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The bread making process of ancient wheat: A semi-structured interview to bakers

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ABSTRACT

The importance of bread made from ancient wheat flours is currently increasing. In literature, several works examine the cultivation phase of ancient wheats, as well as their positive effects on human health. On a technological level, their bread-making process is hindered by the poor workability of these flours, but there are only few scientific studies aimed to enhance their technological performance. However, bakers developed several strategies to improve ancient wheat flour processability. We chose the semi-structured interview as instrument to investigate these strategies, evaluating them according to the existent literature. The study revealed that ancient wheats are usually stone milled, and processed as brown flours. Bread doughs are often prepared with flour blends, resulting from the cultivation of grain mixtures or obtained as flour mix.

The choice of slow mixers, an accurate monitoring of the final leavening phase and the use of sourdough, as well as the selection of flour blends have been proposed as solutions to partially improve the technological performance of ancient wheat flours. Finally, ancient wheat varieties are usually processed following several "good working practices" (i.e. use of non-refined flours, sourdough, organic cultivations) which probably play a role in enhancing their beneficial effects on human health.

1. Introduction

Consumed by billions of people, wheat (*Triticum aestivum* L.) is the major staple food in many diets, providing a large proportion of the daily energy intake, and it is currently cultivated worldwide. About 95% of the wheat produced is *Triticum aestivum* L., usually called "common", "bread" or "soft" wheat (Dinu et al., 2018).

There is not a precise definition of AWVs, but generally this term refers to varieties cultivated before the intensive selection programs occurred during the "Green Revolution". This intensive genetic selection led to the development of high-yielding modern varieties, characterized by higher capacity for nitrogen-absorption than other varieties, reduced susceptibility to disease and insects, an increased tolerance to environmental stresses, a homogeneous maturation, an improved storage protein quality and a higher gluten content. Whilst these breeding programs improved wheat yields and technological quality, a strong decrease of genetic variability occurred in modern varieties. As a consequence, AWVs are characterized by a broader genetic base than modern ones and, therefore, can be considered as a potential source of biodiversity (Dinu et al., 2018).

In recent years, there has been a re-discover of AWVs, probably due to the increased consumer attention to healthy and functional foods. Indeed, many scientific evidences showed the functional properties of AWVs (Di Silvestro et al., 2012). Moreover, studies on regular consumption of bread made with AWVs showed beneficial effects on human health: a reduction of metabolic risk factors, markers of both oxidative stress and inflammatory status (Sofi et al., 2013) and an improvement of lipidic, inflammatory and hemorheological parameters (Sofi et al., 2010).

Despite these health positive effects, the use of AWVs for bread production is hindered by some technological issues. Indeed, AWFs usually produce doughs characterized by low strength, high tenacity and low extensibility (Cappelli et al., 2018).

The lower technological properties of AWFs result in poor quality products if a standard process is applied. Therefore, the use of AWs for the bread making cannot rely on the standard process, but it requires appropriate techniques, specifically designed for these flours. Overcoming bread making issues could lead to a greater use of AWFs, promoting the consumption of products with enhanced nutritional value.

In literature, appropriate bread baking methods purposely developed for the different requirements of AWVs are currently lacking. On

Abbreviations: AWs, ancient wheats; AWVs, ancient wheat varieties; AWFs, ancient wheat flours

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the other hand, in Tuscany, in the last decade, an increasing number of bakeries have started to produce bread from AWs, developing several strategies, protocols and techniques to improve bread quality. Tuscan bread made with AWFs have generally round or elongated shape, weight-size of 0.5–2 kg, fine-grained crumb and thick and crispy hazel crust.

The present study uses a qualitative interview to report the main techniques currently adopted in Tuscany for the bread making process with AWFs. The aim was to reveal the bread making methods currently implemented for AWFs and to find out the existing processing strategies that improve AWFs' workability. Qualitative methods, based on semi-structured interviews, were applied in order to gain a better understanding of the process from the baker's point of view.

2. Methods

2.1. Study design and interview method selection

Our study was carried out using qualitative semi-structured interviews following the systematic methodology described by Kallio et al. (2016). First of all, we evaluated the appropriateness of the semi-structured interview as a rigorous data collection method in relation to our research question. The analysis of the literature revealed a lack of information about bread making techniques specifically designed for AWFs. Considering that AWFs have different characteristics compared to the modern flour blends commonly used in the baker industry, the standard bread making process became inappropriate and new processing strategies had to be designed. It seems very likely that the bread makers have been the first to face the different behaviour of AWFs during each phase of the process. Hence, in the absence of scientific studies on this issue, we decided to directly consult the experts in the field (i.e. bakers) in order to provide an empirical state of the art about the bread making techniques currently developed to improve AWFs workability. To gain this purpose, a qualitative analysis based on a semi-structured interview seemed to be the best method to obtain the bakers' expertise of the study phenomenon. In fact, this interview format consists of a set of predetermined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewee. Therefore, using a semi-structure interview format could provide a deep insight of the research topic.

2.2. Sample selection

The sample was selected using the handpicked sampling method: we identified some reliable mills that milled AWs in Tuscany and used them as a reference point for bakers' selection. The chosen mills were 5: Molino Paciscopi (Montespertoli, Florence, Italy); Molino Val d'Orcia (Pienza, Siena, Italy); Molino Parri (Sinalunga, Siena, Italy); Molino Grifoni (Pagliereccio, Arezzo, Italy); Azienda agricola Floriddia (Peccioli, Pisa, Italy). They gave us addresses of well-known bakers that use AWF in the bread-making process. We selected the sample to be, to the best of our possibilities, representative of the AW bread production in Tuscany. We collected 20 interviews with bread makers; the number of participants was based on the saturation criterion: when no new themes emerged, we stopped acquiring the data (Marshall, 1996).

