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Sourdoughs Used in the Preparation of Traditional Bread in the Province of Figuig in Eastern Morocco

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Abstract

To gather recipes for traditional sourdoughs used to bake traditional bread, a survey was conducted in Figuig, a town located in the southeast of Morocco. The data of this survey is collected from a random sample of 100 rural women using a structured questionnaire. The data shows a total of 17 different traditional recipes mentioned by the interviewed women. Among the ingredients used in these recipes, whole wheat flour and warm water had the highest percentage of citations (31 %). It was also observed that 9 local products were used in these sourdough recipes, including whey, locally called "leben" (19 %), dried beans (16 %) and dates (15 %). Lemon, garlic, dried figs, raisins, flax seeds and carob flour were also mentioned as ingredients (1%). The participants also stated that the sourdoughs are transferred to different shapes and types of utensils for incubation and were alive for a variable amount of time depending on climatic conditions.

Keywords: Food survey; Sourdough; Traditional recipe; Figuig

1 Introduction

Sourdough bread is a traditional food product, fermented with sourdough, and has been known since ancient times (Lau et al., 2021; Marsh et al., 2014). The preparation begins with a sourdough starter, a natural leaven composed of wheat or barley flour and water. This mixture forms a sponge-like product which is then kept at room temperature and refreshed on a daily basis, for several days, to develop into a sourdough chief (Figure 1). The fermentative activity of sourdough, during baking, is the result of the mixture of microflora in the sourdough, composed of "wild" yeasts and lactic acid bacteria (LAB) (Table 1).

Wild yeasts *(Saccharomyces cerevisiae, Saccharomyces exiguus, Candida krusei, Candida guillermondii, Candida holmii, Torulopsis holmii, Hansenula anomala and torulaspora delbrueckii)* are responsible for the production of CO_2, lactic acid and lactic bacteria (LAB). The later are subdivided into heterofermentative and homofermentative lactic acid bacteria *(Fructilactobacillus sanfranciscensis, Limosilactobacillus fermentum, Lactiplantibacillus plantarum, Leuconostoc mesenteroides, Levilactobacillus brevis subsp. lindneri, Lactobacillus fructivorans, Lactobacillus alimentarius)* (Table

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1).
Heterofermentative LAB produce a mixture of lactic acid and acetic acid while homofermentative LAB only produce lactic acid which acidifies the sourdough growth environment very quickly (Galimberti et al., 2021). The synergistic interaction between the wild yeasts and the LAB, during the fermentation phase, allows production of special and unique aromatic precursors, increases volume of the bread and decreases firmness of the bread. It also functions as a probiotic reducing the pH, which helps the optimization of the sourdough bread's shelf life (Carbonetto et al., 2020; Galle et al., 2010; Gobbetti et al., 2014; Hui et al., 2004; Kaditzky et al., 2008; Katina et al., 2009; Lau et al., 2021; Rühmkorf et al., 2012; Tieking & Gänzle, 2005; Zhang et al., 2021).
The purpose of this work was to establish an inventory of sourdough recipes used in the traditional process of sourdough bread making, by women from the town of Figuig. The data will serve as a source of information on the varieties and methods of sourdough starters (Mannaa et al., 2021). It also aims to provide research data in the area of food safety and research into natural probiotics as a way to treat certain metabolic diseases including diabetes, celiac disease and non-alcoholic fatty liver disease which are global health issues (Pasqualone, 2018; Stefan & Häring, 2013).

Figure 1: Sourdough starter. Sourdough starter prepared with a mixture of whole wheat flour (15 %), whole barley flour (15 %) and lukewarm water (70 %). CO_2 production is shown by a smaller size of bubbles. (Taken on 18 March 2020 at Figuig. Picture provided courtesy of the author MOUJABBIR Sara)

2 Materials and Methods

2.1 Study area

The survey took place in the town of Figuig (Figure 2) called in the local language Amazigh language: Ifyyey or Figuig. The province is located in the extreme southeast of Morocco (latitude 32^o 7 '0 "N, longitude 1^o 13 '37 "W). It is bordered by the province of Jerada to the north, the province of Boulemane to the northwest, the province of Errachidia to the west and by the Moroccan-Algerian border to the south and east. Figuig province includes seven different communes (Ighermawen in Tamazight, Arabic: قصر, namely, At-wattay (Hamam tahtani), At-Amar (Hamam Foukani), At-lamiz (El Maiz), At-Sliman (Oulad Slimane), At-Annaj (Laâbidate), At-Addi (Loudaghir) and Iznayen (Zenaga) (Monographie de la province de Figuig, 2013). Figuig is an oasis famous for its different varieties of dates (tiyni), which include "Assign", "Aziza", "Boufeggous", "Mejhoul" and "Tgharas" (Chafi et al., 2015; Yauo, 2012). The province is also known for some famous traditional dishes like "Mihmih", "Zembou", "Ourif", "Klila" (type of cheese) and "Aghroum n'tamtunt" (local bread).

