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INFLUENCE OF SCREEN MESH SIZE OF HAMMER MILL AT DIFFERENT WHEAT MOISTURE

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Abstract

The study focused on evaluation of the influence of moisture content of wheat (independent on wheat cultivar and screen mesh size) on grinding outcomes. Four Iraqi wheat cultivars, two hard Iraqi cultivars (Wahat Al-Iraq *W1*, Um Al-Rabeain *W2* and two soft Iraqi cultivars (Abugraib *W3* and Al-Forat *W4*) were used. Grinding experiments were carried out on a laboratory hammer mill at seven different moisture levels. i.e. 8, 10, 12, 14, 16, 18, and 20% (wet basis) and three screen mesh sizes: 1.0, 2.0 and 3.0 mm. The mill was equipped with a computer system to record grinding energy consumption. The Mastersizer 3000 (laser diffraction method) was used to estimate the mean particle size and surface specific of ground material. Higher values of energy consumption and mean particle size for hard wheat cultivars compared with soft wheat cultivars. When moisture content increased. The parameters of specific surface and grinding ability index had been decreased in condition of experiment. The statistical analyses showed clear differences for all grinding tests results while using the selected screen mesh sizes.

Keywords **:** Wheat, hammer mill, screen size, mastersizer 3000.

Introduction

Wheat crop is the most important crop in Iraq. The wheat production of the Iraq in 2018 was 2177885 ton according to I.A.S.C. (2018). The wheat crop consider main human food and involve in many food industries. Also the residues of wheat grains are used as animal fodder. There are many physicals properties which limit the quality of the outcome wheat grinding process and the efficiency of grinding machine.

Both Evers & Millar, (2002) and Andrew, (2010) revealed that wheat hardness is one of the main wheat properties determining the end-product quality. Endosperm's structure cause the differences in mechanical properties between hard and soft wheat. The endosperm particles consisting of entire cells commonly having fractions of cell wall linked, proposing that the cell contents played a superior role in keeping cell integrity than the walls. A hard wheat has weak cohesion along the cell walls and strong internal adhesion, while that for soft wheat has strong cohesion along the cell walls and weak cohesion internally (Greer & Hinton, 1950; Andrew, 2010). Soft wheat endosperm has a greater and more variable porosity than hard wheat endosperm. Soft wheat whets tend to break along the (weaker) starch–protein interface. In hard wheat, with greater adhesion at the starch–protein interface, breakage occurs preferentially along cell boundaries and the impact of the (lower) porosity is negligible (Osborne & Anderssen, 2003; Andrew, 2010).

The most important characteristics of wheat in milling process is Fracture behavior, and it noticeably controls how a particular wheat variety is milled. The milling of wheat is an important step in wheat processing for both food and non-food purposes. The selection of appropriate method depends on the way of wheat use. The most common way of wheat kernel size reduction is the gradual reduction and separation process during milling (Dziki *et al.*, 2014). Hence, the primary objective of the process is to isolate the endosperm without contamination by the outer parts of the grain and the germ.

In case of milling, brittle fracture is the preferred mechanism as it gives quick crack propagation with little permanent deformation of the surrounding material, producing sharp, angular fragments. Ductile rupture deforms the material irreversibly before failure, giving highly deformed, misshapen and irregular fragments. Large particles will fracture by crack initiation and by brittle fracture, while small particles can break only as the result of plastic deformation and rupture. Vitreous endosperm has been shown to have higher fracture toughness than mealy endosperm in a single wheat cultivar. Fracture toughness was shown to decrease from the outside of grains and increase again towards the central crease. Soft and hard wheat exhibit the same toughening effect with an increase in water content, however, at different rates. Hard wheat has a more linear response between the physical strength and water content than soft wheat (Dobraszczyk, 1994; Delwiche, 2000). Soft wheat tends to exhibit only elastic strain, without plastic phase, and can be considered to be brittle with regard to failure, whereas hard wheat always exhibits plastic deformation and experience ductile failure. The aim of the present work was to expected to help for a better explanation and understanding of interaction between properties of materials and grinding machine for a better process efficiency.

Material and Methods

Material selection

The experiment was contacted using different endosperm types, two hard soft Iraqi cultivars (Wahat Al-Iraq W_1, Um Al-Rabeain W_2 and two soft Iraqi cultivars Abugraib W_3, Al-Forat W_4. They were brought at the end of season 2018.