2.3. Interviews

A preliminary semi-structured interview guide was designed on the basis of key themes identified from issues prevalent in the research literature. The main themes were the following: characteristics of all the ingredients used in the recipe to prepare the bread dough, the accurate description of each phase of the bread making process: mixing, resting, leavening and baking. We also included, at the end of the interview, experts' opinions about the main problems linked to the use of AWFs for bread production. The interview framework was created as a

Ingredients
- Milling method
- Flour refinement degree
- Species and cv of ancient wheat grains
- Bread formula

Sourdough formula and management
- Sourdough formula
- Sourdough processing method

Bread making procedure
- Final mixing
- Resting
- Dividing and moulding
- Final leavening
- Baking

Final considerations
- Issues of using ancient grains for bread making
- Key steps of the baking process
- Main attributes of a quality bread

Fig. 1. Semi-structured interview schedule–topic guide.

list of questions, which helped the interviewer to direct conversation towards the research topic and to achieve the richest possible data. The semi-structured interview guide was then pilot tested in order to make some adjustments to the questions and to improve the quality of data collection. At first, we performed an "internal testing", which referred to the evaluation of the preliminary interview guide in collaboration with the investigators in the research team. In a second step we conducted both an "expert assessment" and a "field-testing" by exposing the preliminary interview to the critique of a reliable baker, who was also one of the potential study participants. This phase was particularly beneficial to our interview guide, because it simulated the real interview situation and it provided valuable guidance about the wording and arrangement of the questions.

Fig. 1 shows the final interview structure used to guide data collection throughout the whole survey. We decided to use the telephone as a medium to perform the interviews for its methodological strength in qualitative research (Cachia and Millward, 2011). All the interviews were performed by the same investigator. During the interviewing, the interviewer attempted not to take any leading position, but was a listener who gently directed the conversation to cover the main themes if necessary. Probing questions were asked to verify the right interpretations of answers. The duration of the interviews varied from 30 to 60 min. Data were noted down during the interviewing activity and immediately transcribed in order to accurately record the whole details expressed by the experts.

2.4. Data analysis

Analysis of the qualitative data was performed according to the approach described by Elo and Kynga (2008) and Green et al. (2007). We identified the inductive content analysis as appropriate for our data, since we started collecting specific and individual data about bread making techniques with AWs, with the aim to achieve a general description of the processing methods.

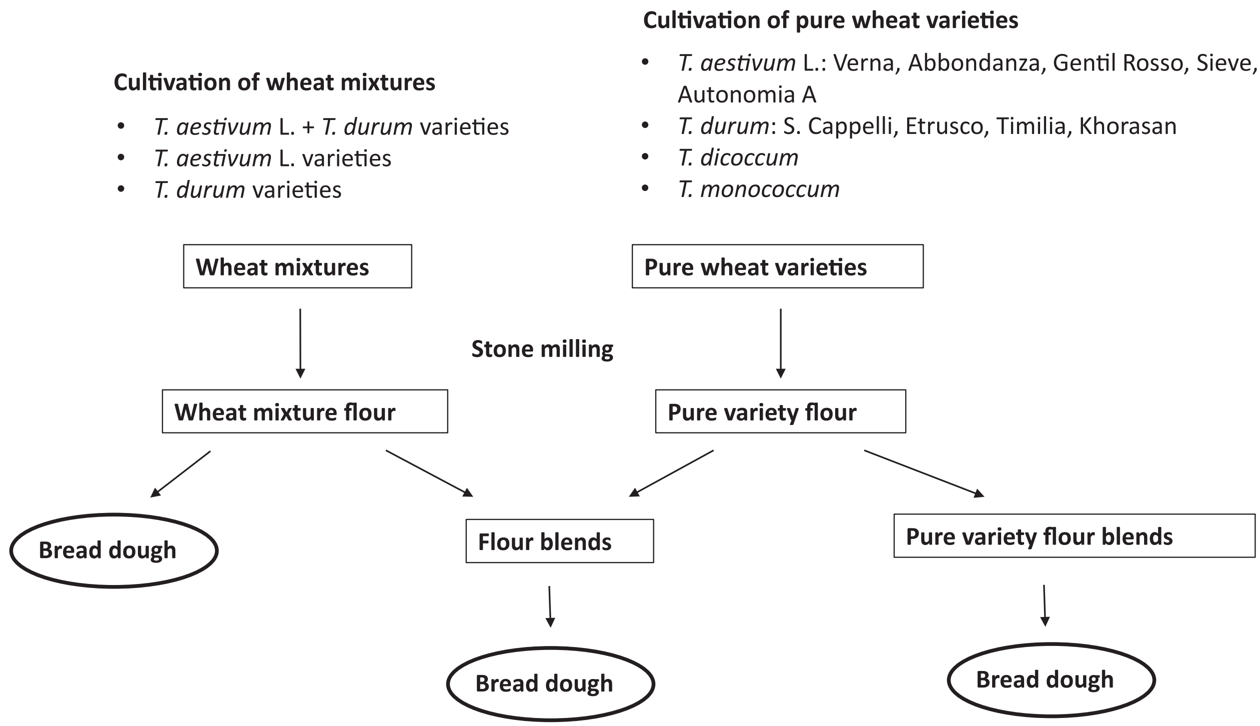

Fig. 2. The main AWs and flours selected for bread production. “Wheat mixtures” means AWs directly cultivated as grain mixtures; “flour blends” means mix of pure variety flours with each other or with wheat mixture flours realized after the milling process for bread baking.

