

In 2015, AACC International is celebrating 100 years of dedication to the advancement of cereal grain science. As part of this centennial celebration, AACCI is exploring the future of grain science. In this series coordinated by Dilek Austin on behalf of the Centennial Planning Committee, experts from around the world will provide global perspectives on the opportunities and challenges that will propel grain science into the future.

Grain Science and Industry in Turkey: Past, Present, and Future

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Although cereal grains such as rice, corn, rye, oats, and barley are consumed as foods in Turkey, wheat is the most commonly consumed cereal grain. Therefore, this article focuses primarily on wheat, discussing the history, agricultural production, traditional cereal products, consumption trends, R&D activities, processing, trade of cereal products (e.g., flour, pasta, bulgur, breads, and cookies), and future prospects for academic and industrial research activities in Turkey.

History and Origin of Wheat

Wheat has played a crucial role in people's lives in Turkey and nearby countries for centuries. Cultivation of wheat is believed to have originated in the Fertile Crescent, which covers parts of Turkey, Iran, Iraq, and Syria. Recent archaeological studies show that the homeland of wheat is Göbeklitepe, which is a prehistoric site in southeastern Turkey (40). Cultivation of wheat later spread to the territories south of modern-day Russia (Afghanistan, Turkmenistan, Uzbekistan, Kazakhstan, and Azerbaijan), parts of Ethiopia, eastern North Africa (Egypt and Sudan), and regions bordering the northern shores of the Mediterranean. In the Fertile Crescent, agriculture was based mainly on cereal grain crops, which allowed the development of a dense human population. Success in agricultural production and the ability to store grains meant a growing population of nonfarming specialists could be fed,

which catalyzed cultural development in this region (22,27).

The ancestors of modern wheat may still be found in abundance growing wild along roadsides in Turkey, Iran, and northern Iraq and Syria. Turkey is located in a privileged area of the world with regard to plant genetic resources and diversity. It generally is agreed that two of the main centers of diversity and origin, the Near East and Mediterranean, overlap in Turkey (22,23,26,27).

Wheat Landraces, Wild Relatives, and Turkish Seed Gene Bank

The Turkish Seed Gene Bank (TSGB) was established in 2010 as a department of the Central Research Institute for Field Crops under the Ministry of Food, Agriculture and Livestock. The main aim of this department is conservation, collection, and molecular and morphological characterization of plant genetic resources, especially the genetic diversity of crop plants, their wild relatives, and plants present in and unique to Turkey. In addition to more than 16,000 *Triticum aestivum* and 2,600 *T. durum* accessions, the TSGB includes a large selection of wheat landraces. There are ≈2,600 landrace accessions, including *T. diccoides*, *T. dicoccum*, *T. monococcum*, *T. turgidum*, *T. polanicum*, *T. urartu*, and other *Triticum* species, as well as 132 *Aegilops* accessions in the TSGB (K. Özbek, TSGB, *personal communication*, 2015).

In Turkey, diploid (cultivated einkorn), tetraploid (cultivated emmer and durum wheats), and bread wheat landraces are still grown on remote marginal ecogeographic farmlands by farmers using traditional methods. Einkorn is a name given to diploid species with 14 chromo-



somes ($2n = 2 \times = 14$) in the genus *Triticum* (39). Cultivated emmer wheat is an allotetraploid species with 28 chromosomes ($2n = 4 \times = 28$). It is a primitive and non-free-threshing type of wheat (28).

Wheat landraces are composed of traditional crop varieties developed by farmers through years of natural and human selection and are adapted to local environmental conditions and management practices (21). Landraces are cultivated in traditional wheat-growing areas in the Middle East, Asia, Africa, and Eastern Europe. Because emmer and einkorn varieties are genetic relatives of domesticated varieties, their valuable gene pool may easily be used in breeding programs to improve the nutritional quality of wheat (42). Wild relatives of wheat and wheat landraces may hold the key to increasing the genetic diversity of grain quality and other important characteristics available to wheat breeders (7,16).

