The Annals of the University *Dunarea de Jos* of Galati
Fascicle VI – Food Technology, 34(2)

ORIGINAL ARTICLE

TECHNOLOGICAL EFFECTS OF THE WHEAT CLEANING EQUIPMENT OF AN INDUSTRIAL MILL

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Received 11 February 2010
Revised 15 April 2010

Romanian wheat, Dropia variety, was cleaned and tempered in an industrial roller mill. Technological effects of the wheat cleaning equipment were investigated as function of the total impurities removed from the cereals. The impurities separated through combi-cleaner and indented separators were 83.42 and 82.83%, respectively. Through scouring, the reduction of the ash content was 0.0225%, while the grains broken were 0.223%. Correlations between the physical parameters and the impurities content were also established. The results indicated negative correlations between thousand kernel weight and impurities content.

Keywords: industrial mill, wheat cleaning process, technological effect

1. Introduction

The main objective of the cleaning process is to separate the grain from coarse and fine impurities by sifting, to use the destoner to remove stones, to eliminate the low-density particles and dust through aspiration, to separate and sort the round and long grains from granular materials with the intended separator. According to Godon and Willm (1994), it is possible to remove about 98% of the larger stones and only 87% of the smaller ones using a perfectly adjusted destoner. Then, grains contaminants such as microorganisms, mycotoxins, toxic heavy metal and filth (insect fragment, excrements, bird feathers, etc.) are removed using the scourer. The intensive surface treatment performed using the scourer improves both quality and sanitation of the cereals (Tkachuk *et al*., 1991; Eugster, 2002; Jouany, 2007; Sarakatsanis, 2007; Kushiro, 2008).

The present study aimed at investigating the technological effects of the wheat cleaning equipment of an industrial mill and at establishing correlations between the physical parameters and the impurities content.

2. Materials and methods

The Romanian wheat, Dropia variety (harvest 2009) was cleaned and tempered in an industrial roller mill (Buhler, Uzwil, Switzerland, capacity 3300 kg/hour). The technological diagram of the cleaning section is presented in Figure 1. The silo of the mill consists of two storage bins, thus it is possible to produce grain blends of a constant quality for longer time. In order to produce the grain blends, the gravimetric proportioning of the free-flowing stream of material was done through automatic flowbalancer (MZAF). The equipments for cleaning are: combi-cleaner (MTKB®) with air-recycling system, magnetic separator (MMUA®), indented separator (MTRI®), scourer (MHXS®) with aspiration channel (MVSG®). The wheat was dampened in three stages using an installation consisting of three units: the moisture controller (MYFC), the water proportioning (MOZF) and the dampener (MOZL).

The samples were collected according to the standard SR EN ISO 13690:2007 (ASRO 2008), for all points (P1, …, P13) indicated in Figure 1.