The analysis process included four key steps: immersion in the data, coding, creating categories, and the identification of themes. Data analysis was done as follow. Immersion in the data is the first stage in the analysis process; it allows a detailed examination of what is said and lays the foundation for connecting disjoined elements into a clearer picture of the issue under investigation. The second step is coding, that is a process of examining and organizing information in each interview and the whole dataset. It forces the researcher to begin to make judgements and tag block of transcript. Categories represent the linking, a “good fit” between codes that share a relationship. The final step is the identification of themes, which is the litmus of a test study; it involves a description of a range of categories, and the interpretation of the issue under investigation (Green et al., 2007). To increase the credibility of this qualitative research, two co-authors independently analysed the same transcriptions and then compared their coded data. This triangulation strategy with multiple analysts helped reduce the potential bias resulting from a single person performing all of the coding and analysis (Patton, 2002). Both investigators undertook analysis, and reliability was enhanced by double coding a subset of transcripts and comparing inter-rater reliability.

3. Results and discussion

As first result of data analysis, all the respondents underline the importance of making further technological improvements, and developing new strategies for the AWFs processing.

3.1. Ingredients

More than 50% of interviewees (i.e. 13) are used to buy flours at their trusted mill; almost 25% (i.e. 6) directly cultivated the grains that they transformed into flours at the mill. Four of them have sufficient amount of grain for their bread making requirements, while the other 2 have to buy some of the flours to support the baking production.

AWFs are generally stone milled: except one, all interviewees preferred this milling method than the roller mills. The common belief is that stone mills are better than roller ones on a nutritional level. However, literature shows that stone mills generate considerable heat due to friction, which could result in considerable damage to starch, protein, and unsaturated fatty acids in comparison with other milling techniques. Undoubtedly, there appears to be a marketing advantage using the term “stone ground” with consumers, as evidenced by the preponderance of unrefined wheat flour products making this claim in both retail and commercial markets. Thus, the interview highlights a discrepancy between the literature and the bakers’ choice, which deserves deeper investigations. However, the milling phase is commonly depicted as a key step of the whole process; this is consistent with literature since the milling operation of unrefined flours appears to have a great impact both on flour composition and on technological properties, hence on the overall baking performance (Doblado-Maldonado et al., 2012).

Brown flour (i.e. type 2 according to the Italian classification) is the most common refinement degree, being chosen by the 50% of interviewees. The second prevalent trend (i.e. 7 bakers) is the contemporary use of flours characterized by different refinement degrees: brown flour, type 1 (according to the Italian classification) flour and whole meal flour. Unrefined flours show a higher nutritional value and several positive effects on human health, related to the protection from chronic diseases like cardiovascular disease, type 2 diabetes and various types of cancer, as well as an improved weight regulation (Ye et al., 2012). Despite the health positive effects, wheat bran addition in bread formulation results in a reduction of loaf volume, an increase in crumb firmness, a dark crumb appearance, a higher water dough absorption and a reduced fermentation tolerance (Boita et al., 2016). Specifically, the negative effects of the fibre components on dough technological properties was linked to the gluten dilution, affecting the dough gas-holding capacity; the disruption of the gluten matrix; and to the competition for water with other polymers, reducing the dough's viscoelastic properties (Boita et al., 2016). Hence, brown flours seem to represent the best compromise between nutritional benefits and technological issues: they show a richer nutritional profile than refined flours, since they contain the germ and some of the external bran components; moreover, the partial removal of the outer fibre fractions seems to improve their processability as compared to that of whole meal flours.

Fig. 2 resumes the AWs selected for bread production. *Triticum aestivum* L., is the wheat specie preferred by all participants. Moreover, in addition to common wheat, about 50% of the bakers (i.e. 11) also use *Triticum durum*. Two other species are more rarely selected, i.e. *Triticum monococcum* and *Triticum dicoccum*.

More than 50% of participants (i.e. 13) do not choose pure wheat varieties of *Triticum aestivum* L., but they use grain mixtures, directly obtained from the cultivation of different wheat varieties (i.e. wheat mixture). Flour mixtures can also be realized after the milling process, by blending pure flour varieties (i.e. flour blends). Fig. 2 schematizes both trends. The two prevalent wheat mixtures belong to different agronomical choice: one is a mixture of *Triticum aestivum* L. and *Triticum durum* varieties, while the other includes only *Triticum aestivum* L. varieties. The cultivation of ancient grain mixtures is reported to provide higher yields, lower yield variability, and better technological properties of the flours obtained. Indeed, the mixed cultivation of different varieties of a crop species in varietal seed mixtures is known in literature as a low-tech method to increase and stabilize cereal yields and to reduce the dependence on pesticides. Moreover, the potentials of seed mixtures of wheat and barley to provide increased grain yields support the hypothesis that positive mixing effects may derive from beneficial interactions between the component varieties (Kiær et al., 2009).

Ten out of 20 respondents use flour blends (realized after the milling) instead of grain mixtures. Three bakers use a mix of different cultivars of *Triticum aestivum* L., while 6 a mix of flours from *Triticum aestivum* L. and *Triticum durum.* Blending the two different wheat species seems to improve the baking performance. Actually, this practice was reported to enhance the bread-making quality (Bakhshi et al., 1989). Moreover, Torbica et al. (2011) found out durum wheat flour as an improvement agent in bread making with common wheat flour having damaged protein structure. Blending activity for AWFs has a different purpose compared to conventional flours: it does not aim to meet functional quality standards for the product destination use, but it seems to improve the technological performance, as if a synergic effect among the different components of AWVs occurs. The latter issue is poorly described in literature; hence, studies aimed to understand the mechanisms underlying these apparent improvements are required to identify suitable flour blends for AWFs.

As *Triticum durum* varieties the most common choice is Senatore Cappelli (i.e. 8 interviewees).

Finally, about the 25% of bakers use pure varieties of *Triticum aestivum* L.. The most popular one is Verna (i.e. 6 bakers); the remaining varieties are utilized less frequently and in a comparable way.

