TECHNOLOGICAL QUALITY OF SPELT WHEAT AND ENVIRONMENTAL IMPACT OF SPELT WHEAT GROWING

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Abstract- The work deals with the baking quality of the spelt wheat grain (Triticum spelta L.). The technological quality of spelt flour was analysed, focusing on standard evaluation methods (protein content, characteristic of gluten). The bread wheat grain was used too and compared with the spelt wheat (Triticum aestivum L.). The analysis was supplemented by complete rheological analysis made by MIXOLAB II. The work also involves an assessment of impact the spelt wheat and bread wheat growing have on the environment, how much greenhouse gases emissions they produce etc. The LCA method has been used there. The results were statistically analysed with STATISTICA 9.1 (StatSoft, Inc., USA). It has been proved that the spelt flour can provide cereal products with higher nutritional value. From a technological point of view, the results have shown that the spelt grain is suitable for baking. Higher protein content and higher resistance of kneading of the dough and starch gelatinization rate, which were statistically confirmed by Tukey HSD test areits advantages. The other benefit of spelt grain is its higher nutritional value compared with common wheat grain. The environmental burdens of organic spelt wheat growing are slightly heavier compared with bread wheat growing. It is caused by a difference in the yield rate. However, substituting the conventional bread wheat for the organic spelt wheat, we can guarantee higher nutritional and technological quality, and the environmental savings as well (the spelt wheat growing generates less greenhouse gases emissions).

Keywords- Spelt wheat; Technological quality; Greenhouse gases emissions; LCA.

I. INTRODUCTION

Cereals are the most common agricultural crops. They are grown worldwide. Wheat is ranked among the most significant crops, as we take the human caloric intake into account. As far as we need to reconsider more aspects of the agricultural and food products(besides the nutritional, health and technological parameters), we also take their impact on the environmental sustainability into account, [1] and the food consumption patterns in particular [2]. Searching for good alternatives to the intensive growing of crops, we also have to reconsider the above mentioned parameters and aspects in case of less frequent crops and the extensive agriculture as well.Spelt wheat is supposed to be a good alternative to bread (common) wheat. The spelt wheat grains are composed of more proteins than the bread wheat ones (13–20%). They contain more or less the same amino acids [3]. In spite of the fact they are composed of a lot of proteins, their grainsare suitable for malt and beer production [4]. Reference [5] noticed a difference in E-vitamin content. The spelt wheat grainsalso contained more zinc [3]. Reference [6] described high baking quality of the spelt wheat in their study, in spite of the fact the spelt wheat gluten was weaker and the spelt wheat dough had worse rheological qualities than the bread wheat dough [7]. Therefore, a mixture of spelt wheat flour and bread wheat flour is supposed to be the best option for baking. It also makes the production cheaper, as the spelt wheat flour is more expensive than the bread wheat flour. Besides the food parameters, we also have to assess the environmental impact of various crops growing and various agricultural systems. There are several appropriate methods [8] that help us study and assess the environmental impacts of agriculture, e.g. Life Cycle Assessment (LCA), Ecological Footprint (EF) or Emergy Analysis (EA) [9], [10]. The LCA method is suitable for assessment of the environmental impact of agriculture, as confirmed by references [11] and[12]. According to [13], the sustainability of system and the environmental impacts of system can be monitored and evaluated via outputs and outcomes. They are re-counted and converted to CO_2e. The LCA method is suitable for the assessment of growing of agricultural crops, recalculation and conversion of the greenhouse gases emissions to the production unit (not only the area unit). It allows us to compare the environmental impacts of the food production (we can use specific crops and take various systems of agriculture into account).