In Turkey, emmer, which is highly adaptable to poor soils, is still cultivated by farmers who live in marginal areas in

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the Kastamonu and Sinop Provinces, in the Black Sea region, at 1,000–2,000 m above sea level. It is still consumed in Turkey in the form of bulgur. The reasons for the rediscovery of emmer include a growing interest in its nutritional content and increasing attention to local traditions and ancient foods by consumers. Emmer contains high levels of healthy phytochemicals such as lutein and ferulic acid and has high antioxidant capacities (42). Furthermore, there is a growing interest in conservation of agrobiodiversity and diversification of cropping systems, and emmer is very suitable for organic production (16).

Traditional Turkish Cereal-Based Foods and Beverages

Given their central role in the Turkish diet, a wide range of cereal-based products have been developed throughout the history of the region and are still consumed today. The major traditional Turkish cereal-based foods and beverages include bulgur, *firik*, *tarhana*, and boza. There are also various types of traditional flat and yeast-leavened breads, especially in rural regions (25).

Bulgur. To produce bulgur, wheat grains are cleaned, cooked, dried, tempered, and the outer layers are removed, followed by grinding, polishing, and classification sorting. The preferred raw material is durum wheat, but bread wheats may also be used. Bulgur is widely consumed in Turkey and the Middle East. The first historical information on bulgur was found in the Catalhoyuk archaeological site (in Anatolia), which dates back 7,000 to 8,000 years. Bulgur is an important source of dietary fiber ($\approx 18\%$), and it has high vitamin B and mineral contents compared with many other cereal products (4,24). In traditional processing, bulgur is sun-dried in the open air; in commercial processing it is dried with hot air. Because the traditional open-air sun-drying process may cause quality degradation and infestation of the product, it is being replaced in industrial production by more effective, less damaging drying methods.

Firik. *Firik* (also referred to as *frikeh* or *frekeh*), an ancient cereal product similar to bulgur, is consumed in Anatolia, the Middle East, and North Africa (14,33,54). It is used mainly as a substitute for rice and bulgur in pilav (pilaf). To produce *firik*, green wheat plants are cut (2–4 weeks postanthesis), bundled, and roasted (scorched) over open flames to burn off

the awns and leafy material. The sun-dried spikes are then threshed, and the kernels are separated and cracked (14). *Firik* generally is made in the home for domestic consumption or commercially produced by small-scale manufacturers. *Firik* pilav is a traditional dish consisting of *firik*, meat, tomatoes, salt, and fat or butter cooked together (30).

Tarhana. *Tarhana* is a traditional fermented cereal food consumed in Turkey. It is manufactured by mixing wheat flour, yogurt, baker's yeast, vegetables, and spices, which is followed by fermentation, drying, and grinding. Legumes and other cereal flours also may be used in *tarhana* production (15,29). It is produced both commercially and domestically. For the preparation of *tarhana* soup, *tarhana* powder is mixed with cold water and cooked for ≈ 20 min with occasional stirring. It is consumed as a thick, creamy, highly flavored soup (13).

Flat Breads. Flat breads are a simple form of bread made from flattened dough. They may be leavened or unleavened and are a very important staple food in eastern Turkey. Flat breads are classified into two groups: single and double layered. The single-layered group is divided into two subgroups: leavened by yeast fermentation (e.g., lavash, *tandır*, *pide*) and unleavened (e.g., *yufka*). Double-layered flat breads (e.g., *gobit*) are leavened with baker's yeast or sourdough and baked at a very high oven temperature, which seals steam inside the bread and causes it to puff up during baking (34). In Turkey, most flat breads are made at home and are widely consumed in rural areas, but they are becoming more popular in cities as well (12). *Bazlama*, lavash, *pide*, and *yufka* are common examples of Turkish flat breads.