The second most abundant ingredient of the bread formula is water. The common trend (i.e. 14) is to add water amount in the range of 55–75% (w/w flour weight). Only 2 use higher quantity of water (i.e. 77% and 80–85%), and 4 lower amounts, between 50% and 30% (i.e. 2 bakers add 50%, one 45% e the last one 40%). A large variability of the water amount added to the bread dough arose; however, a general trend in preparing highly hydrated doughs can be observed. Indeed, water content acts as a swelling agent, which is able to reduce the dough stiffness. Water plays a double role in the baking process: firstly, mixed with flour it allows the development of a visco-elastic dough and secondly, after baking, there is more or less water remaining in the product, which will affect the final product texture (Zhou et al., 2014). Hence, we can assume that developing high hydrated doughs will provide an improvement of the rheological properties. Specifically, a better balance between the alveographic parameters tenacity (P) and extensibility (L) could be achieved, by decreasing their ratio (P/L), that is usually higher than the optimal reference range (Cappelli et al., 2018). This could provide an improvement of the overall baking performance with AWFs.

As leavening agent, the sourdough appeared to be the most popular choice (only one instead of sourdough uses the sponge dough method). Sourdough bread is prepared from a mixture of flour and water that is fermented with typical yeasts in symbiosis with lactic acid bacteria (LAB), generally in ratio 1:100. Doughs made with sourdough become softer and less elastic, and breads show improved structure and flavour. Many inherent properties of sourdough rely on the metabolic activities of its resident lactic acid bacteria (LAB) during their fermentation: lactic fermentation, proteolysis, and synthesis of volatile compounds, anti-mould, and anti-ropiness production. Moreover, sourdough activities can improve the mouthfeel and palatability of whole meal bread without removing any nutritionally important components (Chavan and Chavan, 2011).

Considering the amount of sourdough added in the bread formula (Tab.1), 16 respondents use between the 10 and 30% (w/w flour weight) of sourdough in the final dough, while the other bakers add higher quantities.

Additional ingredients are in some cases used; although in Tuscany bread is traditionally prepared without salt, about 25% of participants (i.e. 6) reported salt addiction in the bread formula (in low amount, always less than 1% w/w flour weight) as a way to improve the technological properties of doughs. While excess salt use is problematic from a nutritional point of view, it has been shown to positively influence every stage of the bread production. Salt effects of most relevance for improving the poor technological quality of AWFs, seemed to be the promotion of a better gluten-structure development during the mixing step and the formation of a fine elastic crumb during baking (Belz et al., 2012).

The use of improvement agents for bread production is out of practice (i.e. 19 bakers do not add improvement agents). This trend is in accordance with the bakers' common purpose: the exploitation of AWFs to obtain high nutritional products, avoiding every kind of supplements.

3.2. Sourdough formulation and management

Sourdough is made with 2 ingredients: flour and water. The most common choice is to use the same AWF of the bread recipe; only 3 bakers prepare the sourdough adding modern wheat flours to facilitate the leavening phase. In literature is reported that the type of substrate, mainly flour, used for sourdough fermentation significantly influences the sourdough properties. Specifically, the bran fraction contains more minerals and micronutrients that are important for the growth of LAB (Chavan and Chavan, 2011).

Two different type of sourdough are used: 11 bakers prepare traditional sourdough (i.e. type 1 according to Chavan and Chavan, 2011), restarted by using a part of the previous fermentation and generally composed by firm dough with low water content (8 bakers add 40–55% w/w flour weight, while 2 use even less quantities 35% and 25%, w/w flour weight); 9 bakers create a high hydrated sourdough making a liquid suspension of flour in water (adding as much water as flour, i.e. 100%, w/w flour weight), which contains adapted strains to start fermentation (i.e. type 2 according to Chavan and Chavan, 2011). This choice significantly influences sourdough flavor profile; the firmer the sourdough, the more acetic acid is produced and the less lactic acid (Chavan and Chavan, 2011). Moreover, it also affects the dough acidification rate (Spicher and Stephan, 1999).

Due to its microbial life, the sourdough is metabolically active and its microflora is generally preserved at low temperatures, i.e. 4 °C (i.e. only 4 preferred higher temperatures). To restart the sourdough activity before using it as leavening agent, a certain number of subsequent addition of flour and water followed by sourdough fermentation (i.e. propagation step), are usually carried out. In Table 1 the sourdough management and its frequency of usage are outlined. All bakers perform the first propagation step at room temperature and room moisture; only one uses low temperature during this step, T = 4 °C. The duration of

Table 1

Summary of the baking procedures from the 20 interviews. Sourdough management: % of sourdough amount in the bread formulation (% w/w_f sourdough weight/flour weight); certain number (1, 2, 3) and duration (h) of sourdough propagation step/s; frequency (Freq.) of sourdough usage a week. Mixing step: mixer type, ingredient addition into the mixer (all ingredients added at the beginning or progressive addition of flour/water), total final mixing time (min). Resting time (h). Final leavening time (h). Baking step: oven type, temperature (T) profile (start temperature, T_{st}; final temperature T_{fin}); baking times of bread loaves < 1 kg and > 1 kg.