2.2 Samples

The women surveyed belong to 7 localities selected as shown in Figure 3. These localities are called "ksar" in the local language (plural "ksour") and are Zenaga "Iznayen": Baghdad, tachraft; Loudaghir "At Addi"; Laâbidate "At ennej"; Oulad Slimane "At Slimane": Dfilia, aarga; Hamam Tahtani "At Wattay"; Hamam Foukani "At Amer" and El Maïz "At Lemaïz". The study participants are rural women randomly selected and their number varies according to each locality in the study area (Table 2; Figure 3).
Inclusion criteria are the rural location of the respondents place of residence and the use of

Table 1: Example of microflora: LAB and yeast most isolated in sourdough (Gobbetti et al., 2014)

Lactic acid bacteria and wild yeast		
Lactic acid bacteria	**Yeasts**	**References**
Lactobacillus delbrueckii, Lactobacillus plantarum, Lactobacillus fermentum, Lactobacillus buchneri, Lactobacillus brevis, Levilactobacillus brevis subsp. lindneri, Lactobacillus fructivorans, Lactobacillus alimentarius	*Saccharomyces cerevisiae, Candida krusei, Candida holmii*	Corsetti and Settanni (2007), Katsi et al. (2021), Zameitat et al. (2007), and Zhang et al. (2021)
Fructilactobacillus sanfranciscensis, Lactobacillus plantarum, Lactobacillus fermentum, Leuconostoc mesenteroides, Pediococcus spp,	*Saccharomyces cerevisiae, Candida stellata, Torulopsis holmii*	García et al. (2018), Zameitat et al. (2007), and Zhang et al. (2021)
Levilactobacillus brevis subsp lindneri, Lactobacillus plantarum, Lactobacillus fermentum, Lactobacillus pontis.	*Candida guillermondii, Candida holmii, Saccharomyces cerevisiae, Hansenula anomala, torulaspora delbrueckii, Saccharomyce exiguus, Candida krusei*	Hellborg and Piškur (2009) and Katsi et al. (2021)

Figure 2: Locality of the study area "Figuig". (Image from Google Earth, modified by the author)

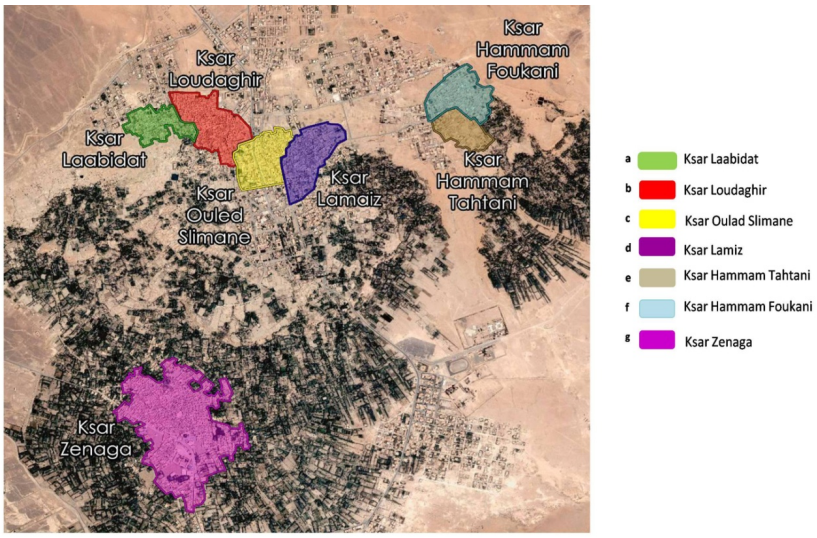

Figure 3: Monograph of seven Ksour in the study area: (a) ksar laabidat, (b) ksar Loudaghir, (c) ksar oulad sliman , (d) ksar Lamiz, (e) ksar hammam tahtani, (f) ksar hammam foukani, (g) ksar Zenaga. (Image from Monographie de la province de Figuig (2013), modified by the author)

Table 2: Distribution of the study sample of women bakers according to age.

	Age range (%)	
Ksar	40-50 yrs	60-80 yrs
Zenaga "Iznayen": Baghdad, tachraft	10	19
Loudaghir "At Addi	-	11
Laâbidate "At ennej "	-	10
Oulad Slimane "At Slimane": Dfilia, aarga	6	12
Hamam Tahtani "At wattay"	-	11
Hamam Foukani "At Amer"	-	10
El Maïz "At Lemaïz"	2	9