II. DETAILS OF THE EXPERIMENT

The spelt wheat and the bread wheat grains originated from the organic farming. According to Kjeldahla – (ICC 105/2), we counted nitrogen content in grains. We also counted wet gluten content (ICC 137/1), Zelenyho sedimentation test values (ICC 116/1) and Falling number (ICC 107/1). The rheological characteristics and dough features were indicated (we used theMixolab II instrument) (ICC 173).
In order to count the emission burden, we used figurestheprevious experiments had generated. These were the figures which were generated during small-plot trials run by the Faculty of Agriculture, University of South Bohemia. We also used figures generated during the trials at the reference operational

and semi-operational stations. We chose yield parameters of 50 Czech agricultural organisations and added them to it. In the framework of the LCA method (Klima impact category), a life cycle of the organic spelt wheat, the organic bread wheat and the conventional bread wheat were simulated with the SIMA Pro software (ReCiPe Midpoint (H) Europe method) (the spelt wheat is rarely grown in the conventional farming system). One kg of grains was set as a functional unit. The calculation referred to the farm stage (field emissions, seeds, fertilizing, pesticides, and agro-technological operations). The elementary data generated by the small plots and farms were extracted from the Ecoinvest database, partial processes were modified and adopted to conditions in the Czech Republic. Burden was expressed in CO_2e : CO_2e = 1x CO_2 = 23x CH_4 = 298x N_2O. Data were processed by the Statistica 9.0 (StatSoft. Inc., Tulsa, USA) program.

The comparison of both species and their division into statistically different categories were provided by the Tukey HSD test.

III. RESULTS AND DISCUSSION

Table 1 shows a summary of all the baking quality parameters. As far as both the wheat species are concerned, high values of falling number were measured and recorded. It is an indicator of grain starch damage caused by pre-harvest spike sprouting. The measured and recorded figures are very high (they have exceeded the norm substantially) and may have a negative effect on the volume of baking products and the sensory assessment of bread [14]. Gluten index (GI) indicates tough and flexible gluten. Higher values are better for the mechanical dough processing. The bread wheat reaches higher values there. From the statistical point of view, there is a difference between the spelt wheat and the bread wheat. There is a minimum difference between them in the Zelenyho test results. The swelling capacity of proteins is almost the same (statistically significant trend in 95%, according to the Tukey HSD test).

Wet gluten content is closely connected with protein content in grain [15]. The spelt wheat usually reaches higher values. From the statistical point of view, there is a difference between a sample of bread and spelt wheat. Assessment of individual protein fractions would also be very important there (it could indicate the technological parameters and the nutritional quality as well). According to the other authors and the experience they have gained (e.g. [16]), there are more proto-plasmatic protein fractions in the spelt wheat grains (more nutritionally valuable albumins and globulins). There are more spectres of prolamins in the bread wheat grains (they have a positive effect on the technological quality – e.g. higher figures of Gluten index – see Table 1). On the other hand, such protein fractions provoke toxicity of wheat for people suffering from celiac disease[17].

Table1: Elementary parameters of the baking quality (two-repetition mean)

Wheat species	Falling number (s)	GI	Wet gluten	Zeleny test (ml)	Protein content (%)
Spelt wheat	585b	52a	43.8b	11.0a	14.84b
Bread wheat	514a	73b	33.1a	12.0b	12.55a

Remark: Values indicated by the same letter do not indicate any statistically significant difference (on the significance level) $P < 0.05$ (Tukey HSD test).

The theological characteristics of dough were analysed with Mixolab II. It provides a complete assessment of rheology (behaviour) of dough during the baking processing (Papoušková et al., 2011). A strength of dough (rising capacity and ability to retain "rising" gas in it – the rising is provoked by yeast cells and produces CO_2) were assessed there. This analysis via Mixolab II also involved an assessment of starch quality [19]. Starch becomes an oily substance and it degrades in the end.

Our results have shown (see Table 2) a greater strength of the spelt wheat flour (dough develops longer). There was no difference in a dough flexibility (an amplitude) between the spelt and bread wheat flour. The spelt wheat flour was very stable, the bread wheat flour was not as stable as the spelt wheat one. It means the spelt wheat dough must be processed and kneaded more intensively [20]. The rheological characteristics of bread wheat flour were slightly worse in all the C2–C5 parameters. It is more difficult to make gel of the bread wheat flour. The bread wheat flour gel is less stable as well (a hot gel). The bread wheat flour retro-gradation values are also slightly lower. In case of α directive (C1-C2), there was a minimum difference in a speed of protein moderation when proteins were heated. The results have shown the spelt wheat baking technology (temperature of baking) should be similar. There was a difference in the speed of starch gelatinization (directive β - C3–C4). The spelt wheat flour starch gelatinized more slowly. Dough needs to be baked more slowly and in lower temperature in the next stage. Enzymes in the spelt wheat flour degrade at a lower speed (Directive γ - C5–C4). Reference [21] state the spelt wheat dough has worse rheological characteristics compared with the bread wheat dough. At the same time, the reference [21] state the rheological characteristics of baking products get better if we put less spelt wheat flour in them. Reference [22] confirm the fact and state less proteins have a negative effect on stability of dough (dough becomes less stable if we put less proteins in it).