n	Sourdough					Final mixing			Resting (h)	Final Leavening (h)	Baking				
	(%) w/w_f	Propagation step (h)			Freq.	Mixer	Addition during mixing	t (min)			Oven	T profile		t (h) < 1 kg	t (h) ≥ 1 kg
		1st	2nd	3rd								T_{st} (°C)	T_{fin} (°C)		
1	10–30	1.5–8	–	–	daily	fork	flour	10–20	–	1–2	gas	250	250	0.7	1
2	10–30	16	6	3	1/week	spiral	all at beginning	10–20	–	1–2	wood	220	200	–	0.5–1
3	10–30	1.5–8	–	–	daily	fork	flour	10–20	–	1–2	heat-cycle	250	250	0.5–0.7	1
4	10–30	1.5–8	4	–	1/week	by hand	flour	10–20	1–2	1–3	wood	300	280	–	1–1.25
5	10–30	1.5–8	–	–	daily	twin arm	water	10–20	< 1	> 4	wood	300–340	↓	–	1–2
6	10–30	1.5–8	–	–	daily	twin arm	water	10–20	< 1	1–3	gas	220	190	0.5–1	–
7	30–40	1.5–8	–	–	daily	twin arm	all at beginning	10–20	1–2	1–3	wood	230	↓	0.8	–
8	10–30	1.5–8	0.5	–	daily	spiral/twin arm	water	10–20	1–2	1–3	electric	240–250	240–250	0.7	1
9	10–30	1.5–8	12	–	1/week	spiral	flour	10–20	12	1–3	wood	280	↓	0.7–0.75	1
10	30–40	1.5–8	7	–	2/week	spiral	water	< 10	1–2	1	heat-cycle	240	215	0.8	–
11	10–30	14	–	–	daily	fork	all at beginning	10–20	< 1	> 4	wood	240	200	1	1.3
12	10–30	1.5–8	4–6	4–6	daily	twin arm	all at beginning	30	< 1	1–2	wood	310	280	–	1
13	–	–	–	–	–	spiral	all at beginning	10–20	< 1	> 4	gas	220	220	0.7	1
14	10–30	24	–	–	daily	fork	water	10–20	–	1–3	wood	240	180–190	0.8	1.5
15	10–30	12	–	–	daily	by hand	water	30	–	1–3	wood	220	↓	–	1
16	80	12	–	–	daily	spiral	all at beginning	10–20	1–2	1–2	wood	220	↓	0.4	–
17	10–30	1.5–8	–	–	daily	twin arm	all at beginning	10–20	–	1–2	heat-cycle	220–230	200–210	0.75–0.8	–
18	10–30	1.5–8	4–8	4–8	daily	by hand	all at beginning	45	1–2	1	wood	300	↓	0.75–1	–
19	10–30	1.5–8	12	–	2/week	spiral	flour	10–20	< 1	1–3	electric	210	180–190	–	1
20	10–30	12	–	–	3/week	twin arm	all at beginning	< 10	1–2	1–3	wood	280–300	140	–	1

this phase is extremely variable: times ranging from 1.5 to 8 h are selected by 13 bakers, while longer times (i.e. 12–24 h) are preferred by 6 bakers. Among the latter, 4 prepare liquid sourdoughs and the other 2 a traditional sourdough. Hence, liquid sourdough appears to need a longer propagation step as compared to the traditional one.

The large variability of the first propagation step could be associated to the complexity of sourdoughs as biological ecosystems, being characterized by different microbial composition. The dough hydration level and the flour compounds, the leavening temperature, and the sourdough storage temperature strongly affect the number and the type of yeast and LAB species found in doughs (Chavan and Chavan, 2011).

After the first propagation step, 11 bakers use the fermented sourdough as leaving agent for the bread dough preparation; all these participants perform a daily sourdough revitalization. Hence, performing just one propagation step appears to be the main trend for a daily sourdough management.

Conversely, a second propagation phase is carried out by 8 interviewees: environmental moisture and temperature are used by 7 respondents, while only 1 works at 4 °C. A strong variability characterizes also the duration of the second propagation step, since it ranges from 4 to 12 h. Looking at the frequency of sourdough utilization, we can observe that the great majority (i.e. 6 bakers among 8) use it once or twice a week (Table 1). Therefore, the number of the sourdough propagation steps is very likely dependent on the sourdough activity: a longer sourdough storage needs longer fermentation times to reactivate microorganism growth.

A third step is performed only by 3 participants (Table 1). It is carried out at room temperature and room moisture except for one (i.e. 4 °C) and the duration of the step ranges from 3 to 8 h.

The same relationship between the frequency of sourdough utilization and the number of propagation steps cannot be observed for this last propagation stage, since 2 of the 3 bakers that perform it use the sourdough every day. Hence, this third step does not seem related to microorganism activity, but it is probably a working choice driven by other factors.

3.3. Final mixing step

Mixing is one of the most important step of the entire baking process, since most of the characteristics of the final product are determined directly or indirectly during this phase (Zhou et al., 2014).

In Table 1 the main features of the mixing step are shown. The most popular machines are the spiral mixer (i.e. 7 bakers) and the twin arm mixer (i.e. 6 bakers), with one baker having both spiral and twin arm mixers. Thus, there is not agreement in the choice of mixer and bakers adopt very different strategies. In fact, twin arm mixers produces a better dough aeration, providing a higher volume increase and oxygenation of the dough, and consequently higher volume of the final product. Conversely, the spiral mixer generates lower gas occlusion, and higher temperature increase during the mixing phase (i.e. 9–10 °C vs 4–6 °C) (Quaglia, 1984). The role of the oxygen within the dough is linked to the proper gluten matrix development: under the kneading action, the original unorganized disulphide bounds of gluten are broken by reduction and new ones are formed by oxygenation. This oxidation strengthens the dough and locks the new “structure” in place (Zhou et al., 2014).

Concerning the beginning of the mixing process, we asked about the order of ingredients' addition into the mixer. Nine interviewees put all the ingredients together in the kneader at the same time, while 11 follow a precise order (Table 1). Among the latter, two different working methods arose: a gradual addition of the water amount (i.e. 6) or a gradual addition of the flour amount (i.e. 5). Both these techniques aimed to achieve a progressive flour hydration during the mixing step, by dosing water or flour addition; bakers report that this technique provides a higher water absorption and a better dough development.

