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Research Article

The Effect of Tempering on Mixed Russian and Ukrainian Wheat Properties During Milling Operations

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Abstract:

The change in physical properties in mixture wheat during tempering stage for milling processes prepared according to mixtures dose was studied. The results showed that the physical properties of wheat seeds before the tempering process for both mixtures, the length values were 6.76 and 5.87 mm, width were 3.02 and 2.88 mm, thickness were 2.88 and 2.91 mm, geometric mean diameter were 3.88 and,3.66, arithmetic mean diameter were 4.22 and 3.89 mm, area of flat surface were 16 and 13.29 mm, volume were 30.86 and 25.84 mm^{3}and 1000 kernel weight were 38.5 and 37.95g. At the tempering process for first dose of mixture, the length of wheat seeds decreased from 6.76 to, 5.93 at the first soaking to 5.88 mm for the second soaking. The width of wheat seeds increased from 3.02 to, 3.15 at the first soaking while increased to 3.18 mm for the second soaking, the thickness of wheat seeds increased from 2.88 to, 3.07 at the first soaking to 3.10. mm for the second soaking. At the tempering process for the second dose of mixture, the length of wheat seeds decreased from 5.97 to, 5.88 at the first soaking to 5.87 mm for the second soaking. The width of wheat seeds increased from 2.88 to, 3.10 at the first soaking while increased to 3.13 mm for the second soaking, the thickness of wheat seeds increased from 2.91 to, 3.00 at the first soaking to 3.20. mm for the second soaking.

1. Introduction

The world's most widely produced cereal crop is wheat (Triticum aestivum L.). It is one of the most significant cereal crops produced for human consumption in Africa because it is regarded as a strategic crop for ensuring food security. As a result, it contributes to about 16% of the needs of some nations and 21% of the total properties requirements for feeding 4.5 billion people in developing nations. With a productivity of 3.2 tons per hectare, it produces 716 million tons of food grains on an area of around 220 million hectares. To meet future demands, wheat production must increase by (77-80%) by the year 2050. The requirement for wheat production has increased in rising nations, especially over the past 50 years. The United States Department of Agriculture (USDA) reports that approximately 2.6 billion tons of grain are produced annually. 29% of it is made up of wheat (Zewdie and Hunegnaw, 2020).

Wheat is the most significant food grain crop in Egypt. Wheat accounts for around 10% of agricultural production and 20% of overall agricultural imports. Egypt is the world's largest importer of wheat. Egypt produces roughly 9.8 million tonnes of wheat grains, imports approximately 11 million tonnes, and consumes approximately 20.6 million tonnes of wheat grains. Annually, around 38% of wheat was imported from other nations. Russia, the United States, France, Ukraine, Australia, Romania, Brazil, Poland, Germany, and Canada import the most wheat. (Maray and Abdel-Mageed, 2022).

Ukrainian wheat came first in three tests, namely moisture content, which ranged from 10.88% to 12.43% with an average of 11.46%, test weight, which ranged from 78.77 to 80.57 kg hl^{-1} with an average of 79.70 kg hl^{-1}, and falling number, which ranged from 12.21 to 13.67% with an average 12.80%, shrunken and broken grains ranged from 0.746 to 1.925% with an average of 1.115%. Ukrainian wheat came in the third order in one test like, insect damaged kernels, which ranged from 0.651 to 0.883% with an average of 0.761%. (El-Naggar et al., 2018)

The physical characteristics of several wheat grain varieties were changed from minimum to maximum, respectively. widths ranged between 0.10 and 1.22 mm The thickness ranged from 0.10 to 1.15 millimeters. Volume ranged from 0.06 to 3.29 mm^3, geometric and arithmetic mean diameters were 0.48 to 1.85 mm, 1.53 to 2.36 mm, and sphericity fell from 38.4 to 10.50 percent. In addition, at a constant moisture content of 12.2%, the surface area rose from 0.72 to 10.70 mm^2. (Fouda and Albebany, 2021)

Wheat is one of the world's most important crops, and it is used for both human consumption and cattle feed. Wheat kernels comprise 80-85% endosperm, 13-17% bran, and 2-3% germ by dry weight; it is the most widely produced cereal grain in the world, used for food (67%), feed (20%), and seed (7%). Durum and hard wheat have higher protein content (12-16%) than soft wheat (8-10%) (Paucean et al., 2016).

Two different types of spelt wheat seed—with and without chaff—had their moisture content's effects on several of their physical characteristics examined. For seeds without chaff, the average length, width, and thickness were 5.89 mm, 3.21 mm, and 2.51 mm; for seeds with chaff, same measurements were 9.47 mm, 3.53 mm, and 2.62 mm. The study revealed that the change in moisture content in the range of 8.1 to 24.3% resulted in an increase in coefficient of friction of 50% and 61% for seeds with and without chaff, The weight increase of 45% and 43% for thousand seeds, a decrease in uncompacted bulk density of 4% and 2%, a rise in compacted bulk density of 8% and 3%, and an increase in modulus of elasticity of 24% and 51%. (Szymanek and Sobczak, 2009).