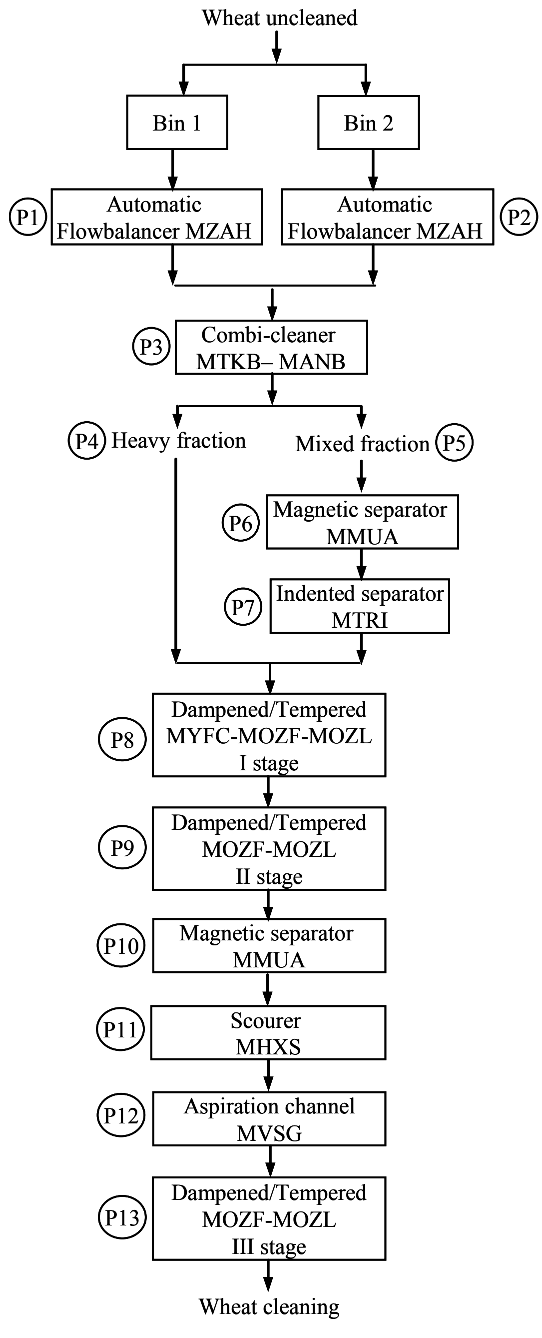

Figure 1. Technological diagram of the cleaning section

The physical-chemical characteristics of the wheat were evaluated as follows: the moisture content using the AACC 44-51 method (2000); the ash content using the SR ISO 2171:2002 method (ASRO 2008); the gluten index and wet gluten content using the SR ISO 21415-2:2007 method (ASRO 2008); the falling number value using the AACC 56-81B method (2000); test weight (TW) through the SR ISO 7971-2: 1995 method; the impurities content through the SR ISO 7979/2001. The 1,000 kernel weight (TKW) was determined for each sample by weighing 100 randomly selected, unbroken kernels amounting up to 0.01 g and multiplying the result by 10.

The technological effect of the cleaning equipments was estimated as follows: for combi-cleaner as the report between the difference of the impurities (P3 – P4) and the impurities from P3; for indented separator as the report between the difference of the impurities (P5 – P7) and the impurities from P5; for scourer and aspiration channel as the report between the difference of the ash content and the grain broken (P11 – P13) and the ash content and the grain broken from P11.

Statistical analysis: in the period November 2008 – July 2009, in triplicate nine experiments were carried out, and the average values were reported together with their standard deviation (SD). Their standard deviations and correlation coefficients were determined by using Microsoft Excel.

3. Result and discussion

The combi-cleaner (P3) was used to remove all the impurities larger than the grain kernel (straw, strings and large stones) and all impurities smaller than the grain kernel (sand, broken kernels and foreign seeds), sorting the materials according to their specific gravity into one heavy (P4) and one low fraction (P5). Moreover, the low-density particles (dust, hulls, chaff, shriveled kernels and foreign seeds) were removed by air classification. The low fraction (P5) was cleaned in an indented separator for round granular materials. After this separation, the heavy and low fraction were mixed and submitted to the dampening stages.

By passing the wheat through the combi-cleaner, a concentration of low-density impurities and round granular materials occurs in fraction P5. As depicted in Figure 2, from an average impurity content of 2.6%, a low fraction results as well as a heavy fraction of 6.2% and 0.4%, respectively.