With regard to the total mixing period, short times (i.e. 10–20 min) are generally preferred (i.e. 15 bakers). The other bakers are split into two groups: 3 of them select longer mixing times, between 30 and 45 min, but among them, 2 bakers do not use a mixer, since they work the dough by hand; hence, longer times are probably linked to this different mixing method. On the contrary, the other 2 participants use shorter mixing times (i.e. < 10 min). Choosing short times of the mixing phase seems to be essential to face the poor stability of AWFs, that cannot support longer mixing period without losing dough quality. Despite the environmental conditions during mixing are not controlled, an accurate monitoring of the dough temperature arises from the interview. Dough is kept around 24°C-26 °C by adjusting the water temperature. This result is consistent with literature; it is well known that during mixing, the temperature of the developing dough begins to rise as a direct consequence of energy being transferred to the dough. The adjustment of ingredient temperatures, most notably the temperature of the water, produces dough with a consistent final dough temperature for uniform processing after mixing and optimises the final product quality (Cauvain and Young., 2007).

3.4. Dough resting and piecing

Once the mixing step is completed, 15 out of 20 respondents give to dough a resting period (Table 1): 1–2 h is the most frequent choice (i.e. 8), followed by shorter times, < 1 h (i.e. 6); the process occurs at room temperature and room moisture almost for all, hence, the resting period can vary in relation to the seasonal changes. During long resting times, care should be taken to prevent the dough skinning; all the interviewees report to accurately cover the doughs in order to preserve their original moisture. Several phenomena occur during the dough resting period. Yeasts start to generate carbon dioxide gas, increasing the bubble size within the dough and thus affecting the final bread cell structure. The extent of the activity depends on resting time and dough temperature. Furthermore, resting time can enhance the fermentation process, allowing a “natural” dough conditioning, thus requiring lower levels of reducing agents and other dough improvers to be used (Cauvain and Young., 2007).

Moreover, nearly the 50% of participants observed that during the resting period a better development of the gluten matrix could be obtained by folding the dough many times on itself.

The next phase of the bread making process is the dough make up which includes both the dividing step, that consists of cutting the dough (by hand or mechanically) into loaf size pieces and the moulding step, which consists of the dough pieces moulded into the desired shape. The major part of the bakers uses the dividing machine, while the moulding process is commonly carried out by hand in order to preserve the dough structure. Moulding step can notably affect the dough development; in fact, the gluten matrix acquires its final orientation under the moulding mechanical work (Quaglia, 1984). The most prevalent bread sizes are those of 0.5, 1 and 2 kg, but the survey also reveals a great demand of little sizes, less than 1 kg (i.e. 0.3, 0.5, 0.6 kg), since a great part of the consumers are used to buy fresh bread pieces every day.

3.5. Final leavening step

Leavening is one of the most important steps of bread making after mixing. The use of natural leavening may result in variation of the quality of the fermented dough due to variable types and amounts of microorganisms in the system. Yeast generates carbon dioxide gas, resulting in an increase in dough volume, and hetero-fermentative LAB yields lactic acid (which decreases pH), acetic acid (which acts as an antifungal agent), exo-polysaccharides (which can act as a gut health promoter), and volatile compounds (which act as a flavouring agent). In addition, protein is degraded through proteolysis to amino acids, promoting microorganism growth and the development of Maillard flavour compounds (Zhou et al., 2014).