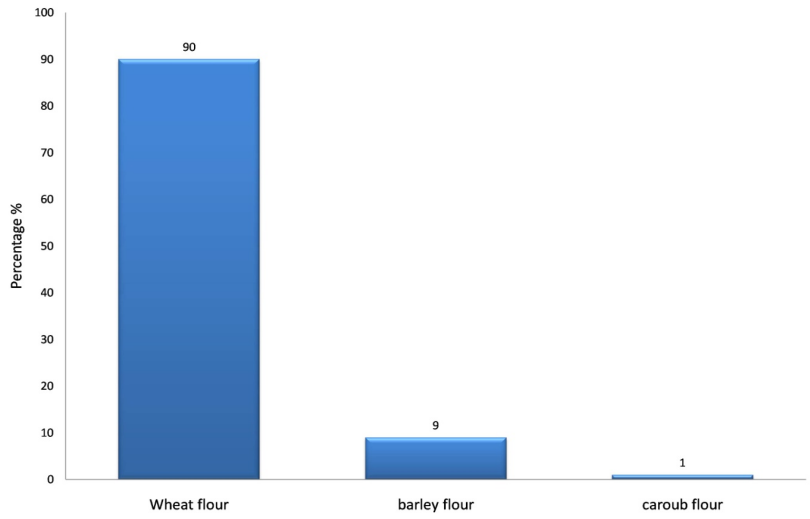

Figure 4: Basic ingredients used to make the initial sourdough starter

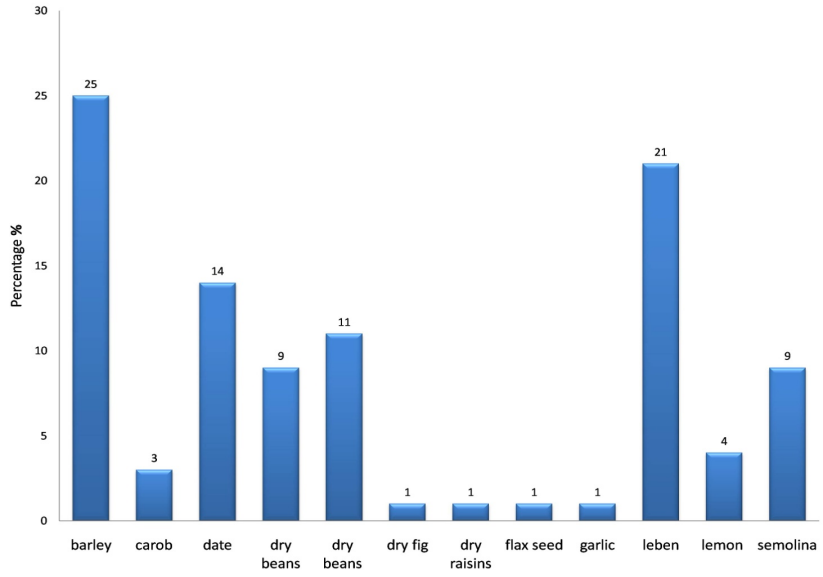

Figure 5: Ingredients used to speed up the fermentation process

Table 3: Description of the sourdough

Recipe		Sourdough type	Usage	Incubation condition	Conservation utensil
125 g wheat + 125 g water + 125 g barley	12%	Stiff or dry or liquid	- Bread - Moroccan soup or 'Harira'	- Stiff and liquid: ambient temperature - Dry: solar exposure	- Stiff: flour - Liquid: glass jars - Dry: raffia dish
125 g wheat + 250 g water + 2 dates	9%	Liquid	Bread	Ambient temperature	Goat skin
125 g wheat + 125 g water + 125 g 'lben' + 1 spt lemon juice	1%	Liquid	Bread	Ambient temperature	Glass jars
125 g wheat + 125 g water	32%	Stiff or dry or liquid	- Bread - "Harira" soup	- Stiff and liquid: ambient temperature - Dry: solar exposure	- Stiff: flour - Liquid: glass jars - Dry: raffia dish
125 g wheat +125 g water +125 g "lben"	12%	Liquid	Bread	Solar exposure	Clay jars
125 g wheat + 500 g water + 100 g barley + 100 g carob + 1 spt flax seed + 1 date	1%	Liquid	Bread	Ambient temperature	Glass jars
250 g wheat + 125 g water + 125 g barley + 2 date	3%	Stiff	Bread	Ambient temperature	Flour
250 g wheat + 125 g water + 1 garlic	1%	Stiff	Bread	Ambient temperature	Glass jars
125 g wheat + 2 dry beans + 250 g "lben"	3%	Liquid	Bread	Ambient temperature	Glass jars
250 g barley + 2 dry beans + 125 g water	6%	Stiff	Bread	Ambient temperature	Glass jars
125 g wheat + 125 g water + 1 spt yeas t+ 2 date + 125 g "lben"	1%	Liquid	Bread	Ambient temperature	Glass jars
125 g wheat + 125 g water + 2 dry beans + 125 g "lben"	5%	Liquid	Bread	Ambient temperature	Glass jars
125 g wheat + 125 g water + 125 g barley + 125 g semolina	1%	Stiff	Bread	Ambient temperature	Glass jars
125 g wheat + 2 date+ 250 g "lben"	2%	Liquid	Bread	Ambient temperature	Clay jars
125 g wheat + 125 g water + 125 g semolina	8%	Stiff	Bread	Ambient temperature	Glass jars
125 g wheat + 250 g water + 125 g barley + 3 dry fig	1%	Liquid	Bread	Ambient temperature	Glass jars
125 g wheat + 500 g water + 125 g barley + 15 dry grapes	1%	Liquid	Bread	Ambient temperature	Glass jars

traditional sourdough in bread making. An exclusion criterion is the use of dry yeast in this process. The questionnaire was completed with each woman in the household. Two main languages, Arabic and Tamazight, were used to collect information from the participants.
The questionnaire is designed to obtain information on:

Socio-demographic characteristics: ethnic origin, mother tongue (Arabic or Tamazight), locality of belonging (ksar) and duration of experience;

Traditional recipes of sourdough starter, type of cereal used in the kneading process, sourdough texture, fermentation conditions, fermentation time, storage utensils and storage temperature;

Profile of sourdough dishes provides information on the sensory profile and texture of wheat or barley bread and harira soup (local soup) subsequently by adding an appropriate and special type of sourdough depending on the recipe.