Moisture determination

The initial moisture content of a batch sample of wheat kernels was determined using the air oven method. Three samples of grains (5 g for each sample) were dried for 2 hours at the temperature of 130°C, in the accordance to ET ISO 712: 2001. Seven various levels of wheat moisture content, i.e. 8, 10, 12, 14, 16, 18 and 20% (wet basis) were assigned in the experimental plan. The watered samples were stored in refrigerator for more than 48 hours before grinding tests.

Grinding process

Grinding experiments were carried out using a laboratory hammer mill. The mill is equipped with a computer system which allowed grinding energy consumption to be recorded by a special software. The experiments were performed at different three screen mesh levels: 1, 2 and 3 mm. For each sample, five measurements were achieved. The ground samples were submitted to the analysis by laser diffraction method for particle size distribution. Mastersizer 3000 laser analyser by Malvern Instruments Ltd, Worcestershire, UK was used in the analysis. Time of each was set at 20 s. For each cultivar of wheat, moisture content, and mesh screen size, three samples were examined. The mean value of the parameters were estimated from 15 replications. Based on the volumetric distribution of particles, mean particle size (P_s in μm) and specific surface of particles (S_{sp} in m^2/kg) were calculated. Both mean particle size and surface specific were determined automatically by using Malvern software. For calculations of the specific surface, the true density of wheat (1.3 g/cm^3) was used (Gürsoy & Güzel, 2010). In order to connect the grinding energy expenditures with the resulted distribution of particles, a grinding ability index (GA) was determined from the following equation:

$$GA = \frac{S_{sp}}{E_{sp}} \ [\ m^2/kJ] \quad (3)$$

where: S_{sp} – specific surface of ground particles in m^2/kg, and E_{sp} – specific grinding energy in kJ/kg.

Statistical analyses

Experimental data were analyzed using Statistical, Dell Inc. (2016) version 13. Tukey's test, were used to estimate the significant differences in order to compare the means of parameters at 0.05 level (p<0.05)

Results and Discussion

Figures 1,2,3,4 show the effect of moisture content of wheat on grinding results, including, the specific energy consumption (E_{sp}), mean particle size (P_s), specific surface (S_{sp}) and grinding ability index (GA). As the moisture content increased from 8 to 20%, the specific energy consumption also increased from about 72.4 to 115.5 kJ/kg. This was also followed by an increase in the mean particle size from 428.9 to 552 μm and a decrease in the specific surface from 62.4 to 58.5 m^2/kg. The grinding ability index declined considerably from 0.93 to 0.56 m^2/kJ. Statistical differences between means of each moisture levels were calculated by applying Tukey procedures and their results are shown in the figure. The corresponding relation was described by means of a square polynomial equation with high determination coefficient (0.990, 0.994, 0.984 and 0.995 for the specific energy consumption, mean particle size, specific surface, and grinding ability index respectively). The above effects are caused by the increased plasticity of kernels at high moisture content, which leads to an increase in the grinding energy consumption (Dziki *et al.*, 2014; Al Aridhee & Łysiak 2018).