All participants except 2 leave the doughs leavening without any

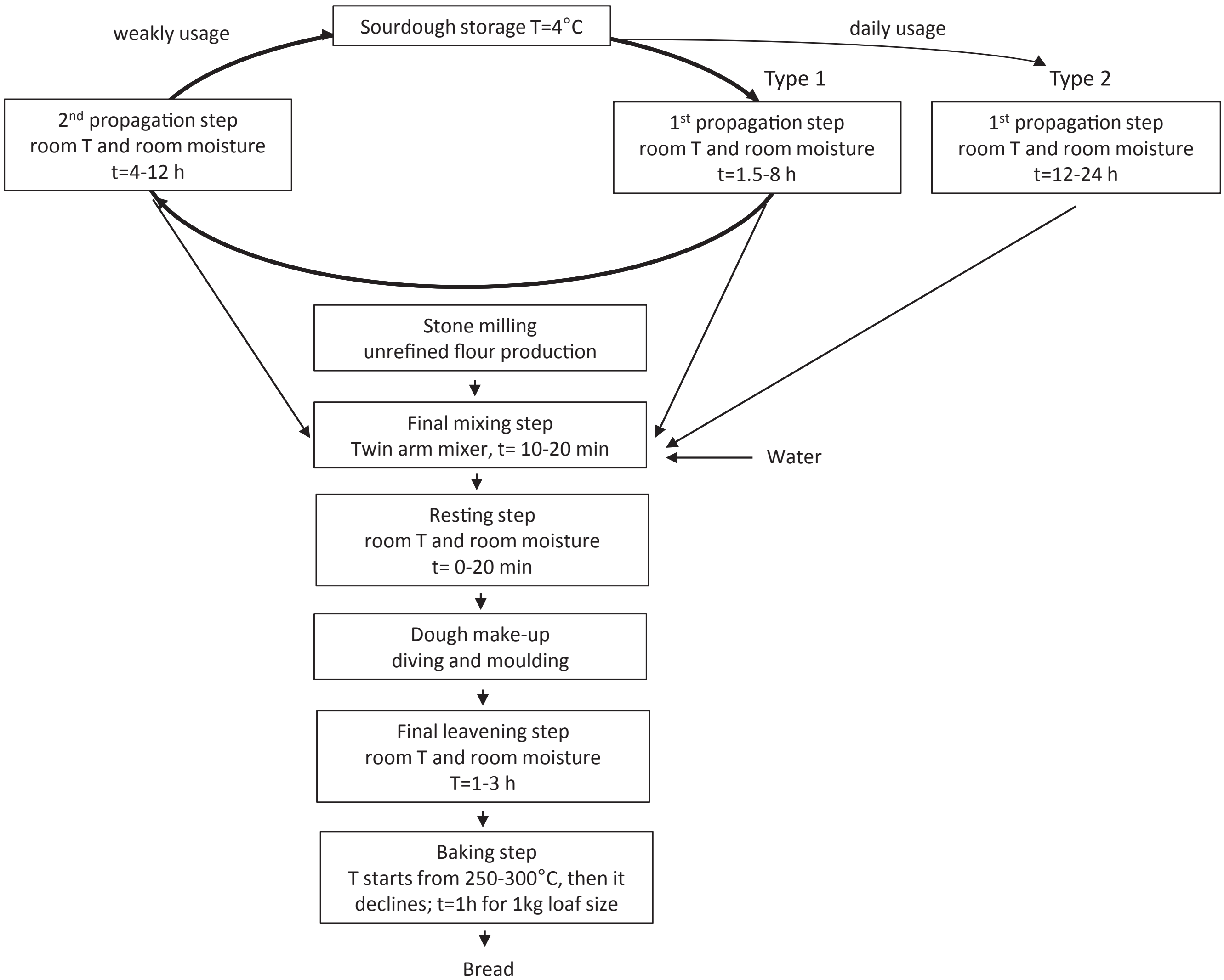

Fig. 3. The bread making process with AWFs in Tuscany.

containers; they state that bread doughs have to maintain their structures and shapes on their own. The 2 remaining bakers prepare highly hydrated doughs, and have to put dough pieces into moulds, since they are not able to develop a proper structure on their own. All bakers perform the leavening step at room temperature and room moisture. In Table 1 the duration of the leavening step is shown. The most common trend (i.e. 16), independently of the presence of the resting step, is to carry out a leavening phase of about 1–3 h, depending on the external conditions; the other 4 bakers select longer leavening times (i.e. > 4 h). Moreover, the duration of the total leavening step changes with the environmental conditions, following the seasonal temperature trend throughout the year; longer times are necessary in cooler seasons while shorter times are appropriate in warmer conditions.

The large variability of sourdoughs requires an accurate control of the leavening step. In fact, different microorganism-substrate interactions could be established in the leavening dough. As discussed below, bakers are used to manage this high variability of the leavening performance by keeping high the sourdough viability.

3.6. Baking step

Table 1 shows the results of the baking step. More than the half part of the interviewees (i.e. 12) use a wood oven for baking. Other oven typologies used are: heat-cycle oven, gas oven, electric oven. With regard to the initial temperature, half of the wood oven users choose very high values, around 300 °C, while all the others use values between 200 °C and 250 °C. During the baking phase, temperature naturally decrease in wood ovens; with the other oven typologies, 50% of bakers create a temperature drop, while the remaining bake in a steady condition. Therefore, regardless the different oven types, data reveals a common trend in the temperature profile management during the baking process: bread doughs are generally baked under a decreasing heat condition. Temperature profile markedly impacts product quality since it affects enzymatic reaction, volume expansion, starch gelatinization, protein denaturation, non-enzymatic browning reactions, and water migration (Zhou et al., 2014). Furthermore, it has been reported that the use of different baking temperatures affects the crust-crumb ratio of high-moisture products (Ahrne et al., 2007). High heat transfer limits the extent of the oven-rise because the gases do not have enough time to complete their potential for expanding cells. On the other hand, long baking times tend to decrease crumb softness (Cauvain and Young, 2007). The common use of higher temperatures at the beginning of the baking phase followed by a temperature decrease is probably linked to the necessity of obtaining a rapid crust development in order to create a thick crust and a soft crumb, both elements that characterized Tuscan bread quality. Moreover, it could be a strategy to improve the final product quality. In fact, the higher heat at the beginning of the phase can probably lock the loaf leavened structure without allowing any further expansion of its inner gas, which could not be retained by the weak AWFs. Hence, the volume growth obtained during the leavening step could be preserved.

Humidity level in the oven represents another key factor during the baking process. Wood ovens naturally provide a moisture release, hence, no additional moisture has to be added during baking. Table 1 shows that 3 out of the 9 bakers who do not use wood ovens are used to add moisture in the baking chamber, specifically in the first phase of the baking process in order to improve the final product quality. Indeed, steam injection delays the evaporation of water at the dough surfaces by condensation of water from the oven atmosphere onto the dough surface. Condensation proceeds as long as the crust temperature is below the dew point temperature of the oven atmosphere, which occurs during the first minute of baking (Zhou et al., 2014). This phenomenon produces a barrier on the dough surface against the release of carbon dioxide, resulting in a higher bread volume development and in a thinner, softer and lighter crust (Quaglia, 1984). When baked in a dry atmosphere, bakery products have a dull surface appearance and a rather harsh colour (Zhou et al., 2014).

The time taken to achieve a satisfactory baked product depends to a considerable extent upon the properties of the product itself, its surface/mass ratio, and its weight (Quaglia, 1984). The duration of the baking phase reported is close to 1 h, or a little over, for bread doughs between 1 and 2 kg, while it is around 30–40 min for smaller dough pieces. These data are consistent with literature; 30 min for 350 g dough with oven temperatures of 200 °C or 235–275 °C; and 35 min for 600 g dough at 225 °C (Zhou et al., 2014).