Bazlama is a single-layered, flat, circular, leavened bread with a creamy yellow color. It is generally 1–2 cm thick and 20–25 cm in diameter. It is made with wheat flour, water, salt, and sourdough or yeast. After 1–2 hr of fermentation, 150–250 g pieces of dough are divided, rounded, sheeted to the desired thickness, and baked on a preheated metal plate (called a “*sac*” or “*sadj*” in Turkish). During baking, the dough pieces are turned over to be baked on both sides (2,44).

Lavash is a single-layered, flat, oval-shaped, leavened bread (12). Wheat flour, salt, water, and yeast are mixed into a dough and fermented for 1–3 hr. The fermented dough is divided into 100–250 g pieces, rounded, and fermented further for at least 15 min, after which it is sheeted

into a layer that is 40–60 cm long, 20–30 cm wide, and 3–5 mm thick. The sheeted dough is placed on the hot walls of a special tandoor oven (called a “*tandır*” in Turkish) and baked on the oven wall or the oven hearth for 20–40 sec (43, 44). This soft, pliable flat bread is perfect for wrap sandwiches (called “*dürüm*” in Turkish) and roll-ups (for shish kebab). Lavash has a short shelf life, drying quickly and becoming hard and brittle.

Pide is a flat bread made from leavened dough and has a soft consistency. It may be either circular or oval and is generally 1.5–2 cm thick. Circular *pide* has a diameter of 20–30 cm. In *pide* production, wheat flour, salt, water, and yeast are mixed for 15–20 min. The dough is fermented for 40–50 min and then divided, rounded, and fermented for an additional 30–40 min. It is flattened manually, decorated with sesame seeds and black cumin, and baked at 300°C for 18 min (43).

Yufka is a thin, round, unleavened flat bread with a diameter of 50–80 cm. It should be flexible enough to be rolled easily (3). In the production of *yufka*, flour is kneaded with water and salt. The dough is divided into 60–100 g pieces, rounded, rested for at least 15 min, and flattened into a circular sheet using a rolling pin. Sheets of *yufka* dough are baked on a preheated metal plate for a short period of time (40–60 sec). During baking, the bread is turned over to produce a creamy color with brown spots on both sides (44). The moisture content of *yufka* can be decreased to $<5\%$ to obtain dry *yufka*, which can have a shelf life of up to 6 months. Before consumption, dry *yufka* is wetted and rested for a few minutes to provide flexibility and enabling it to be rolled.

Boza. Boza is a traditional Turkish fermented beverage made with various cereal flours, yeast, and lactic acid bacteria. It is a thick, pale yellow liquid with a characteristic acidic–alcoholic odor and slightly sour or fairly sweet taste (1). Boza contains very little alcohol and CO₂ due to the fermentation that provides its characteristic flavor (17). Its pleasant flavor and high nutritional content has made boza a very popular beverage in Turkey (8). Boza is a rich source of probiotic lactic acid bacteria and can be marketed as a functional food product.

Boza production involves preparation of the raw material followed by boiling, cooling, addition of sugar, and fermentation with yeast and lactic acid bacteria. The raw ground material is placed in a

cooking pan and water (1:6) and boiled to obtain a homogenous paste (1,17). The paste is allowed to cool overnight and then filtered (17) to obtain “raw boza,” which is diluted with water. Boza should contain a minimum of 15% sugar (19). Finally, the mixture is left in a cool place to mature overnight (1,6,17).

Clearly, a number of nutritious functional foods that are high in fiber, low in fat, and low in phytic acid can be derived from traditional Turkish cereal-based food and beverage products. Intensive research efforts are needed in this area to exploit their potential to contribute to a health-promoting diet.

Recent Trends in Consumption of Cereal-Based Products in Turkey

The majority of the bread produced in Turkey is white hearth bread. However, over the last decade, the popularity of nonwhite breads, such as bran-supplemented and whole wheat breads, has increased rapidly. This is likely due in part to the government’s new policy encouraging the consumption of whole wheat breads and increasing consumer awareness of the health benefits of adopting a high-fiber diet. In Turkey, consumption of wheat bread and similar bakery products supplemented with other cereal grain flours, such as rye, oats, and barley, also has increased.