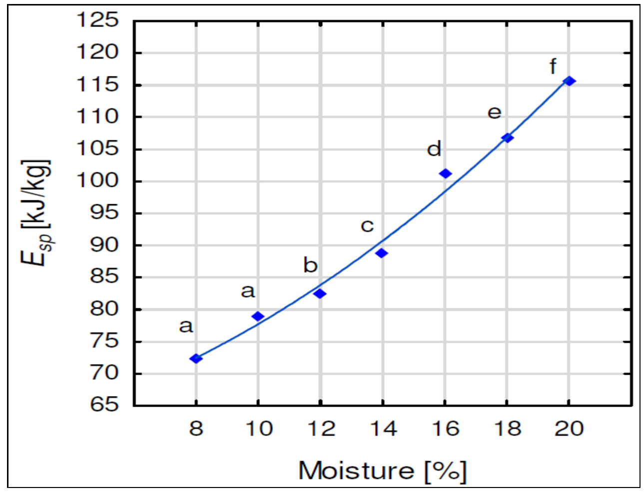

Fig. 1 : Influence of wheat moisture content on the specific energy consumption

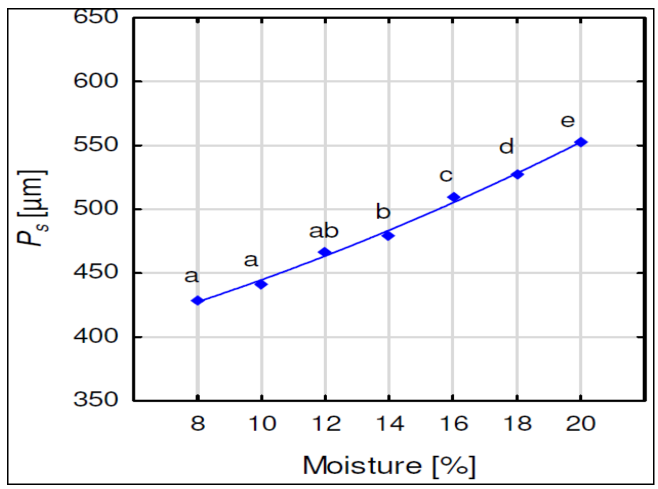

Fig. 2 : Influence of wheat moisture content on the mean particle size

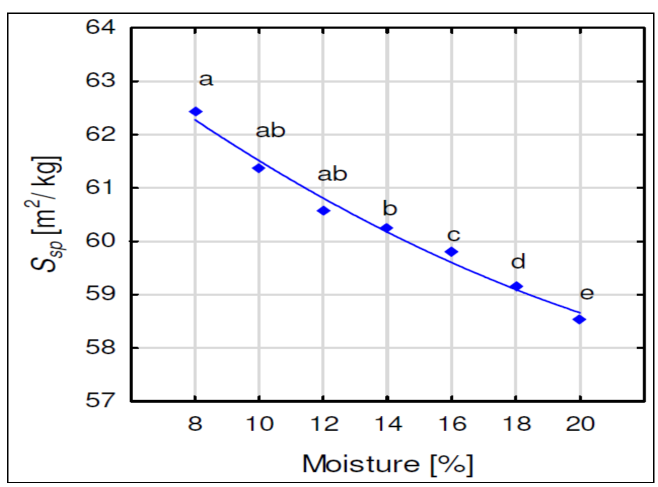

Fig. 3 : Influence of wheat moisture content on the specific surface

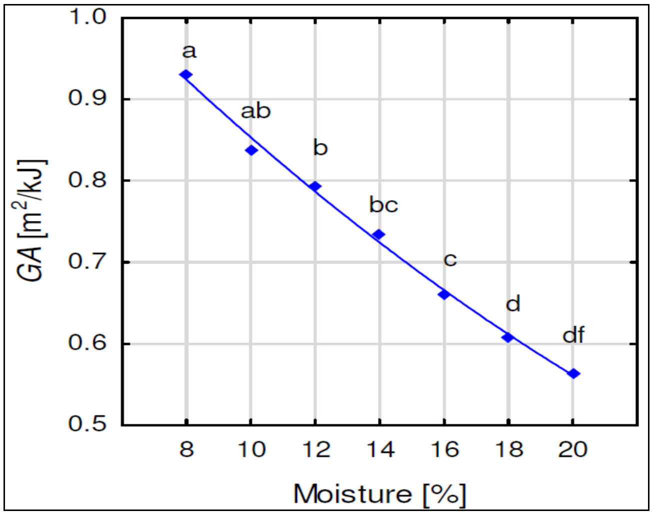

Fig. 4 : Influence of wheat moisture content on The grinding ability index

The effect of screen mesh size levels on the grinding outcome is demonstrated in Figures 5,6,7,8. The results showed that the increase in the size of screen resulted in a linear decrease in the specific grinding energy from 117.8 to 60.2 kJ/Kg. However, the size of particles increased significantly. The mean particle size changed from about 344.8 to 665.6 µm. At the same conditions, the value of specific surface decreased from about 63.2 to 57 m^2/kg. Finally, the grinding ability index was higher for larger screens a mostly 0.56, 0.64 and 0.98 m^2/kJ for screens size 1, 2 and 3 mm respectively. Significant differences among means of all grinding parameters with applied screens size were confirmed. The results are illustrated in the Figures 5,6,7,8. The corresponding relations were described by means of a square polynomial equations with high determination coefficient (0.999, 0.999, 0.999 and 0.999 for the specific energy consumption, mean particle size, specific surface, and grinding ability index respectively).