Table2: Detailed results of the individual analysescarried out with Mixolab II (parametersof the dough rheology)

Wheat species	C1	Amplitude	Stability	C2	C3
	min	Nm	min	Nm	Nm
Spelt wheat	2.72a	0.07a	6.99b	0,396b	1.6605a
Bread wheat	3.07a	0.055a	4.05a	0,3645a	1.5585a
Wheat species	C4	C5	α	β	γ
	Nm	Nm	Nm	Nm	Nm
Spelt wheat	1.5235a	2.471a	-0.076a	0.652b	0.001ab
Bread wheat	1.427a	2.1585b	-0.069a	0.3ab	-0.024a

Remarks: Values indicated by the same letter do not indicate any statistically significant difference (on the significance level) $P < 0.05$ (Tukey HSD test).

Time for C1 (min)	Dough development period. The stronger the flour is, the longer the period of dough development is (time needed for reaching C1).
Amplitude (Nm)	Dough flexibility. The higher the valueis, the more flexible the flour is.
Stability (min)	Resistance of dough against excessive kneading. The longer the period is, the stronger the flour is supposed to be.
C2	It indicates weak proteins being a function of the mechanical work and temperature.
C3	It indicates gel structure of starch.
C4	It indicates stability of hot gel.
C5	It indicates retro-gradation of starch in the cooling stage.
Directive α (C1–C2)	How fast proteins weaken if we heat them.
Directive β (C3–C4)	How fast starch gets oily.
Directive γ (C5–C4)	How fast enzymes degrade.

The results of LCA assessment of the emission burden of the spelt and bread wheat growing have shown the organic spelt wheat growing produces slightly more emissions (0.385067 CO_2e /1 kg of seeds)compared to the organic bread wheat (0.363064 CO_2e /1 kg of seeds), as the spelt wheat yield rate is lower. Anyway, in both cases, the recorded figures are much lower compared to the conventional bread wheat (0.460560 CO_2e /1 kg of seeds). The main difference between the organic and conventional system lies in a fertilizing technique. Synthetic fertilizers (mostly nitrogenous ones) which are used in the conventional system of farming produce much more emissions of CO_2e. We are following a contrary trend in agro-technological operations. The conventional system produces less CO_2e emissions per kg of seeds (because of lower yield rates of the organic farming system). See Table 3 for partial values reached in individual field stages.

Table3: CO2e emissionsper 1 kg of seedsof particular cereals grown under the conventionaland organic farming conditions

	Field emissions	Fertilizers	Seeds	Agrotech. operations	Pesticides	**Total**
Conv. bread wheat	0.137781	0.221072	0.022981	0.077736	0.000991	**0.460560**
Org. bread wheat	0.160154	0.059424	0.030327	0.113159	0	**0.363064**
Organic spelt wheat	0.169860	0.063025	0.032165	0.120017	0	**0.385067**

CONCLUSIONS

Cereal products with higher added value can be made with the spelt wheat flour. The results of our research have shown that, from the technological point of view, the spelt wheat grains are suitable for baking. It has been confirmed by classical methods of assessment of the baking quality, and the complete rheological analysis carried out with the Mixolab II instrument. The spelt wheat grains have higher nutritional value than the bread wheat ones (which is another advantage of the spelt wheat). The emission burden produced during the organic spelt wheat growing does not differ from the bread wheat one too much. If we substitute the conventional bread wheat for the organic spelt wheat, we gain higher technological and nutritional value and better and positive environmental impact, as we produce less emissions.

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