Recently, a new regulation concerning bread has been issued by the Ministry of Food, Agriculture and Livestock (No: 2012/2), and the Turkish Food Codex on Bread and Bread Types has been revised (37). The aim of these recent revisions is to change Turkish people’s attitudes toward consumption of whole wheat and bran-supplemented breads. Another objective of the latest revisions was to decrease the salt content of bread by 25%. In addition, the minimum ash content of bakery flour was increased to 0.65% to allow an increase in the bran content of

bread. It also now mandatory to make whole wheat and/or bran-supplemented breads available in bakeries and retail stores that sell breads. These changes are expected to promote consumption of whole wheat and bran-supplemented breads in Turkey.

A significant percentage of the world’s population is struggling with hunger. Therefore, prevention of food waste, especially bread and its basic raw component wheat, is becoming increasingly important. In response, “The Campaign for Preventing Bread Waste” was initiated by the Turkish Grain Board in 2013 as a social responsibility project. The main objectives of this campaign are to increase public awareness of bread waste and prevent bread waste during production and consumption. In a short time, important achievements have been observed as a result of these efforts and with the voluntary participation of stakeholders. As a result of this campaign, 384 million loaves of bread were saved in 2013, with a cash value of 2.5 billion TL (Turkish lira), and consequently, an ≈18% reduction in bread waste was achieved (48).

Cereal Science and Technology Research in Turkey

Collaboration among Universities, Research Institutes, and Industry. The Scientific and Technological Research Council of Turkey (TÜBİTAK), established in 1963, is the leading agency for managing, funding, and conducting research in Turkey. The TÜBİTAK not only supports innovation and academic and industrial R&D studies, but, in line with national priorities, also develops scientific and technological policies and manages R&D institutes conducting research, technology, and development studies. Furthermore, the TÜBİTAK funds research projects carried out in universities and other public and private organizations, conducts research in strategic areas, and

develops support programs for the public and private sectors. It also publishes scientific journals and books, organizes scientific activities, and supports undergraduate and graduate students through scholarships (www.tubitak.gov.tr). Recently, it was decided that the TÜBİTAK will give top priority to a variety of research fields. The thesis projects of M.S. and Ph.D. students are financially supported if their topics are related to these high-priority fields. Cereal science and technology was one of the topics included in this top priority list in 2014. In the past five years, a total of 207 food industry projects were supported by the TÜBİTAK-TEYDEB program; 15% of them were related to cereal and confectionary products. In 2014, the percentage of cereal and confectionary product-related projects increased to 29% (N. Saglam, TÜBİTAK, TEYDEB, *personal communication*, 2015).

The TÜBİTAK is also responsible for several international and national programs, such as bilateral and multilateral programs, EU framework programs, and European research programs (e.g., European Cooperation in the field of Scientific and Technical Research [COST], European Molecular Biology Conference [EMBC]).

The General Directorate of Agricultural Research and Policies (under the Ministry of Food, Agriculture and Livestock), Scientific Research Projects Coordination Units of Universities, Regional Development Agencies (under the Ministry of Development), and Industrial Thesis Supporting Program (SAN-TEZ; under the Ministry of Science, Industry and Technology) also provide support to R&D activities in Turkey. Cereal science- and technology-related research conducted by universities, research institutes, and industry have received important support from these programs.

Institutes Working on Wheat and Other Cereals.

There are 13 agricultural research institutes under the Ministry of Food, Agriculture and Livestock that are working on wheat and other cereal grains in Turkey (www.tarim.gov.tr/TAGEM/Link/13/Enstituler). One of the most important institutes is the Central Research Institute for Field Crops (CRIFC), which was founded in 1926 in Ankara. The fundamental objective of the institute is to develop new field crop varieties using conventional and molecular breeding methods and to produce elite seeds of these varieties to perform applied and basic scientific research. The Winter Bread and Durum Wheat Breeding Pro-

Table I. Wheat flour, pasta, bulgur, and cookie production (in tons) in Turkey from 2005 to 2012^a

Year	Wheat Flour	Pasta	Bulgur	Cookie
2005	4,496,459	580,516	83,081	401,527
2006	4,930,108	558,517	82,786	429,512
2007	4,586,938	571,292	70,498	489,525
2008	5,184,577	640,985	91,940	628,541
2009	5,211,947	595,160	135,308	583,548
2010	6,785,247	732,411	189,014	570,274
2011	7,511,115	863,968	222,210	605,028
2012	7,441,797	976,644	277,545	619,174
2013	–	1,202,840 ^b	–	–

^a Source: Turkish Statistical Institute (51).

