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How organic farming of wheat may affect the sourdough and the nutritional and technological features of leavened baked goods

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ABSTRACT

Organic farming is gaining broad recognition as a system that complies well with sustainability, an overarching principle that should drive agriculture now and in the coming year. Different cultivars and products can harbour different abundances of specific bacterial groups, farming system may influence the composition and abundances of microbial communities found on food product. Despite the growing interest towards organic foods, we still have a limited understanding of the diversity of food-associated microbial communities and the factors that influence the composition of these communities. Consumers in developed nations are commonly exposed to differences in farming practices through their choice between organic and conventionally farmed foods. Organic farming practices can differ from conventional farming practices in a variety of ways, including the types of fertilizer and pesticides that are used. This review aiming to gather current knowledge on chemical, technological, toxicological and functional properties and microbiota composition of wheat flours originating from organic and conventional farming systems and how the use of these may affect the sourdough fermentation and breadmaking. Sourdough fermentation is the most natural and best-performing process to ensure optimal sensory and functional characteristics. It fits perfectly into the processing chain that starts with the organic farming, especially for old wheat varieties with weaker technological properties. Recently, organic and sourdough microbiota diversity was investigated and in some case a comparison between organic and conventional microbial ecosystem was also carried out. Opposites evidences arise. Once a higher diversity of lactic acid bacteria species was found in conventional wheat sourdoughs, while when the diversity of Firmicutes was investigated, organic sourdoughs showed the highest complexity. When occurring, the differences between conventional and organic sourdough microbiota and their effects on bread properties are difficult to be identified and categorized due to the extremely large variability in baker's practices. Besides, this review would provide a critical view of this topic in order to avoid the speculation that in this field unavoidably arise.

1. Introduction

Organic farming is gaining broad recognition as a system that complies well with sustainability, an overarching principle that will drive agriculture activities in the years to come (Knight and Newman, 2013). The demand for organic products has markedly increased during the last decade representing up to 3–20% (mean 5.7%) of agricultural acreage in European Union Countries (Agence Bio, 2014; Kesse-Guyot et al., 2013). Consumers perceive organic products as healthier and safer for the environment. Avoidance of pesticides (70%), freshness (68%), health and nutrition (67%), and chance to avoid genetically modified foods (55%) were the main reasons for which consumers purchased organic foods as highlighted during specific surveys (Whole Foods Market, 2005). Organic may be also characterized as a kind of value-based food in the premium-price sector.

Raw materials or foods, which are sold as organics in the European Union (EU), have to be produced strictly respecting European legislation (European Commission EC 1881/2006, 2006). In the period 2006 through 2010, certified organic production in Europe has increased by >40% (Willer and Kilcher, 2012). According to the Italian Institute for Food and Agricultural Market, organic farming in Italy contributes to over 25% of the organically cultivated products in Europe (ISMEA, 2014). Among the arable crops, cereals represent the most important category with 1.57 million ha in 2013, i.e. 15.2% of all EU organic land and 2.5% of the total EU cereal area (Eurostat data on the basis of Council Regulation No. 834/2007 on organic production; Agence Bio, 2014). The largest organic cereal areas are located in Germany (13% of the cereal production), Italy (12%) and France (10%). Cereal foods (e.g., leavened baked goods and, in particular, breads) are, indeed, important elements

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of the daily diet, which mainly provide carbohydrates, proteins, dietary fibres and vitamins. The estimated annual intake of bread in European countries widely differs. The highest consumption levels are recorded in Turkey (ca. 104 kg) and Bulgaria (ca. 95 kg) and the lowest consumption is in UK (ca. 32 kg). On average the European consumer eats 59 kg bread/head based on the statistics from 15 countries, Belgium (55 kg), Bulgaria (95 kg), Denmark (45 kg), Finland (42 kg), France (57 kg), Germany (56 kg), Greece (68 kg), Italy (52 kg), The Netherlands (62 kg), Russian Federation (55 kg), Slovenia (42 kg), Spain (37 kg), Turkey (104 kg), Ukraine (89 kg), and United Kingdom (32 kg) (AIBI Bread Market Report, 2013). Nevertheless, in 2015 Italy showed a reduction of bread consumption (ca. 15%), where only organic breads or those variants with health-promoting features such as wholegrain breads and sourdough breads, were the most appreciated (www.coldiretti.it).

This trend is perfectly aligned with the actual aim to exploit organic cereal flours for bread making. Sourdough fermentation is the most natural and best-performing process to ensure the optimal sensory and functional characteristics (Gobbetti et al., 2014) and fits perfectly into the processing chain that starts with the organic farming. Besides, sourdough fermentation represents one of the oldest biotechnologies to ferment cereal flours, which was mainly studied for its effect on the sensory, functional, and rheological and shelf life properties of leavened baked goods (Gobbetti et al., 2014). Overall, organic food quality assessment might be evaluated through specific aspects and criteria (Kahl et al., 2011). For evaluation, each criterion has to be described by indicators, whose determination should be carried out by parameters, which in turn are described by methods. An adaptation of a quality assessment tree for organic sourdough bread (Kahl et al., 2011) is proposed (Fig. 1). When organic products are considered, many criteria and associated indicators have to be taking in account to join expectations in terms of sustainability and consumer acceptance. Based on this global approach, promoting microbiota diversity, food functionality, and sensory properties might be considered some of the key points of organic sourdough breadmaking. While the number of consumers of organic food is markedly rising, limited or controversial knowledge is available regarding the effects of organic farming of grains on chemical, technological, functional, rheological properties and structure of the flour microbiota, which in turn may affect cereal sourdough fermentation and breadmaking.