The main criterion used to categorize sourdough recipes as old and inherited traditional recipes is frequency of reference by the participants.

2.3 Statistical analyzes

Experimental data were subjected to analysis of the percentages and frequencies obtained, using simple descriptive statistical methods with Microsoft Office Excel 2007.
Ethical considerations: Participants were informed about the purpose of the study, the respect of data confidentiality, that their participation is voluntary and that they can leave the

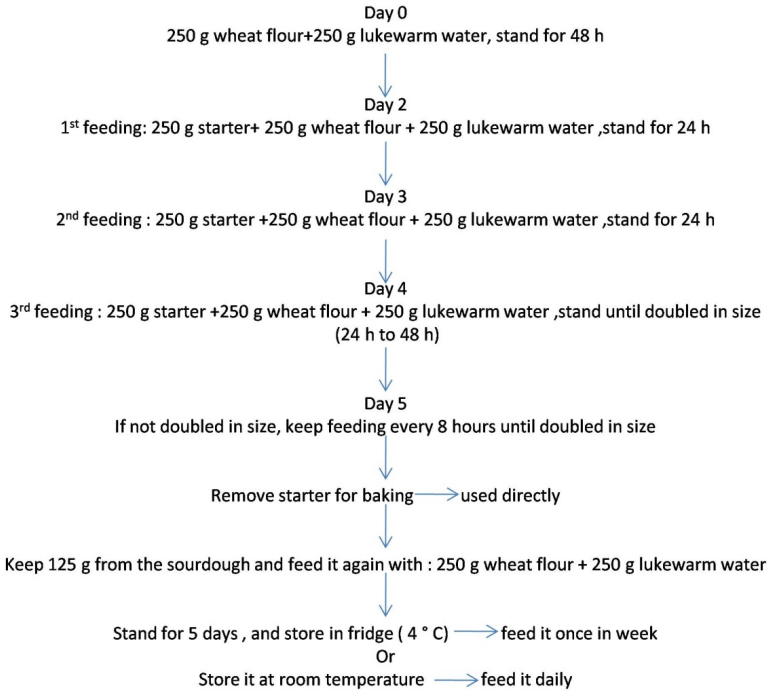

Figure 6: Common procedure adopted by women to make a sourdough chief

survey at any time if they wish. Formal consent was obtained before starting the survey.

3 Results and Discussion

3.1 Sociodemographic characteristics of the participants

The study focused on a total of 100 rural women aged 40 to 80 years old, corresponding to the age group characteristic of the study population that has enough knowledge and significant information on sourdough (Table 2).
As shown in Table 2, the majority of respondents were in the age group of 60 to 80 years representing 82 % of the study population, while 18 % had an average age of 45 years. The high percentage of older women testifies to the know-how inherited from old recipes of sourdough. Moreover, the diversity of these traditional recipes is part of a specific culinary custom and belongs to each ksar (locality) of the study area.

3.2 Origin of knowledge

The majority of the respondents (90 %) declared having acquired almost all of their information and methods of making sourdough by inheritance from their ancestors. Consequently, all the know-how is exclusively transmitted by the oldest members of the community (over 60), which proves that traditional food knowledge is monopolized by the elderly members of families.

3.3 Chronology of sourdough production

Main ingredients for the preparation of sourdough starter

The most popular recipes described by the rural women for the preparation of the sourdough