^b Source: M. Bozkurt, Pasta Industrialists Association of Turkey, *personal communication*, 2015.

gram was initiated to breed varieties with high yields and quality that also are resistant to diseases and biotic stresses encountered in Central Anatolia (11). The institute is also a partner in the International Winter Wheat Improvement Program, which is a cooperative effort between Turkey, CIMMYT (International Maize and Wheat Improvement Center), and ICARDA (International Center for Agricultural Research in the Dry Areas).

As of 2015, 176 bread wheat, 57 durum wheat, and 75 barley varieties have been registered in Turkey by the Seed Registration and Certification Center (41). The CRIFC has developed 21 bread wheat, 12 durum wheat, and 15 barley varieties. Among these, Eminbey, Kızıltan-91, Ç-1252, and Mirzabey-2000 (durum wheat); Tosunbey, Bayraktar-2000, and Demir-2000 (bread wheat); and Tarm-92, Bülbül-89, Çetin-2000, and Aydanhanım (barley) are the varieties most commonly grown in Turkey (10). All quality analyses and evaluation of varieties and breeding lines are conducted by the CRIFC Quality Evaluation Department. The main aim of the department is to evaluate and improve the quality of breeding lines and new varieties.

Quantitative Data on Cereals and Cereal Products

The total area cultivated in Turkey is 23.8 million ha, which is ≈30% of the total land available. Almost half of this cultivated area (11.5 million ha) is reserved for cereal crops, among which wheat ranks first (67.2%), followed by barley, maize, rye, rice, oats, and triticale. During the last 20 years, the total quantity of wheat produced in Turkey has ranged between 17.20 and 22.05 million tons. The lowest wheat production in recent years was 17.2 million tons in 2007 due to a harsh

drought. Total wheat production was 709 and 22 million tons worldwide and in Turkey, respectively, for the 2013–2014 growing season (49).

The Turkish Grain Board (TGB), an autonomous state economic enterprise founded in 1938, plays a significant role in cereal grain-related issues, such as production trends, storage, and trade, in Turkey. The mandate of the TGB is to prevent abnormal decreases or increases in wheat prices against producers and consumers, respectively, and to protect and regulate the wheat industry. It is also responsible for importing and exporting wheat when necessary, monitoring wheat production trends and market movements around the world, and performing tasks related to other agricultural products as specified by the Council of Ministers if required. The TGB compiles statistical data by continuously monitoring domestic and international markets, and it analyzes the data and factors belonging to previous periods and takes required actions (47). Cereals subject to intervention purchases are wheat, barley, rye, triticale, oats, corn, and paddy rice. Headquartered in Ankara, the TGB was formerly founded under the Ministry of Economy, but it was put under the auspices of the Ministry of Trade in 1939 and later under the auspices of the Ministry of Food, Agriculture and Livestock. Since its founding, the TGB has constructed warehouses in various types and tonnages, considering ports and intensive production areas in every district of Turkey. The total storage capacity of the TGB warehouses is 4.5 million tons (3.2 million tons has ventilation capabilities); 546.700 tons of this capacity is located in ports. The TGB provides services for the agricultural industry, with facility teams and temporary receiving centers throughout the country that can increase

their operations during peak procurement periods (www.tmo.gov.tr).