This review gathers current knowledge on chemical, technological, toxicological and functional properties and microbiota composition of organic wheat flour and how its use affects the sourdough fermentation and the overall quality of bread.

2. Organic wheat production in the European Union and profitability

Within the supply of organic products in Europe, Italy accounted for ca. 18% of all organic crops in the EU when the others countries account far less (e.g., 9% for France, 6% for Austria and ca. 2% for Denmark). The organic supply is currently one of the most expanding sectors of the food industry in many European countries. Across Europe, the market for organic food grew substantially from 2000 by >8% per year with approximately 19.6 billion € in 2010 (David et al., 2012). Although the organic grain market has developed rapidly, the growth in production has not matched the growth in demand. Consequently, Western European countries have been net importers of cereals from Eastern Europe, Australia, Canada and the United States and widespread scarcity of organic cereals led to discernible price increases at both the producer and consumer level. The economic viability of organic wheat production in Europe is clearly affected by the support payments, the technical performance but also by the existence of an adequate marketing structure. In the EU, farmers are receiving premiums for organic wheat from 30% up to 200% depending on countries and sales channels. Prices for organic cereal used for human nutrition can reach 100% above conventional prices. High profits observed in organic arable farms relative to comparable conventional farms were essentially due to high prices offered to organic products (Offermann and Nieberg, 2000). Nevertheless, the large difference between farm-gate and consumer price for organic products strongly limit the development and expansion of the organic cereal sector. The key question is whether the relative profitability of organic wheat will still be maintained if the premium paid by consumers is reduced. First, it depends on the combined growth in consumer demand and production level. Secondly, it is also determined by direct policy support compensating yield gap. Finally, the profitability of organic grains should be also guaranteed by the improvement of yield performance compensating the decline of the price premium (David et al., 2012).

Wheat is the most important organic cereal in EU with ca 432.000 ha in production. Durum wheat (*Triticum turgidum* subsp. *durum*) (109.031 ha) is particularly cultivated in Italy while large areas for soft wheat (*Triticum aestivum*) production are found in Germany (76.000 ha), France (50.169 ha) and Austria (36.719 ha). The development of organic soft wheat in Italy and Switzerland is low or null while the organic share has largely increased for others products (Agence Bio, 2014). Nevertheless, organic and conventional durum wheat is cultivated on over 3.7 million ha in the EU, and more than one-half of the acreage lies in the Mediterranean area, wherein Italy

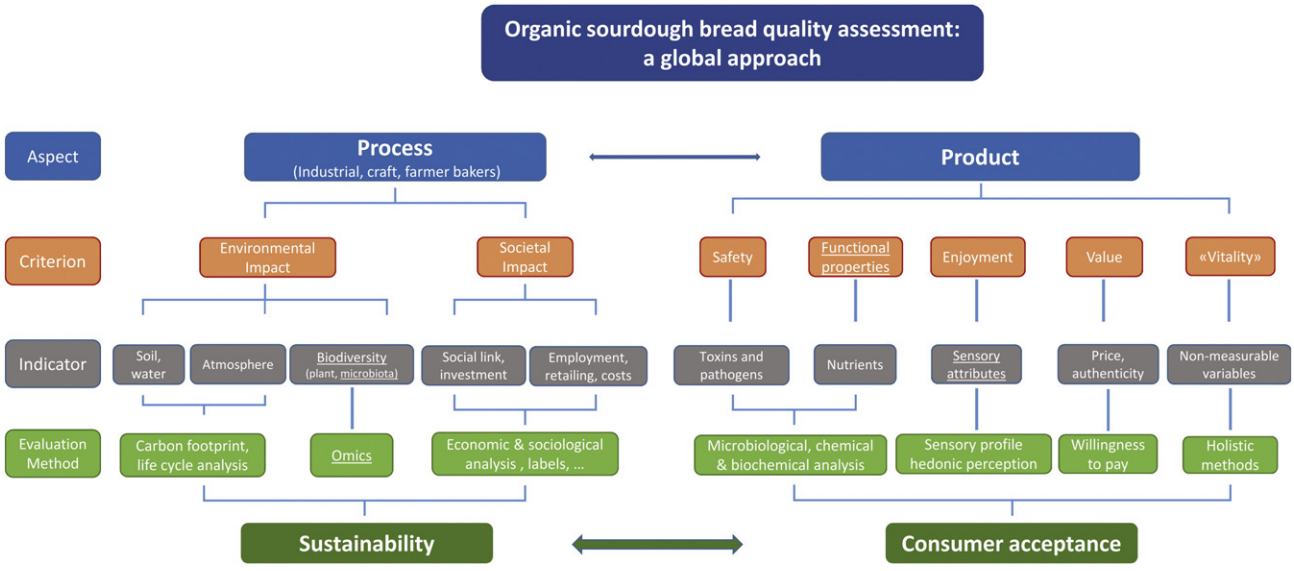

Fig. 1. Flow chart of the organic sourdough bread quality: the stepwise connection from quality to the parameters through which it is described (adapted from Kahl et al., 2012).