Bayburt)	Wheat, rye, oat and barley flours with L. rossiae, L. plantarum, L. brevis ve Weissella cibaria strains sourdough production	Alkay, 2017
Traditional sourdough	14 yeasts from 62 isolates, mostly Saccaromyces cerevisiae strains	Alkay et al., 2021
Traditional sourdough (Black Sea and Aegean regions)	26 yeast species isolates; Saccharomyces cerevisiae (50%), Torulaspora delbrueckii (40%), Kluyveromyces marxianus (10%). S. cerevisiae, the most dominant species in Aegean region; T. delbrueckii, the most dominant species in Black Sea region	Arici et al., 2018
Traditional sourdough (Trabzon, Giresun, Ordu, Samsun)	933 lactic acid bacteria isolates	Arsoy et al., 2022
Traditional sourdough (Central Anatolia, Black Sea, Mediterranean, Aegean, Southeast Anatolia, Marmara region)	345 endogenous yeast isolates; Saccharomyces cerevisiae predominated the microflora, followed by Kazachstania servazzii, K. humilis, Wickerhamomyces anomalus, Torulaspora delbrueckii, Pichia kudriavzevii	Aydın et al., 2022a
Traditional sourdough (Central Anatolia, Black Sea, Mediterranean, Aegean region)	96 Saccharomyces cerevisiae isolates	Aydın et al., 2022b
	Continuation of Aydın et al., 2022a, b	Aktepe et al., 2024

Traditional sourdough (Mersin, Antalya, Ankara)	Lactobacillus spp. were identified as the major group, such as Fructilactobacillus sanfranciscensis and Lactiplantibacillus plantarum.	Boyacı Gündüz et al., 2022
Traditional sourdough (Mersin, Antalya, Ankara)	148 yeast isolates; Saccharomyces cerevisiae (106), Kazachstania bulderi (11), Pichia fermentans (9), Pichia membranifaciens (8), Kazachstania servazzii (7), Kazachstania unispora (4), Hanseniaspora valbyensis (3)	Boyacı Gündüz and Erten, 2020
Einkorn flour sourdough	32 lactic acid bacteria isolates; 7 lactic acid bacteria species, L. crustorum (10), Pediococcus (4), L. brevis (6), L. paraplantarum (1), L. plantarum (5), L. fermentum (4), L. curvatus (2) identified by PCR (16S).	Çakır et al., 2020
Traditional sourdough (Eastern Black Sea region)	249 lactic acid bacteria isolates; 47 distinct LAB strains belonging to 11 different species: L. plantarum, L. paraplantarum, L. curvatus, L. rossiae, L. sanfranciscensis, L. brevis, L. paralimentarius, Weissella paramesenteroides, Leuconostoc mesenteroides, Leuconostoc pseudomesenteroides, Weissella cibaria.	Dertli et al., 2016
Traditional sourdough (Gaziantep, Mardin, Konya)	60 lactic acid bacteria and 40 yeasts isolates; The dominant LAB microflora; L. brevis (43.33%), Pediococcus acidilactici (21.67%), L. plantarum (18.33%). Dominant yeasts; Saccharomyces cerevisiae (27.5%), Pichia kudriavzevii (25.0%), Kluyveromyces marxianus (12.5%).	Sevgili et al., 2021
Traditional sourdough (Gaziantep, Mardin, Konya)	11 lactic acid bacteria and yeasts isolates from 36 sourdough; LAB species; L. brevis (45.0%), Pediococcus acidilactici (20.0%), L. plantarum (18.3%), Yeast species; Saccharomyces cerevisiae (27.5%), Pichia kudriavzevii (25.0%), Kluyveromyces marxianus (12.5%)	Sevgili et al., 2023
All Turkey	Mapping of sourdough microbiota in Turkey The most frequently isolated yeast in all regions was Saccharomyces cerevisiae, followed by Torula delbrueckii and Pichia guilliermondii the most frequently isolated yeasts	Sevgili and Erkmen, 2024
Traditional sourdough (Uşak)	60 sourdough samples	Şimşek et al., 2006

Technological Effects of Sourdough

The changes and metabolites that occur as a result of the activity of sourdough positively affect many technological properties of the raw material on which it operates. These technological effects are shown in Figure 3.