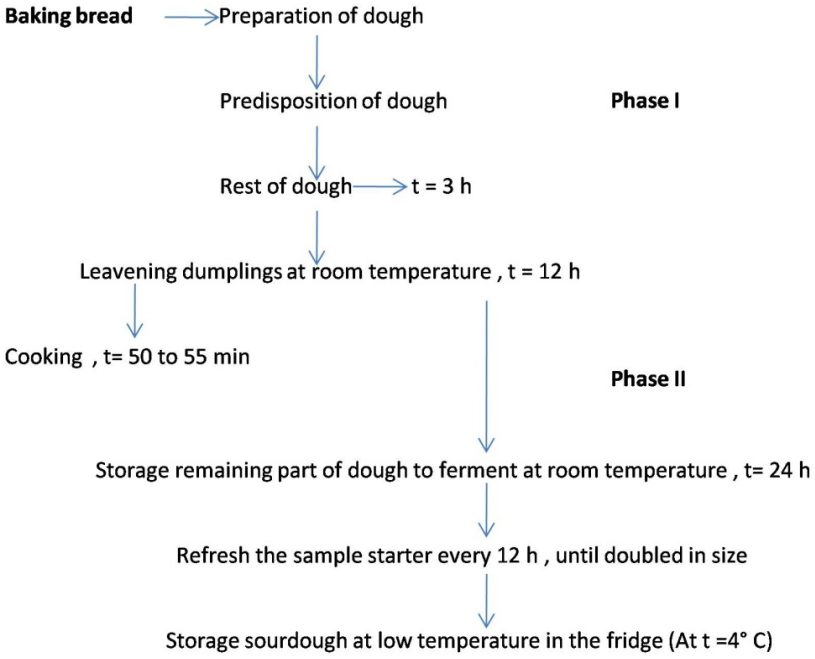

Figure 7: Baking protocol 1, adopted to create a sourdough starter

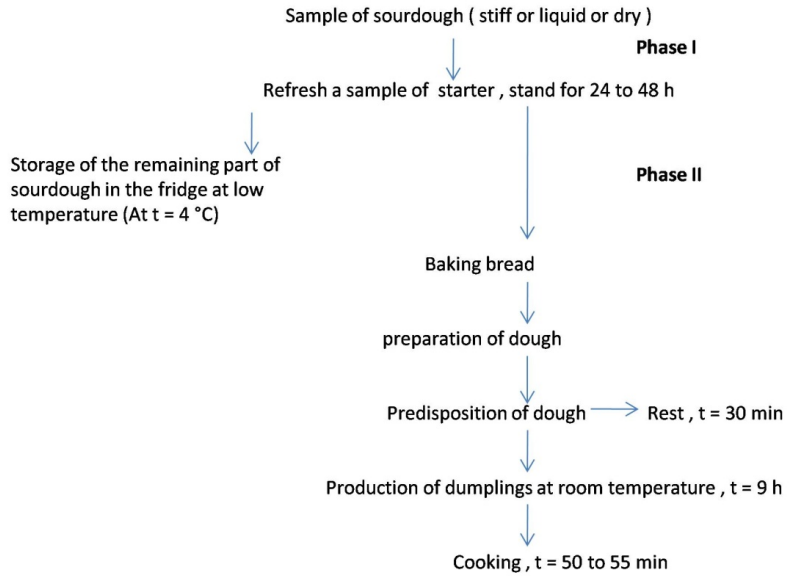

Figure 8: Baking protocol 2, adopted to create a sourdough starter

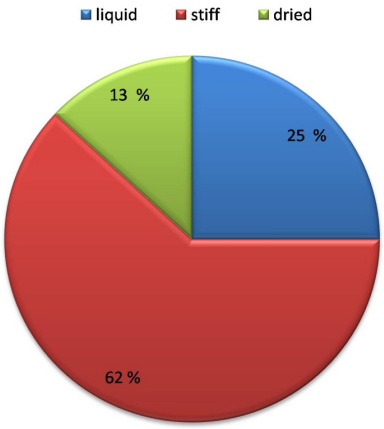

Figure 9: Final texture of sourdough starter

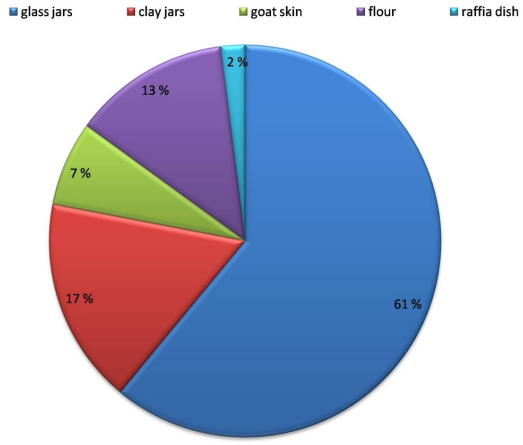

Figure 10: Types of utensil used to preserve different sourdoughs.

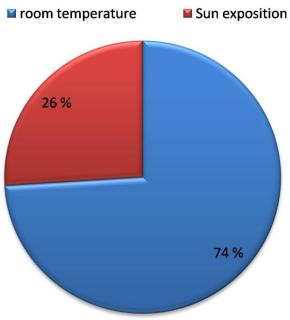

Figure 11: Incubation temperature according to the fermentation method of sourdough