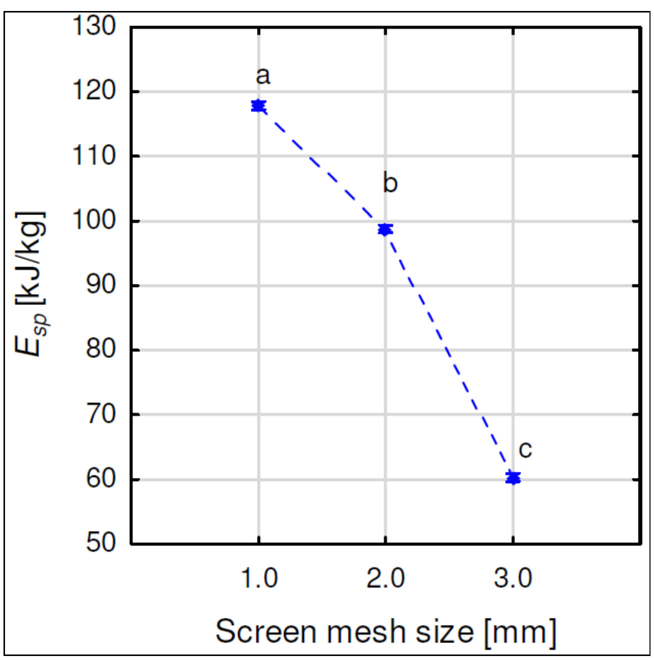

Fig. 5 : Influence of screen mesh size on the specific energy consumption

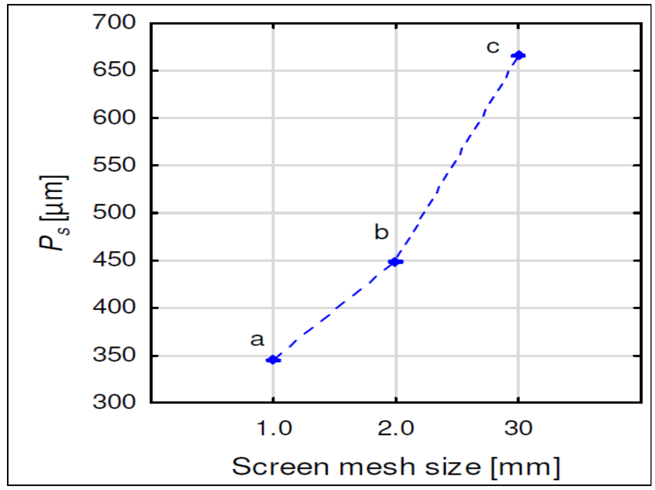

Fig. 6 : Influence of wheat moisture content on the mean particle size

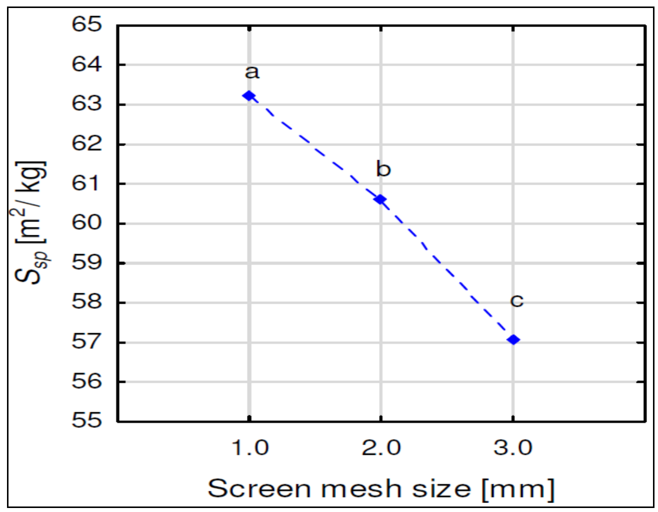

Fig. 7 : Influence of wheat moisture content on the specific surface

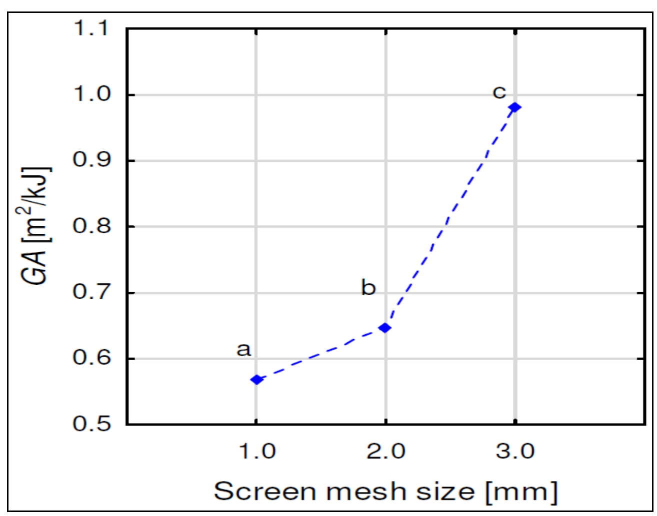

Fig. 8 : Influence of wheat moisture content on The grinding ability index

Table. 1. The effect of four wheat cultivars on results of grinding. Higher values of the specific energy consumption were achieved for hard wheat cultivars, whereas lower values were obtained for two soft cultivars. Similar results were observed for the mean particle size. The specific surface was higher for soft cultivars, which broke to smaller particles. In addition, the grinding ability was significantly higher for soft cultivars. Significant differences among means for all four parameters were confirmed with the group types of the cultivars. The corresponding relation was described by means of a square polynomial equation with high determination coefficient (0.437, 0.625, 0.555 and 0.308 for the specific energy consumption, mean particle size, specific surface, and grinding ability index respectively). This effect can be attributed to the differences in endosperm's hardness and its ability to be reduced to smaller particles, which inherently varies among different wheat cultivars (Doblado-Maldonado, 2012).

Table 1 : Influence of wheat cultivar on the grinding parameters

Effect	**Mean**				
	Level of factor	E_{sp}	P_s	S_{sp}.	***GA***
Wheat cultivars	W1	113.2 a	559 a	58 a	0.587 a
	W2	91.3 b	549 a	59 a	0.708 b
	W3	85.9 c	441 b	61 b	0.778 bc
	W4	78.7 c	395 b	62 b	0.854 c

Conclusions

- Specific energy consumption and mean particle size, depend on the moisture content and increased significantly for levels of moisture content higher than 12%. On contrary, decline considerable for specific surface and grinding ability index were confirmed.