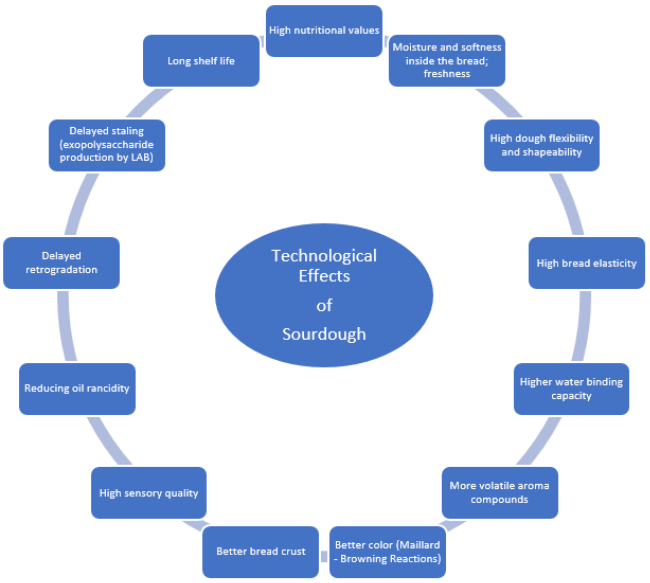

Fig 3 Technological effects of sourdough (El et al., 2024: 4; Elva and Harsavii, 2024: 341; Fernández-Peláez et al., 2020: 1; Siepmann et al., 2018: 243; Arendt et al., 2007: 165; Stolz, 2003: 38).

Health Effects of Sourdough

The changes that occur as a result of the activity of sourdough and the metabolites formed positively affect human health. These health effects are shown in Figure 4.

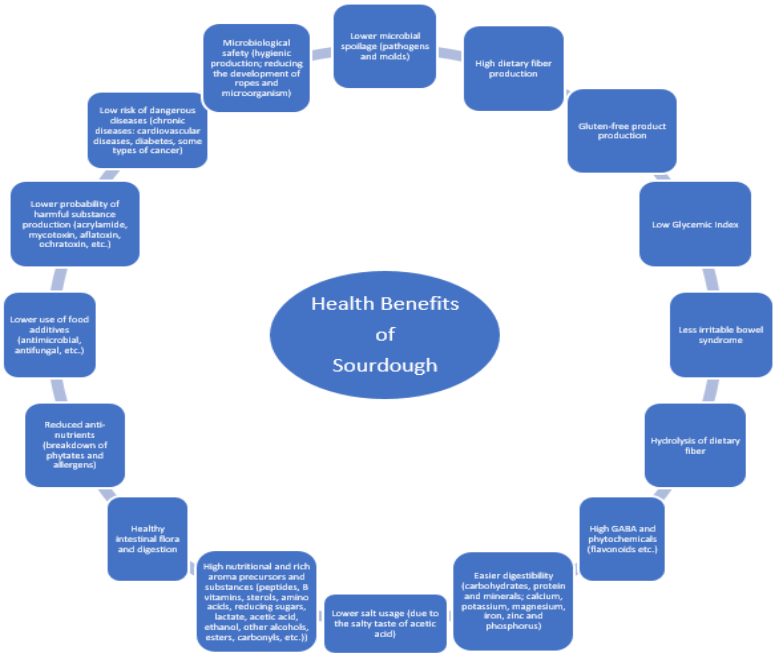

Fig 4. Some of the health benefits of sourdough (Elva and Harsavii, 2024: 341; Zhang et al., 2022; Arora et al. 2021: 78-80; Fernández-Peláez et al., 2020: 1; Gobbetti et al., 2019: 104-108; Hutkins, 2019: 327; Sakandar et al., 2019: 7; Siepmann et al., 2018: 261; Bartkiene et al., 2017: 2371; Katina and Poutanen, 2013: 229; Diowksz and Ambroziak, 2006: 374-376; Stolz, 2003: 38; Hammes and Ganzle, 1998: 206).