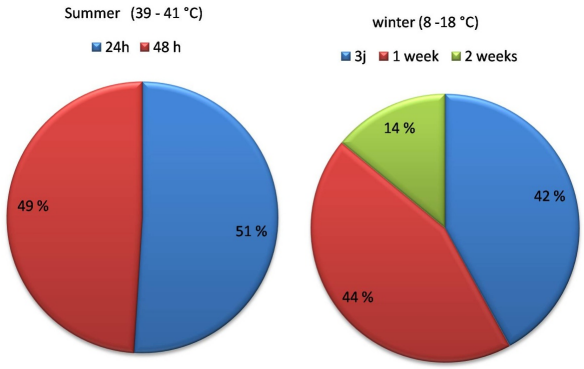

Figure 12: Incubation period according to climate change

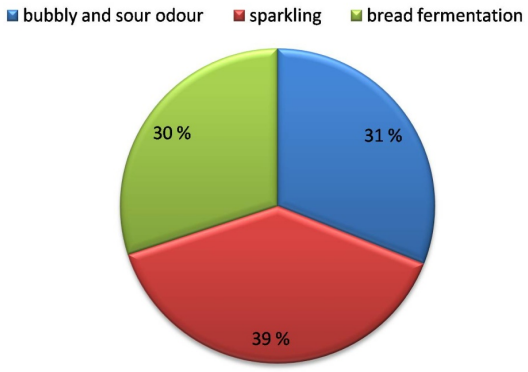

Figure 13: Markers of sourdough liveliness during the fermentation phase

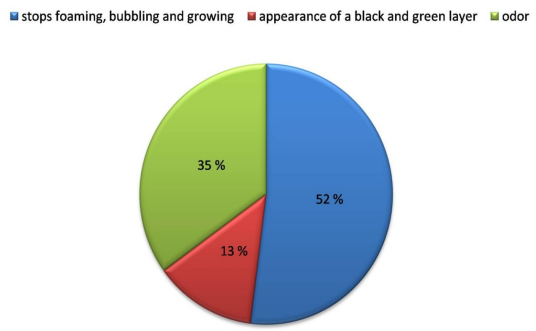

Figure 14: Markers of the death of the sourdough starter

starter are shown in Figures 4 and 5. The collected data comprises 17 different recipes (Table 3), revealing that whole wheat flour "Timzine" (90 %) is mixed with warm water (10 ^{o}C - 15 ^{o}C) in all recipes. However, some women prefer to include other ingredients such as barley flour "Irdan" (25 %), a variety of dates "Tayni" boufeggous (14 %) or whey "Aghi" (21 %) in the wheat/water mixture, to speed up the fermentation process, which varies depending on the season and the climate.

Initial manufacturing process of sourdough starter

After collecting all the recipes from the respondents, a common method of making the sourdough starter and two different protocols of bread baking were revealed. The process of making an initial sourdough starter is relatively long (at least 5 days), depending on the different combination ratios of the yeast and the bacteria existing in the initial whole flour/sourdough starter mixture (Corsetti & Settanni, 2007). To create the initial sourdough starter, the women combine a certain amount of flour with warm water and sometimes a specific local ingredient, to enhance the texture and accelerate the fermentation process.
As shown in Fig. 6 a-c, the current and basic procedure for each woman differs only in the conditions of the fermentation phase (time, temperature and storage condition).

All the prescribed recipes are based on the use of whole wheat or whole barley, or any other type of local ingredients as shown in Table 3.

Sourdough texture

The final texture of the sourdough starter (Figure 9) is determined by the mixture of the ingredients used and the fermentation conditions and time (Figures 10 to 12), and these also determine the viscosity, total acidity and microbiota composition of the final sourdough.
The majority (62 %) of respondents prefer to prepare pasty sourdough, while 25 % favor a liquid texture and 13 % would rather prepare a dry sourdough. Once the process is carried out and the mixture is homogenized, the sourdough is immediately transferred to utensils of different shapes and sizes, mainly in glass jars (61 %) "boukala" but also in clay jars "Taklilte" (17 %) or flour "Aren" (13 %). Then, the preparation is incubated at room temperature (74 %) or sometimes exposed to the sun (26 %) for a period varying between 24 hours (44 %) and a week (42 %). This period can sometimes be longer depending on the season and climate (14 %).

Characteristics of liveliness and stoppage in the fermentation phase of sourdough

Once the sourdough is established, successful fermentation and growth are noticeable in different aspects of sourdough liveliness. According to women, a sourdough is very active and ready to be used as soon as it becomes very foamy or very sparkling (39 %), or if it starts to smell sour (31 %) or when it has an active aspect during bread fermentation (30 %) (Figure 13).
However, 52 % of the women reported that their sourdough does not progress at all (stops foaming, bubbling and rising), while 35 % noted the release of an unusual and unbearable smell. 13 % said that their sourdough forms a green or black layer on the surface because of contamination by harmful bacteria. The appearance of one or the combination of all these markers at the same time indicates the death of the sourdough starter (Figure 14).