- As a coarse grinding (large screen mesh size of hammer mill) increased the specific energy consumption as well as specific surface were decreased significantly. On other hand, mean particle size and grinding ability index were increased.
- The highest values of specific energy consumption and mean particle size were achieved during grinding of Iraqi hard wheat cultivars. The lowest values of specific surface and grinding ability index were observed during grinding of soft wheat cultivars.

References

Al-Aridhee, J. and Łysiak, G. (2018). Investigation and Modelling of Stress Relaxation of Wheat Kernels in View of Grinding Prediction Doctoral dissertation, the University of Life Sciences in Lublin/poland.

Dziki, D.; Cacak–Pietrzak, G.; Miś, A.; Jończyk, K. and Gawlik–Dziki, U. (2014). Influence of wheat kernel physical properties on the pulverizing process. Journal of Food Science and Technology, 51(10): 2648–2655.

Evers, T. and Millar, S. (2002). Cereal grain structure and development: some implications for quality. Journal of Cereal Science, 36(3): 261–284.

Andrew M.A. (2010). Morphological features of wheat grain and genotype affecting flour yield. Doctoral dissertation, University of the Lismore, Australia.

Greer, E.N. and Hinton, J.J.C. (1950). The two types of wheat endosperm. Nature, 165(4202): 746–748.

Osborne, B.G. and Anderssen, R.S. (2003). Single–kernel characterization principles and applications. Cereal Chemistry, 80(5): 613–622.

Dobraszczyk, B.J. (1994). Fracture mechanics of vitreous and mealy wheat endosperm. Journal of Cereal Science, 19(3): 273–282.

Doblado–Maldonado, A.F. (2012). New technologies for whole wheat processing addressing milling and storage issues. Master thesis, University of the Nebraska.

Delwiche, S.R. (2000). Wheat endosperm compressive strength properties as affected by moisture. Transactions of the ASAE, 43(2): 365–373.

Dell Inc. (2016). Dell Statistica (data analysis software system), version 13. Software.dell.com.

I.A.S.C. (2018). Iraqi Agriculture Statistical Center/ Ministry of agriculture.

ET ISO 712, (2001). Cereals and Cereal Products-Determination of moisture content - Routine Reference method" (https://archive.org/stream/et.iso.712.2001/et.iso.712.2001_djvu.txt)