Bread Types

Bread is a food prepared by mixing the flour of grains such as wheat, barley, corn, and rye with a sufficient amount of water and salt, kneading the dough with or without yeast, shaping it, and baking it. Breadmaking with wheat flour and rye flour is widely preferred worldwide. Sourdoughing is particularly favored in the production of rye breads. While wheat flour remains the primary choice for sourdough breadmaking in Türkiye, a considerable number of breads are made with chickpea sourdough.

In general, breads can be divided into three main groups, as shown in Figure 5.

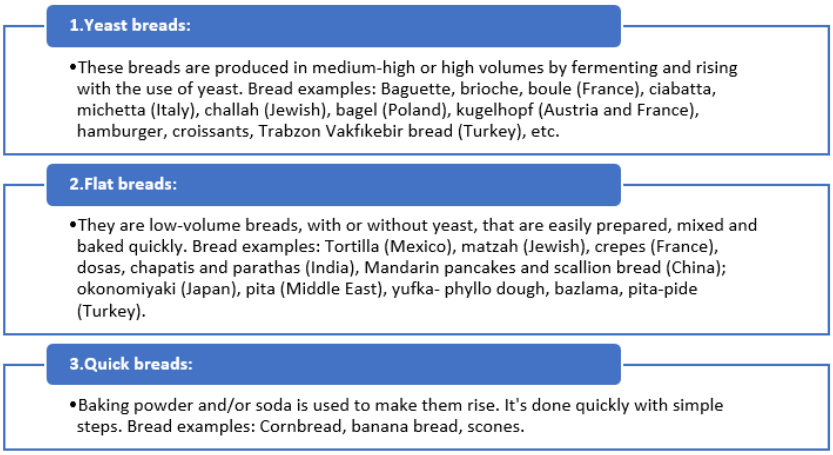

Fig 5 Bread types (Das et al., 2023, p. 4; El Sheikha, 2016, p. 9).

Breads can be categorized into two main groups namely, leavened or unleavened breads, depending on the use of the leavening agent. The leavening process is conducted through two methods: with microorganisms (commercial yeast or sourdough) and with chemical leavening agents (baking soda, cream of tartar). Breads are also divided into four groups according to the baking method as shown in Figure 6 (Hui, 2012, p.4).

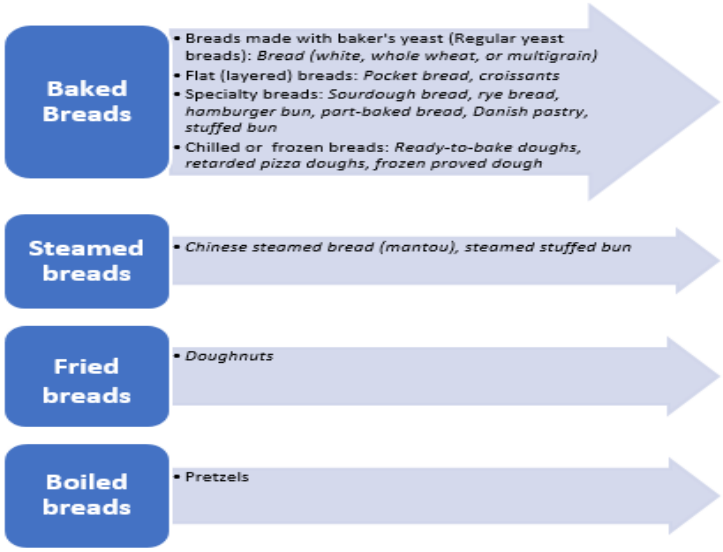

Fig 6 Bread types according to baking method (Hui, 2012, p. 4).

Bread in the Turkish Cuisine

Agriculture began in Anatolia, on the Asian side of Türkiye, between 8,000 and 12,000 BC. Kitchen and agricultural tools and plant remains obtained from archaeological sites in Türkiye such as Burdur-Hacılar, Diyarbakır-Çayönü, Kahramanmaraş-Domuztepe, and Konya-Çatalhöyük provide evidence for this situation (Karakas et al., 2022, p.407; Ünsal, 2021, p.44). It has been determined that 300 types of bread were made from archaeological documents written in Sumerian and Akkadian, belonging to the Sumerians who came to the region of Central Asia in the 5,000s BC and lived around Mesopotamia - Anatolia (Ünsal, 2021, p.25, Çetinkaya et al., 2019, p.88). More recently, Hittites, who lived in Anatolia between 2.200 and 1.190 BC (Akurgal, 2019, p.49, 111), made aproximately 180 breads, cakes, pastries, and bakery products (Şensoy, 2018, p.81). Turkish tribes who migrated from Central Asia to Anatolia brought about culinary culture and bread culture to the region.