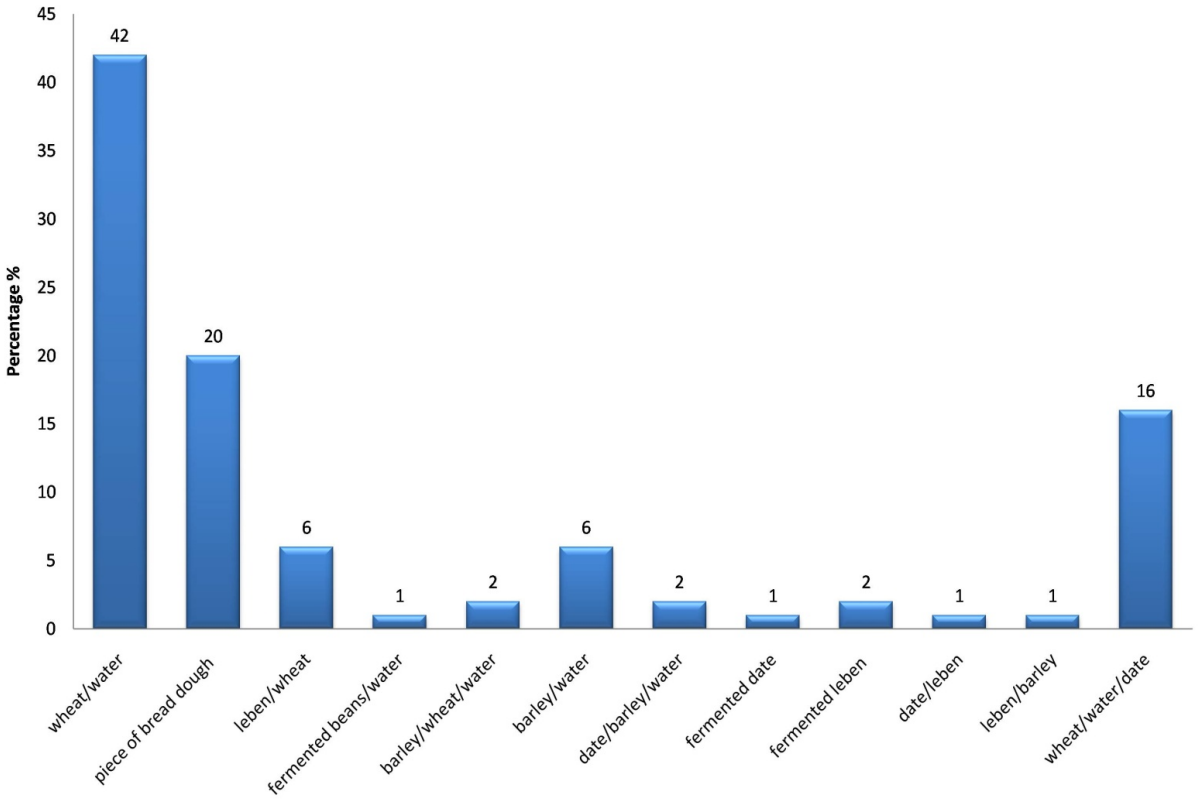

Figure 15: Ingredients used daily or weekly to feed a sourdough chief

Main sourdough "Tamtount"

The term "Tamtount" is used to refer to the final sourdough in the Amazigh language. Once the sourdough is ready, it takes the nomination "main sourdough" (sourdough chief), which must always be fed and refreshed before each kneading to control its sour aspect. 42 % of the study women prefer to refresh their sourdough by adding the same quantities of warm water and flour, depending on how much bread they want to make. However, some women preferred to boost their sourdough with added dough (20 %) or a mixture of wheat, dates and water (16 %). Others preferred to use fermented leben and wheat (6 %) or a mixture of barley and water (6 %) which slightly activates the drowsy sourdough (Figure 15).
At the end of the sourdough-making process, the final volume doubles and the sourdough chief has a very acidic taste, low pH level and a light to dark brown color. Some of these sourdoughs will go through a drying phase for several days in the open air. The dried sourdough obtained is then ground and stored dry at room temperature, while the liquid and stiff sourdough is most often stored cold.

4 Conclusions

This research describes 17 sourdough recipes collected from seven ksour (localities) in the province of Figuig. The data obtained shows that local ingredients are also integrated into the main recipes of sourdough, to accelerate the fermentation process and create a special flavor according to each respondent's recipe. The generated data has created a database on the diversity of sourdoughs and can help safeguard traditional

knowledge about sourdoughs and the different ingredients used as well as the different stages of sourdough preparation and methods of sourdough refreshing.

The results of this study were obtained from rural kneaders in one of the Amazigh regions of Morocco. The data reveals different sourdough recipes for traditional meal preparations such as the famous Moroccan soup "harira" or the traditional Amazigh bread "aghroum". These data also show that these inherited recipes and methods are exclusively known to the oldest members of the family and passed on to younger generations to be saved from extinction.

An analysis of the composition of these sourdoughs according to bacterial microbiota and the determination of their microbiological activity as well as their antioxidant activity would be an important subject of research to further understand the contribution to the improvement of the quality of bread as reported in the literature. The main objectives would be to translate this traditional oral culinary knowledge and heritage into scientific knowledge and, provide invaluable micro and macronutrient compounds of sourdough bread to develop a new food system against health problems such as celiac disease, diabetes and hypercholesterolemia.

Acknowledgements

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References

Carbonetto, B., Nidelet, T., Guezenec, S., Perez, M., Segond, D., & Sicard, D. (2020). Interactions between *Kazachstania humilis* yeast species and lactic acid bacteria in sourdough. *Microorganisms*, *8*(2), 240. https://doi.org/10.3390/microorganisms8020240

Chafi, A., Benabbes, R., Bouakka, M., Hakkou, A., Kouddane, N., & Berrichi, A. (2015). Pomological study of dates of some date palm varieties cultivated in Figuig oasis. *J. Mater. Environ. Sci.*, *6*(5), 1266–1275. https://www.jmaterenvironsci.com/Document/vol6/vol6_N5/149-JMES-1385-2015-Chafi.pdf

Corsetti, A., & Settanni, L. (2007). Lactobacilli in sourdough fermentation. *Food Research International*, *40*(5), 539–558. https://doi.org/10.1016/j.foodres.2006.11.001

Galimberti, A., Bruno, A., Agostinetto, G., Casiraghi, M., Guzzetti, L., & Labra, M. (2021). Fermented food products in the era of globalization: tradition meets biotechnology innovations. *Current Opinion in Biotechnology*, *70*, 36–41. https://doi.org/10.1016/j.copbio.2020.10.006