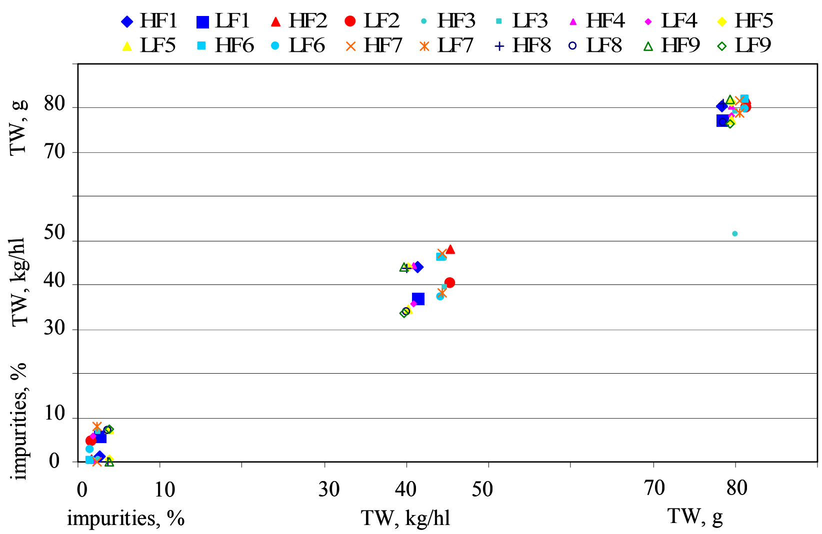

Figure 2. Physical indices of the heavy (HF) and low fractions (LF) separated with the combi-cleaner from the sample collected in the nine months of experiment (the coefficient 1 corresponds to the month of November, while 9 corresponds to the month of July in Table 2)

The largest product impurity content (3.86%) that fed the combi-cleaner was recorded in March, and the separated low fraction had a rate of 7.27% impurities. The impurities content of the low fraction depend on the types of impurities in the raw wheat. As shown in Table 1, the larger content in the broken grain, the larger the low fraction was.

The physical parameters of the wheat were influenced by the amount and the types of impurities. Our results in terms of test weight and 1,000 kernel weight (Table 1) showed that these parameters increased in case of the heavy fraction and decreased in case of the low fraction over the feed product, and depended on the types of the impurities. When the raw product had a large content in round particles (weeds, vetches and broken grains), the test weight and 1,000 kernel weight were much lower. Standard deviation of the test weight and 1,000 kernel weight ranged between 1.302 and 2.430 for the low fraction, and between 9.970 and 1.547 for the heavy fraction, over 1.082 and 2.308 for the wheat fed from the combi-cleaner (Table 1). The large variations of the standard deviation for the same parameters are explained by the large variations in the round impurities (especially broken grain) of raw wheat.

The technological effect of the combi-cleaner increased from 57.7%, in November, (first month) to 98.7%, in July (last month) (Table 2). In case of an indented separator, the average of technological effect was 82.83%. This effect was possible through a correct regulation of specific charging on the first screen, but also counting on a correct regulation of the airflow used for aspiration in the combi-cleaner.

Table 1. Physical indices of the feed, heavy and low fractions separated from the combi-cleaner

Sample	**P3**			**P4**			**P5**		
Month/ Physical indices	**Impurities %**	**TW, kg/hl**	**TKW, g**	**Impurities %**	**TW, kg/hl**	**TKW, g**	**Impurities, %**	**TW, kg/hl**	**TKW, g**
November	2.6	78.3	41.4	1.1	80.4	44.1	6.0	77.5	36.9
December	1.69	81.4	45.4	0.50	81.9	48.0	4.60	80.1	40.3
January	2.50	80.0	44.7	0.72	51.5	45.8	6.91	79.2	39.4
February	1.82	79.5	40.9	0.31	80.4	44.3	5.86	78.4	35.8
March	3.86	79.6	40.2	0.5	81.4	44.1	7.27	77.5	34.4
April	1.42	81.2	44.2	0.27	82.0	46.2	2.76	79.9	37.2
May	2.40	80.5	44.4	0.12	81.7	47.1	7.90	79.0	38.3
June	3.6	78.5	40.0	0.1	81.0	43.8	7.1	76.9	33.9
July	3.8	79.3	39.7	0.05	82.0	44.1	7.4	76.5	33.5
Statistical parameters									
Average	2.6	79.8	42.3	0.4	78.0	45.3	6.2	78.3	36.6
Min	1.42	78.3	40.2	0.05	51.5	44.1	2.76	77.5	34.4
Max	3.86	81.4	45.4	1.1	82	48	7.9	80.1	40.3
SD	0.928	1.082	2.308	0.340	9.970	1.547	1.633	1.302	2.430