Turkish culture evolved through interactions with many civilizations residing in Anatolia such as Hatti, Assyrians, Hittites, Phrygians, Lydians, Ionians, Lycians, Urartians, Persian Empire, Alexander Empire, Roman and Byzantine Empire (Işın, 2021, p.9; Akurgal, 2019, p.1; Oktay, 2018, p. 67) and later, under the rule of Seljuk and Ottomans, these civilizations formed the foundations of the Republic of Türkiye. Thus, "Anatolian culture", a new synthesis culture specific to Turkish society, emerged (Ülken, 2021, p.10, Baysal, 2018, p.124). The rich diversity of bread in terms of bread is cultural interaction from the past and from intertwining with neighboring countries and religious beliefs (Middle Eastern countries such as Iran, Georgian, Greek, Armenian, and Jewish (Badem, 2023).

In Turkish cuisine, wheat and its products, which are the main food sources, are made with sourdough or commercial yeast, breads such as tandoori-tandır, bazlama, pyllo-yufka, pita-pide, and lavash-lavaş, other bakery products such as pastries, buns, cookies, and many traditional foods such as tarhana and boza (Turk Patent, 2024, Badem, 2023).

The values and some properties attributed to bread in Turkish culture are given in Table 3, and the properties of Turkish sourdough breads are given in Table 4.

Table 3 Values Attributed to Bread in Turkish Society and General Characteristics of Bread in Turkish Cuisine (Badem, 2023).

Bread is one of the basic elements of Turkish cuisine.
It is more or less a staple for everyone (rich or poor).
Dozens of different types of bread are produced using flour, water, salt and yeast.
Simple kitchen utensils such as a rolling pin - oklava, dough board and sheet metal - sac are sufficient to make bread.
Making bread (usually) consists of simple processes and requires a simple oven, stove or fuel.
Bread, with its many varieties, is a carrier of various additives. Katik is any kind of food that can be put between bread and squeezed. Breakfast ingredients such as green onions and cheese can be squeezed into bread, while difficult-to-prepare foods such as meat and chicken (doner or kebab, etc.) can be served on, in, or together with bread.
Bread embodies the cultural elements of society.
Bread is sacred.
Bread represents abundance.
Bread (and wheat) is a blessing for the Turkish society due to belief; It is a blessing from God.
Bread makes itself felt in the life of Turkish society, at every moment and place, both concretely and abstractly (in religion, folklore, literature, proverbs, idioms, etc.).
Sharing bread is a symbol of sincerity, friendship and peace.
Bread has been a status symbol in Turkish society throughout history. For example, in the Ottoman Empire, high-level administrators ate bread made from special flour, while people in the lower classes consumed bread made from fodula flour.

Bread is a sustainable product in Turkish cuisine, it is not wasted, even stale bread is used. The best example of this is tirit dishes, which have many varieties and can be made from dry bread.
The first ancestors of wheat, such as einkorn, siyez, gernik, spelt, karakılçık, yellow wheat- sarıbuğday, white wheat – akbuğday; akbaşak, red wheat- kızılca, germir and topbaş, are wheat native to Anatolia and spread throughout the world from there.
Bread has been enriched by the interaction of Turkish society with other nations. While phyllo-yufka production was important in the nomadic lifestyle (bozkır kültürü) in Central Asia, in Anatolia, with the interaction with Iranian culture, bread making in tandoor-like ovens was also adopted and became quite widespread.
Bread composition, production style, consumption style, etc., especially after settling in Anatolia, were influenced by the culture of the nations that lived in the region in the past, such as the Hittites, etc., and were enriched by geography-based interaction and the contribution of flora and fauna.
Bread is a word that means blessing, work, satisfaction, belief, culture, labor, abundance, tradition, sacred food, power, civilization and many things for humans.