The TGB also leads licensed warehousing operations in Turkey. The Licensed Warehousing Law of Agricultural Products (No: 5300) was enacted in 2005 (36). The warehouse receipt system has a number of advantages for the agricultural sector, such as introducing agricultural products into the market in accordance with quality standards and warehousing products under proper conditions. It also maintains product pricing during periods of high supply; ensures products against hazards; protects producers from price discrimination, market risks, and the possibility of receiving loans in return for product notes; and keeps records of the economy (45,52).

Wheat Flour. There are roughly 700 flour mills operating in Turkey, with a total milling capacity of 27.5 million tons/year (46, 53). Total flour production in 2012 was ≈7 million tons and was obtained using less than half of the total milling capacity (46,51) (Table I). There are also some small-scale flour mills in rural areas, and some local people bring their wheat to these smaller mills for milling. Therefore, the actual amount of flour produced in Turkey is estimated to be higher than the reported amounts (51).

In recent years Turkey has ranked first in global wheat flour exports, with a share of up to 20% (20). Within the last decade, Turkey's wheat flour exports have increased by 181% in quantity (from 786,017 to 2,209,928 tons) and ≈4.7-fold in cash value (from US\$197.5 to US\$932.6 million) (Table II). The main reason for Turkey's leading role in wheat flour exports is its close proximity to countries that are major wheat flour importers. Turkey exports wheat flour to countries across a wide geographical range, including the Middle

Table II. Wheat flour, pasta, bulgur and cookie exports from Turkey between 2004 and 2014^a

Year	Wheat Flour		Pasta		Bulgur		Cookie	
	Export (tons)	Export (U.S. dollars)	Export (tons)	Export (U.S. dollars)	Export (tons)	Export (U.S. dollars)	Export (tons)	Export (U.S. dollars)
2004	786,017	197,464,316	125,992	50,252,306	36,106	14,399,227	117,341	132,722,710
2005	1,978,904	425,870,020	164,399	65,500,861	68,551	24,193,457	118,204	143,733,642
2006	1,250,088	272,833,038	191,975	80,269,705	56,646	21,468,345	119,981	154,260,555
2007	1,216,761	424,398,825	177,924	107,786,602	73,918	37,609,805	144,224	203,217,431
2008	1,213,078	617,825,496	175,597	181,915,625	71,009	56,977,972	140,305	255,482,924
2009	1,805,652	580,904,540	213,506	149,422,907	115,227	63,209,287	131,752	239,015,815
2010	1,836,100	596,156,518	297,280	185,888,023	160,649	80,024,511	151,288	269,666,672
2011	1,984,078	891,363,842	404,039	285,261,094	122,443	70,297,089	164,259	322,430,057
2012	1,992,528	840,423,103	505,569	357,800,281	122,678	69,502,330	161,543	324,340,358
2013	2,142,079	946,402,353	693,101	493,928,791	159,990	97,157,211	178,930	359,647,164
2014	2,209,928	932,592,737	727,592	501,852,093	211,972	122,895,233	186,007	372,746,371

^a Source: Turkish Statistical Institute (50).

East, North Africa, and Far East. Iraq was the largest importer of wheat flour from Turkey in 2014, with a share of 47%, followed by Syria, the Philippines, Angola, Sudan, Israel, Indonesia, Benin, Guinea, Ghana, Palestine, Madagascar, and Sierra Leone (50). Another reason for Turkey's leading role in wheat flour exports is the Inward Processing Regime regulation (No: 2006/12) issued by the Ministry of Economy, which is related to Turkey's export incentive system (35). This regulation has proven to positively affect the competitiveness of Turkish exporters. The aim of the Inward Processing Regime is to enable Turkish exporters to supply goods at world market prices for production of their export commodities.

Pasta Products. Twenty-four pasta factories are actively operating in Turkey, with a total capacity of 1.25 million tons/year. The total capacity of the five largest factories is 600,000 tons/year. The next largest eight factories have capacities ranging from 50,000 to 90,000 tons/year each (31). Approximately 1.2 million tons of pasta was produced in Turkey in 2013 (M. Bozkurt, Pasta Industrialists Association of Turkey, *personal communication*, 2015) (Table I).