Fig. 3 outlines the bread making process with AWFs in Tuscany resulting from our interview study. Furthermore, the interview allows to highlight the critical points in the bread making process as perceived by bakers. Fig. 4 resumes the critical points and the number of bakers consider each of them important. We can observe that the most important working procedures resulted: the selection of short mixing times (i.e. 13); the identification of the proper leavening time (i.e. 9); the use of flour mixtures/blends (i.e. 7); the proper flour hydration (i.e. 6); the sourdough viability (i.e. 5).

Finally, before drawing conclusions, it is important to point out on some of the study limitations. First of all, results are obtained from a sample of 20 Tuscan bakers. The saturation criterion was adopted by the authors, to limit the drawback due to the number of respondents. However, more detailed information may arise from a bigger sample. The baking process here reported is intrinsically linked to the Italian and, more specifically, Tuscan tradition of bread making. Hence, in other parts of the world, different practices and techniques could be found by a similar interview.

4. Conclusions

In the literature many papers focus on the evaluation of AWF genetic, agronomic and nutritional characteristics, while few studies focus on AWFs' bread making process. On the other hand, bakers develop several strategies to improve the AW final bread quality. Hence, we performed a survey to find out the techniques currently adopted by Tuscan bakers.

It has been extensively reported that these flours positively affect human health as well as they yield environmental benefits. However, the adoption of several "good working practices" during the whole production process enhances the AWFs positive effects on environment and health. In fact, AWFs are baked with the purpose to preserve their valuable nutritional value during each phase of the transformation process, from farming to flour exploitation during baking (i.e. organic cultivation, use of non-refined flours, use of sourdough). All these choices provide environmental and nutritional positive effects, regardless if flours are ancient or modern. However, on a technological level, adopting these good practices sometimes results in a worsening of the already poor AW grain workability.

The main "good working practices" revealed by the survey involve a cultivation step under organic farming and a milling phase performed with stone-mills, which results in unrefined flours as products. Therefore, AWFs contain significant amounts of fibre and germ in their composition, which negatively affect the dough workability but improves the bread nutritional values. With regard to the bread formula, the interview discloses a common trend to realize grain mixtures or flour blends with the aim to achieve both an agronomic advantage and

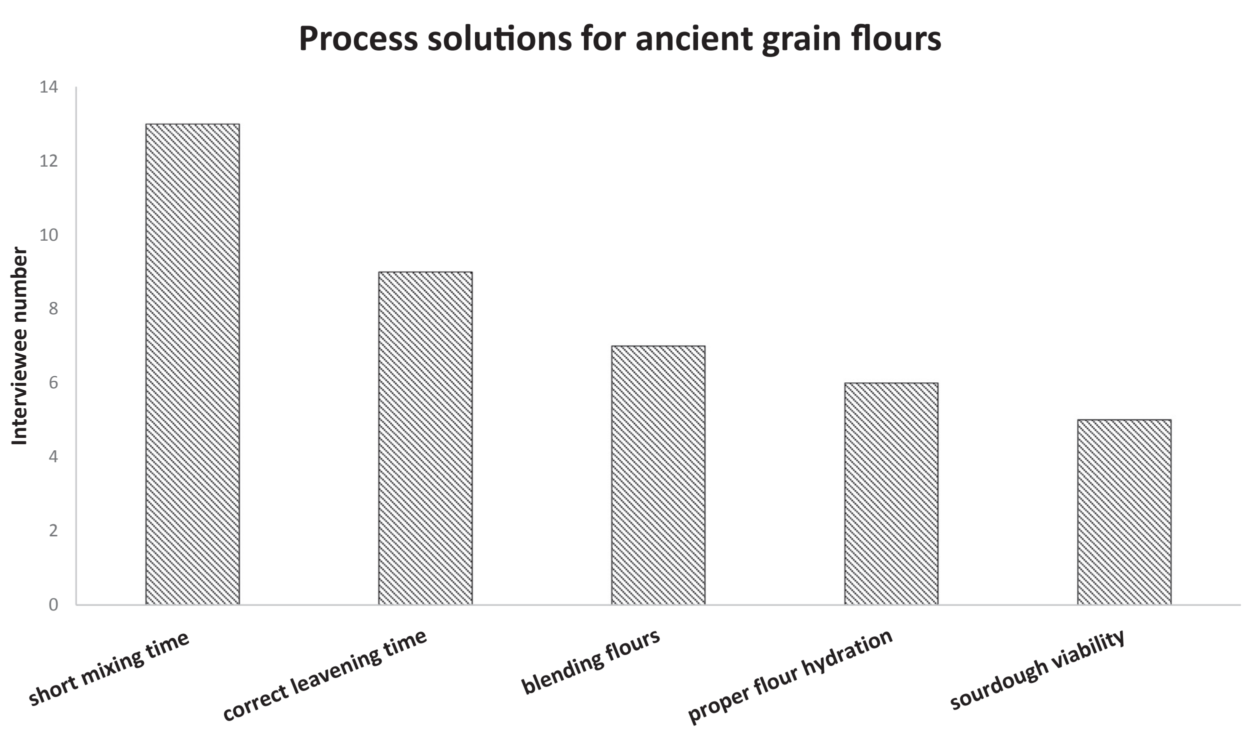

Fig. 4. The main critical points of the bread making process highlighted by the survey: short mixing time, correct leavening time, blending flours for bread formulation, maintenance of the sourdough viability

an improvement of the flour workability.

Concerning the baking process, our results reported some common processing methods that appear to increase AWF workability as well as the final product quality. These baking methods include: the use of the sourdough as a leavening agent, the optimization of the sourdough activity, short mixing time to optimize the dough development, a gradual flour hydration throughout the mixing, a resting period after the mixing phase (around 1 h), a long leavening step (around 3 h), and a baking step performed in wood ovens, with high temperature at the beginning followed by a heat decline.

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