Table 4 General characteristics of Turkish sourdough breads (Badem, 2023).

They have a rather sour taste.
They do not contain additives.
It has turned into a healthy product due to the components formed during the production phase.
As a result of long-term fermentation, its overall taste and smell have improved considerably.
Most of them are made using whole wheat flour, and some also add potatoes to the dough. Contrary to what is common in other countries, rye flour is not used in sourdough or bread dough.
Most of them are made from dough separated from previous bread making - üretme.
Nowadays, only sourdough was previously used in breads in which commercial yeast was also added.
Sourdough is produced using the following raw materials (including those that are not commonly used): whole wheat flour, bread wheat flour, chickpea flour, Durum wheat flour, corn flour, barley, yoghurt, buttermilk, flowers, potatoes, onions, grapes, tarhana, ash and dew yeast.
Most bread dough is coated with slurry (a mixture of flour, water, yoghurt, etc.) before or during baking.
The fact that the yeast is transferred from the previous dough means that the same bread aroma and taste has been enjoyed for generations.
They are mainly cooked with wood fire.
It is cooked in a stone-based oven, brick oven, migrant oven, tandoor oven or on sheet metal - sac.
The equipment used in bread making is simple.
The shelf life of bread is quite long.
Because of its sourness, it is difficult to spoil microbiologically.
Large-volume breads have thick crust and base.
Sourdough breads include lavash, bazlama and pita-style - pide flat breads, as well as high-volume breads such as Trabzon Vakfıkebir bread.

Traditional Stoves and Fuels in the Turkish Cuisine

Some resources used as traditional fuel in Türkiye are given in Table 5. Additionally, the types of stoves and ovens in which these fuels are used are shown in Table 6.

Table 5 Some traditionally used fuels in Türkiye (Badem, 2023).

Fuel Type	**Example**
High energy forest tree woods	alder, oak, pine, fir, hornbeam, olive
Weak energy forest tree woods	willow, poplar
Fruit tree woods	cherry, apple, plum, peach
Dwarf tree/maquis/shrub type tree wood	piner; piynar, çangal
Other fuels of poor quality	twigs, tree branches, stalks, straw, herbs, undersized plants
Fuels made from animal waste	different animal waste fuel; tezek, kemre, yapma
Other	coal

Table 6 Some ovens and stoves traditionally used in Türkiye (Badem, 2023).

Fireplace and Oven Type	Kitchen Utensils Type
Stone oven, stone-based oven, neighborhood oven, black oven, …	Tekne; large rectangular shaped wooden bowl in which dough is kneaded
Brick oven	Senit; wooden board for cutting, rolling and processing dough
Immigrant oven	Oklava; long cylindrical wooden stick
Tandoor oven	Eysiran; metal spatula with long thin handle
Small fireplace	Pasa; wooden vehicle with compartments
Kuzine, a kind of oven made metal	Plate / Tray / Sifting tool / Clay pot / Bucket
Wood stove	Hıla; The cloth in which the baked bread is wrapped
Sac, sheet metal	Rapata; Pillow used to stick bread to the tandoor
Taş sacı, stone sheetlike metal	Pişirgeç; sheet metal etc. wooden tool that turns baked bread
Pileki, oven made from a mixture of stone, clay and glass	Gelberi; Tandoor etc., tool/stick for stirring fire and making bread
-	Silengi; Tandoor etc. oven interior wiper

Traditional Turkish Sourdough Breads

Turkish bread, which has many diverse features and distinct properties influenced by factors such as the yeast used in its making, the ovens used for baking, the types of fuel, and the kitchen utensils utilized is briefly mentioned above. Some Turkish sourdough breads with these features are given in Table 7. Certain sourdough breads listed in the table have geographical indications, while others are currently undergoing the process of obtaining geographical indications.

Table 7 Türkiye's traditional sour and sweet sourdough breads (Metro Gastro, 2023; Badem, 2023; Ünsal 2021).