Galle, S., Schwab, C., Arendt, E., & Gänzle, M. (2010). Exopolysaccharide-forming weissella strains as starter cultures for sorghum and wheat sourdoughs. *Journal of Agricultural and Food Chemistry*, *58*(9), 5834–5841. https://doi.org/10.1021/jf1002683

García, M., Esteve-Zarzoso, B., Cabellos, J. M., & Arroyo, T. (2018). Advances in the study of *Candida stellata*. *Fermentation*, *4*(3), 74. https://doi.org/10.3390/fermentation4030074

Gobbetti, M., Rizzello, C. G., Di Cagno, R., & De Angelis, M. (2014). How the sourdough may affect the functional features of leavened baked goods. *Food Microbiology*, *37*, 30–40. https://doi.org/10.1016/j.fm.2013.04.012

Hellborg, L., & Piškur, J. (2009). Yeast diversity in the brewing industry. In V. R. Preedy (Ed.), *Beer in health and disease prevention* (pp. 77–88). Elsevier. https://doi.org/10.1016/B978-0-12-373891-2.00007-9

Hui, Y. H., Meunier-Goddik, L., Josephsen, J., Nip, W.-K., & Stanfield, P. S. (Eds.). (2004). *Handbook of food and beverage fermentation technology* (Vol. 134). CRC Press. https://doi.org/10.1201/9780203913550

Kaditzky, S. B., Behr, J., Stocker, A., Kaden, P., Gänzle, M. G., & Vogel, R. F. (2008). Influence of pH on the formation of glucan by *Lactobacillus reuteri* TMW 1.106 exerting a protective function against extreme pH values. *Food Biotechnology*, *22*(4), 398–418. https://doi.org/10.1080/08905430802470235

Katina, K., Maina, N. H., Juvonen, R., Flander, L., Johansson, L., Virkki, L., Tenkanen, M., & Laitila, A. (2009). In situ production and analysis of *Weissella confusa* dextran in wheat sourdough. *Food Microbiology*, *26*(7), 734–743. https://doi.org/10.1016/j.fm.2009.07.008

Katsi, P., Kosma, I. S., Michailidou, S., Argiriou, A., Badeka, A. V., & Kontominas, M. G. (2021). Characterization of artisanal spontaneous sourdough wheat bread from central Greece: evaluation of physico-chemical, microbiological, and sensory properties in relation to conventional yeast leavened wheat bread. *Foods*, *10*(3), 635. https://doi.org/10.3390/foods10030635

Lau, S. W., Chong, A. Q., Chin, N. L., Talib, R. A., & Basha, R. K. (2021). Sourdough microbiome comparison and benefits. *Microorganisms*, *9*(7), 1355. https://doi.org/10.3390/microorganisms9071355

Mannaa, M., Han, G., Seo, Y.-S., & Park, I. (2021). Evolution of food fermentation processes and the use of multi-omics in deciphering the roles of the microbiota. *Foods*, *10*(11), 2861. https://doi.org/10.3390/foods10112861

Marsh, A. J., Hill, C., Ross, R. P., & Cotter, P. D. (2014). Fermented beverages with health-promoting potential: past and future perspectives. *Trends in Food Science and Technology*, *38*(2), 113–124. https://doi.org/10.1016/j.tifs.2014.05.002

Pasqualone, A. (2018). Traditional flat breads spread from the fertile crescent: Production process and history of baking systems. *Journal of Ethnic Foods*, *5*(1), 10–19. https://doi.org/10.1016/j.jef.2018.02.002

Rühmkorf, C., Rübsam, H., Becker, T., Bork, C., Voiges, K., Mischnick, P., Brandt, M. J., & Vogel, R. F. (2012). Effect of structurally different microbial homoexopolysaccharides on the quality of gluten-free bread. *European Food Research and Technology*, *235*(1), 139–146. https://doi.org/10.1007/s00217-012-1746-3

Stefan, N., & Häring, H. U. (2013). The role of hepatokines in metabolism. *Nat Rev Endocrinol*, *9*, 144–152. https://doi.org/10.1038/nrendo.2012.258

Tieking, M., & Gänzle, M. G. (2005). Exopolysaccharides from cereal-associated lactobacilli. *Trends in Food Science and Technology*, *16*(1-3), 79–84. https://doi.org/10.1016/j.tifs.2004.02.015

Yauo, N. (2012). *L'architecture de l'oasis, respect de l'environnement et développement durable: cas de l'oasis de Figuig* [Master thesis]. Faculté des Sciences et Techniques Settat.

Zameitat, E., Pierik, A. J., & andMonika Löffler, K. Z. (2007). Dihydroorotate déshydrogénase de *Saccharomyces cerevisiae*: Des investigations spectroscopiques avec l'enzyme recombinante éclairent les propriétés catalytiques et le métabolisme des analogues du fumarate. *FEMS Yeast Res*, *7*, 897–904. https://doi.org/10.1111/j.1567-1364.2007.00275.x

Zhang, G., Qi, Q., Sadiq, F. A., Wang, W., He, X., & Wang, W. (2021). Proteomic analysis explores interactions between *Lactiplantibacillus plantarum* and *Saccharomyces cerevisiae* during sourdough fermentation. *Microorganisms*, *9*(11), 2353. https://doi.org/10.3390/microorganisms9112353