Table 2. Technological effect of the combi-cleaner and of the indented separator

Statistical parameters	**Technological effect, %**	
	Combi-cleaner	**Indented separator**
Average	83.42	82.83
Min	57.7	55
Max	98.7	99.1
SD	14.15	16.22

Statistical correlations were established between measured physical parameters. Our results indicated significant positive correlation between TKW and TW, and negative correlation between TKW and the impurities content. The regression equation found was the following: TKW = –79.367 – 0.681 x Imp + 1.538 TW ($r^2 = 0.857$, $p < 0.05$).

For the feed product and the separated fractions of the combi-cleaner, the wet gluten (Gu), gluten index (Ix) and falling number (FN) value were analysed (Table 3). A significant positive correlation was obtained between TKW and Gu, FN, and a negative correlation between TKW and Ix. The regression equations found between TKW, Gu and Ix, respectively TKW, Gu and FN were the following: TKW = 23.579 + 0.328 x Gu – 0.409 x Ix ($r^2 = 0.64$, $p < 0.05$), and TKW = 38.478 + 0.82 x Gu + 0.058x FN ($r^2 = 0.422$, $p < 0.05$), respectively.

The adhering impurities were removed through scouring from the surface of the grains. The technological effect of this operation is usually estimated by the ash content of the wheat and the percentage of grain broken at the outlet over the feed product. The operation is efficient when the reduction of the ash content is about 0.02-0.03%, and the percentage of the grains broken increase up to 1% (Godon and Willm, 1994). The results obtained in our study are shown in Table 4. The average and standard deviation for the ash content reduction were 0.022%, 0.0044 respectively, and for the grains broken were 0.223%, 0.049 respectively.

Table 3. Technological indices of the samples from the combi-cleaner

Sample	**P3**			**P4**			**P5**		
Technological indices	**Gu, %**	**Ix, %**	**FN, s**	**Gu, %**	**Ix, %**	**FN, s**	**Gu, %**	**Ix, %**	**FN, s**
Statistical parameters									
Average	26.0	90.7	420.3	25.2	93.0	415.0	26.6	85.0	399.6
Min	22.6	81	398	22.4	88	372	23.4	78	360
Max	29	98	460	28.5	97	499	29.9	93	429
SD	2.69	5.73	26.27	2.45	3.05	43.91	2.75	5.16	24.32

Table 4. Technological effect of the scourer

	P11	**P13**	**Technological effect**	**P11**	**P13**	**Technological effect**
Indices	**c11, %**	**c13, %**	**c11-c13, %**	**imp11, %**	**imp13, %**	**imp11-imp13, %**
Statistical parameters						
Average	1.572	1.550	0.022	0.868	1.091	0.223
Min	1.51	1.46	0.02	0.3	0.5	0.15
Max	1.65	1.64	0.03	1.5	1.8	0.3
SD	0.057	0.057	0.0044	0.401	0.424	0.049

4. Conclusions

The technological effects of the combi-cleaner and of the indented separator were 83.42 and 82.83%, respectively. Through scouring, the reduction of the ash content was 0.0225%, while the increase of the grains broken was of 0.223%. The results indicated a negative correlation between TKW and the impurities content. The overall physical parameters of the grain were influenced by the large variations of round impurities, especially broken grain, of the raw material.

Acknowledgment

This research was financially supported by the Project 52-132/01.10.2008 of the Romanian National Centre for Programme Management (R&D Programme Partnerships in Priority S & T Areas / 2nd National Plan for Research, Development & Innovation 2007-2013).

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