Name of Bread	Region of Production in Türkiye	Type A/L/G)*
Wheat bread with chickpeas	Acıpayam; Denizli	L
Afyonkarahisar potato bread	Afyonkarahisar	L, G
Tandoor bread	Ağrı	A
Village bread with potato-sourdough	Akçakoca; Düzce	L
Melemez bread	Akdeniz: Mersin	A
Alaşehir bread	Alaşehir: Manisa	A, G
Village bread	Amasya	A
Ankara ebelemesi	Ankara	A
Ankara cızlaması	Ankara	A
Kürtün Araköy bread	Araköy: Gümüşhane	A, G
Home bread	Ayaş; Ankara	A
Village bread	Ayvacık: Çanakkale	A
Eşkili	Bahadın; Yozgat	A
Village bread	Balıkesir	A
Corn bread	Balıkesir	A
Sourdough bread	Balıkesir	A
Chickpea sourdough (bread)	Balıkesir	L
Zucchini village bread	Balıkesir (Adaören)	A
Bartın çöven bread	Bartın	A, G
Tandoor bread	Batman	A
Village bread	Bergama: İzmir	A
Bolu potato bread	Bolu	L, G
Sourdough home bread	Bursa	A
Chickpea bread	Bursa	L
Immigrant bread	Ceyhan: Adana	A

Cihanbeyli gömeç bread	Cihanbeyli: Konya	A, G
Plate bread	Cihanbeyli: Konya	A
Village bread	Çanakkale	A
Lokum bread	Çanakkale	L
Cızlama bread	Çaycuma: Zonguldak	A
Sweet sourdough (Chickpea bread)	Didim	L
Nane patile	Diyarbakır	A
Germiyan bread	Germiyan: İzmir	A
Simit bread	Göçbeyli: İzmir	L
Çavuşlu bread	Görele: Giresun	A, G
Erzurum lavash bread	Erzurum	A, G
Sourdough bread	Gebze	A
Gümüşhane bread	Gümüşhane	A, G
Mayalı (şıllık)	Güneydoğu Anadolu Bölgesi, Konya, Karaman, Niğde	A
Gelveri bread	Güzelyurt (Gelveri): Aksaray	A, G
Hasankale lavash	Hasankale: Erzurum	A, G
Isparta sourdough bread	Isparta	A, G
İslamköy bread	Isparta	A, G
Immigrant bread	İncesu: Kayseri	A
İslambeyli bread	İslambeyli: Kırklareli	A
Immigrant bread	Kadirli: Osmaniye	A
Kahrat bread	Kahrat: İzmir	A
Kalecik bread	Kalecik: Ankara	A, G
Gelveri bread	Kapadokya: Nevşehir	A
Keskiç	Kapadokya: Nevşehir	A
Chickpea sourdough bread (Avanos bread)	Kapadokya: Nevşehir	L
Zığır (Sıyır, Karahöyük) bread	Karahöyük: Denizli	L
Immigrant bread	Karaman	A
Sourdough bread	Kemer: Antalya	A
Bazlama bread	Konya (Kavak)	A
Plate bread	Konya (Kavak)	A
Tandoor bread	Konya (İçeri Çumra)	A
Kula bread	Kula: Manisa	A
Stone oven bread	Malatya	A
Malatya sour bread	Malatya	A, G
Malatya bilik bread	Malatya (Battalgazi)	A, G
Mamak kutludüğün sourdough Bread	Mamak: Ankara	A, G
Mende bread	Mende: Uşak	A
Chickpea bread	Mustafapaşa: Nevşehir	L
Sweet sourdough / chickpea bread	Ormanköy: İzmir	L
Chickpea sourdough sweet bread	Tire, Ödemiş: İzmir	L
Fragrant bread	Özbek: İzmir	A
Karakılçık-eincorn wheat bread	Seferhisar: İzmir	A
Immigrant bread	Silifke: Mersin	L
Immigrant bread	Silivri: İstanbul	A
Sour bread	Sivas	A
Söke sweet sourdough bread	Söke: Aydın	L, G
Flat bread	Suşehri: Sivas	A
Şanlıurfa açık bread	Şanlıurfa	A, G
Şanlıurfa tırnaklı bread	Şanlıurfa	A, G
Bread	Tarsus: Mersin	A

Egg bread	Tarsus: Mersin	A
Village bread	Tekirdağ	A
Chickpea bread	Tekirdağ	L
Tokat bread	Tokat	A, G
Vakfıkebir bread	Trabzon	A, G
Sourdough village bread	Trabzon	A

*Sourdough Type, A: Sour: More acidic breads, usually produced by LAB fermentation with raw materials other than chickpeas and potatoes, Sourdough Type, L: chickpeas and potatoes, and less acidic, sweet breads, Geographical Indication Status, G: Geographically indicated.