In recent years, pasta production has been an increasing trend in Turkey, making it the second largest exporter of pasta in the world (693,101 tons/year) after Italy in 2013 (20,50). Within the last decade, Turkey's pasta exports have increased by 478% in quantity (from 125,992 to 727,592 tons) and ≈10-fold in cash value (from US\$50.3 to US\$501.9 million) (Table II). As in the case of wheat flour exports, Turkey's close proximity to countries that are major pasta importers and the Inward Processing Regime can be cited as the main reasons it has become one of the leading exporters of pasta. Among the countries to which Turkey exports pasta, Angola ranks first, with a 13% share, followed by Benin, Syria, Iraq, Togo, Japan, Djibouti, the United Arab Emirates, Cameroon, Congo, Libya, Somalia, Lebanon, and Niger (50).

Table III. Daily bread consumption (g) by Turks in various age groups in 2010^a

Age (years)	Men	Women
2–11	87.9–162.6	80.7–159.1
12–18	224.6–266.4	157.9–165.1
19–64	221.6–248.8	150.9–157.4
>65	179.4–200.0	138.2–158.8

^a Source: Turkish Ministry of Health (38).

Bulgur. Turkey is currently the world's largest producer and exporter of bulgur. There are nearly 120 factories operating in Turkey, with a total capacity of ≈700,000 tons/year (53). Approximately 278,000 tons of bulgur is produced annually in Turkey's facilities, which utilize modern production technologies as well as traditional methods (51) (Table I). Turkey's bulgur exports totaled nearly 212,000 tons in 2014. Iraq, Syria, Lebanon, Belgium, Germany, Saudi Arabia, Jordan, Israel, England, the United States, Sweden, the United Arab Emirates, and the Netherlands are all major importers of bulgur from Turkey (50) (Table II). There are some small-scale bulgur manufacturers in rural areas, and local people may also produce their own bulgur at home. Therefore, the actual amount of bulgur produced is estimated to be higher than the amounts reported (51).

Cookies and Other Soft Wheat Products. There are roughly 50 cookie factories actively operating in Turkey, with a total production quantity of 620,000 tons in 2012 (9,51,53) (Table I). Turkey ranks sixth in global cookie exports (20). Within the last decade, Turkey's cookie exports have increased by >50% in quantity (from 117,341 to 186,007 tons) and ≈2.8-fold in cash value (from US\$133 to US\$373 million) (Table II). Iraq ranks first in the import of cookies from Turkey, with a 23% share, followed by Yemen, Syria, Saudi Arabia, Azerbaijan, Algeria, Romania, Albania, Palestine, Lebanon, Germany, Angola, Jordan, Libya, and the United States (50).

Bread. In Turkey, bread generally is consumed within 24 hr of baking. Therefore, small- and medium-scale local bakeries are very common. There are roughly 23,000 small- and medium-scale local bakeries, 2,500 artisan type bakeries, and 70 industrial bakeries operating in Turkey (M. Sanlı, Ankara Municipality Bakery Plant, *personal communication*, 2015). Metropolitan Municipality Bakery Plants are operating with modern technological infrastructures as industrial bakeries in Ankara (capacity of 1.5 million loaves/day), Istanbul (capacity of 1.8 million loaves/day), and most of the other metropolitan cities in Turkey (www.ankarahalkekmek.com.tr; www.ihe.com.tr).

Bread is the fundamental staple food in Turkey. Daily bread consumption shows great variation according to the life styles and habits of consumers. Bread consumption in families with low socioeconomic status in small towns and villages is much

higher than in families with a higher socioeconomic status in cities. Although there is a decreasing trend in bread consumption in general, it is still the most important energy source for Turkish people. In the 1990s daily bread consumption by Turkish citizens was ≈400 g/person (5), whereas it ranged between 221.6 and 248.9 g for men and between 150.9 and 157.4 g for women (19–64 years old) in 2010. Daily bread consumption rates for Turkish people in different age groups are presented in Table III (38).