CONCLUSION

The most important transformations in human nutrition arguably occurred after the introduction of agriculture. With the settlement of humans, the domestication of animals and the cultivation of plants began. Considering that wheat was the first grain to be domesticated, the nutritional value of bread has become apparent. The introduction of sourdough bread production in Egypt significantly changed breadmaking. There are many ancient civilizations (Hatti, Assyrians, Hittites, Phrygians, Lydians, Ionians, Lycians, Urartians, Roman, etc.) that ruled in and around Anatolia. There are also protected archaeological sites in Türkiye with important archaeological remains (Çatalhöyük, Göbeklitepe, Karahantepe, etc.). Part of Mesopotamia, one of the places where humanity first existed, also includes part of Anatolia. In summary, sourdough bread has been made in Anatolia for at least 5.000-6.000 years, dating back to the Sumerians and Egyptians.

Turkish sourdough breads also have a positive effect on health, and sourdoughs have a technological improvement effect on bread. In addition, Turkish sourdough breads have many sociological and gastronomic features. Sourdough, in essence, is the fermentation of dough by naturally occurring microorganisms. As a result of this process, many beneficial compounds such as lactic, acetic, tartaric, phosphoric acid, octane, ethyl acetate, ethanol, benzaldehyde, diacetyl, and hexane, which are important for human nutrition emerge. In addition to the formation of compounds important for nutrition (peptides, B vitamins, sterols, amino acids, etc.), harmful substances are not produced (acrylamide, mycotoxins, etc.) thereby eliminating or reducing many microbial risks. Enhanced digestibility (easier absorption of carbohydrates, protein, and minerals; calcium, potassium, magnesium, iron, zinc, and phosphorus), a lower glycemic index, and reduced salt usage are other notable effects. A wide variety of sourdoughs and breads are made in Türkiye. There are up to 21 types of sourdoughs specifically tailored for Turkish cuisine, and it has been observed that they are produced using different ingredients under different names. According to the data obtained from studies conducted on Turkish sourdough, the prevalent microorganisms in sourdough are Lactobacillus plantarum, L. paraplantarum, L. brevis, L. pentosus, L. curvatus, Lactococcus lactis ssp. lactis, Saccharomyces cerevisiae, Kazachstania servazzii, and K. humilis. Notably, some lactic acid bacteria are probiotic that are bacteria beneficial for human health. It seems that comprehensive studies are needed to more accurately determine the dominant microflora of Turkish sourdough. Eighty-two types of sourdough bread crafted using traditional sourdough methods were identified. While 22 of them are geographically indicated, 17 of them are sweet chickpea yeast breads. All traditionally produced breads are baked in places such as iron sheet – “sac”, tandoor – “tandır”, stone ovens, etc. heated with wood fire or fuel made from animal manure. The most common microorganisms in Turkish sourdough include Lactobacillus plantarum, L. paraplantarum, L. brevis, L. pentosus, L. curvatus, Lactococcus lactis ssp. lactis, Saccharomyces cerevisiae, Kazachstania servazzii, and K. humilis. It was determined that certain sourdough breads display medium-high to high volumes (Trabzon Vakfıkebir bread) while others are low-volume breads (yufka-phyllo dough, bazlama, pita-pide). The majority of these breads are produced using traditional methods and are baked in different wood-fired stoves and stone ovens. Also, tarhana and boza are other traditional foods in Turkish cuisine, that are commonly produced from sourdough.

In conclusion, this study emphasizes the necessity for detailed studies to determine both the gastronomy and microbiological aspects of Turkish sourdoughs and breads.

DECLARATIONS

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List of Abbreviations:

LAB: Lactic acid bacteria.

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