Future Prospects for Cereal-Based Research and Industry in Turkey

In Turkey, cereal-based research is conducted by universities, public research institutes, and industry (private sector). In recent years, a significant increasing trend has been observed in the research activities of private-sector companies. This is probably due to various programs managed by a number of ministries to support collaborative research between the private sector and universities and public research institutes. There has been an enormous amount of research activity related to various aspects of cereals in general and wheat specifically in the past. Further studies are needed to increase the productivity and quality of cereal grains. However, the necessary improvements in productivity as well as nutritional and processing quality will not be forthcoming unless investments in research and education focusing on cereals are maintained or increased (32).

Malnutrition and hidden hunger are among the most injurious obstacles affecting a large portion of the world's population. Many people in Turkey and around the world suffer from hidden hunger or micronutrient deficiencies and do not get enough of the micronutrients that are essential for healthy lives. The diets of people with low incomes consist of very high amounts of bread and other cereal products. The nutritional properties of wheat are extremely important for these people because it is grown extensively as an inexpensive staple food source. Breeding programs provide an opportunity to improve further the nutritional and processing qualities of wheat cultivars that are also agronomically desirable. Unquestionably, the future will see many innovations in cereal science and technology. The following is a list of some research areas that should be given top priority in cereal research activities in Turkey, as well as globally.

- Biotechnology is expected to have major impact on revenues from cereal production, both through increased yield and improved quality. Molecular techniques such as marker assisted selection should be more commonly used in breeding programs to screen or select wheat breeding lines with higher micronutrient contents and better quality. In addition to developing new varieties with high nutritional and processing qualities, resistance to biotic and abiotic stress should be considered (e.g., wheat varieties with good breadmaking properties at relatively high suni bug damage levels might be beneficial for production in Turkey and surrounding countries).
- There is an urgent need for development of wheat varieties with improved protein, zinc, and iron contents. Landraces can be good source of micronutrients, and they can be used in breeding programs to develop new varieties that are rich in micronutrients. More emphasis should be given to genetic conservation of crop germplasm, since ancient cultivars and landraces and the wild relatives of domesticated species are being lost as modern varieties are adopted by farmers.
- There is also an urgent need to develop cereal-based products (especially whole grain cereal products) with health benefits that can help to overcome chronic diseases frequently encountered in developed countries (e.g., type 2 diabetes, cardiovascular diseases, and certain types of cancers) (18). For a healthy diet, a decrease in fat intake and increase in dietary fiber consumption are recommended. To meet this recommendation, it is necessary to develop raw materials and processing technologies to obtain food products with preventative and therapeutic health effects (e.g., improved colonic health, lower plasma cholesterol and lipid levels, etc.). Cereal products have great potential to fulfill these properties because they are high in soluble and insoluble fibers and resistant starch and low in fat and have a low glycemic index and high antioxidant capacity. Unfortunately, increasing dietary fiber and decreasing fat in products generally deteriorates the sensory and textural properties of foods. Therefore, appearance, texture, and mouthfeel must also be considered.
- Further research should be conducted to develop new cereal-based products for individuals who have cereal-related disorders, such as celiac disease, gluten sensitivity, wheat allergies, etc. (e.g., new cereal varieties could be bred for patients suffering from celiac and other cereal-related diseases).
- Research efforts should be intensified to increase utilization of modern technology in cereal processing facilities (e.g., computerized grain supply and product selection in flour mills, fully automated operation in factories, and air classification for protein control).
- Profit margins in the cereal processing industry are quite tight. Therefore, R&D activities related to decreasing manufacturing costs in flour mills, pasta and cookie factories, and bakeries are essential.

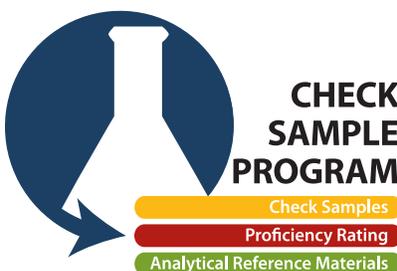
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