Tempering, which involves adding water to wheat before milling in order to toughen the bran and soften the endosperm of the kernel and so increase the effectiveness of flour extraction. Wheat cultivar, starting wheat water content, kernel size, and temperature all have an impact on the pace at which moisture is absorbed by wheat during tempering. Despite variations in the velocity of water penetration into wheat during tempering for various cultivars, the general direction of movement remained the same. The endosperm shape, protein content, and distribution also had an impact on the rate. (Delwiche, 2000)

By toughening the pericarp, grinding produces fewer tiny pericarp particles. However, the rate of flour extraction fell as tempering moisture in the kernel rose. As a result, the tempering process should strike a balance between the appropriate level of bran in the wheat and the degree of flour extraction. The majority of tempering research has been on milling yield and tempering mechanism rather than flour quality. Few studies relate the effects of tempering to aspects of flour such ash concentration, farinograph, and extensigraph quality. The measurement of inorganic compounds, ash level of flour has been utilized as a bran contamination indication. (Ibanoglu, 2001)

A full factorial design involving beginning wheat moisture, tempered wheat moisture, tempering temperature, and tempering time at two levels was used during the tempering process. The biggest impact on flour functioning and milling efficiency was temperate wheat moisture. All samples that were tempered at 15% moisture had a lower flour yield than samples that were tempered at 12% moisture. Due to decreased bran contamination, as determined by flour ash and PPO, the 15% tempered sample's flour quality was superior than the 12% tempered samples. Tempering is the practice of adding water to wheat before milling in order to toughen the bran and soften the kernel's endosperm and increase the effectiveness of flour extraction. (Kweon et al., 2009)

It is a well-known fact that the wheat should ideally be tempered mostly based on its initial moisture content. The miller must add additional water when the grain is dry. This water addition may require two processes, depending on the grain's original moisture content and the milling procedures used. The impact of wheat hardness on resting time is the second crucial element. The amount of resting time needed for water to reach the wheat kernel increases with the hardness of the wheat. Additionally, hard wheats typically have a somewhat higher moisture content when processed than soft wheats. (Willm and mouture, 2009)

Before milling, wheat grains are treated to a tempering procedure that softens the endosperm and toughens the bran. Nonetheless, during the tempering process, the extended duration (about 24 hours), the ideal temperature (around 25 °C), and the right humidity are advantageous for microbial growth and reproduction. The flour will thus have a high microbiological concentration. Due to the low water activity of flour, the resulting microorganisms can stay dormant for an extended amount of time (Li et al., 2013).

Crude fiber in wheat is the most impacted ingredient after traditional tempering, followed by ash (minerals) and vitamins, which have an unfavorable influence on properties value. Without the bran and germ, around 25% of the grain protein is lost, as are 66% of the fiber, 92% of the selenium, 62% of the folate, and up to 99.8% of the phytochemicals. (Rosell and Garzon, 2015) The main objectives of this study to monitor change in physical, and chemical properties in mixture wheat during tempering stage for milling processes

2. Materials and Methods

Wheat: varieties and characteristics

The experiments were conducted at Al-Massa Mills Company, located in Sadat City, Menoufia Governorate, Egypt, during the period 2022-2023. The three principal types of wheat used in modern food production are Triticum vulgare (or aestivum), T. durum, and T. compactum. The wheat grain, the raw material of flour production and the seed planted to produce new plants, consists of three major portions: (1) the germ (including its sheaf, the scutellum) that produces the new plant, (2) the starchy endosperm, which serves as food for the germinating seed and forms the raw material of flour manufacture, and (3) various covering layers protecting the grain. Although proportions vary, other cereal grains follow the same general pattern. Average wheat grain composition is approximately 85 percent endosperm, 13 percent husk, and 2 percent germ

The physical properties of wheat seed

The physical properties of the types of wheat used in the experiment separately were (Russian 12.5, Russian 11.5, and Ukrainian 11.5), as well as some of the properties of the two mixtures of wheat: the first mixture (70% Russian 12.5 + 30% Ukrainian 11.5) and the second mixture (60% Russian 12.5 + 40% Russian 11.5%) The results were close in most characteristics between Russian wheat 12.5 and Russian wheat 11.5, except for protein and gluten, Ukrainian wheat was close to Russian wheat 11.5 in protein and gluten, and the detailed results are shown in Table 1

The main objectives of this study to study change in physical, and chemical properties in mixture wheat during tempering stage for milling processes.

Table 1. Physical properties of wheat seed and wheat mixes

Wheat seed	Russian 12.5	Russian 11.5	Ukrainian 11.5	70%Rus12.5 +30%Ukr 11.5	60%Rus12.5 +40%Rus 11.5
Length (mm)	5.83 - 6.09	5.72 - 5.90	5.71 - 6.11	6.71 - 6.82	5.81 - 5.93
Width (mm)	2.83 - 3.37	2.66 - 3.19	2.79 - 3.24	2.96 - 3.08	2.85 - 2.90
Thick-ness (mm)	2.65 - 3.19	2.70 - 3.15	2.77 - 3.09	2.85 - 2.92	2.90 - 2.93
1000 Kernel Weight (g)	37.9 - 38.2	37.7 - 38.1	38 - 39.1	38.0 - 38.5	37.8 - 38.1
Test Weight (kg/hl)	79.6 - 79.9	79.4 - 79.7	79.1 - 79.2	79.1 - 79.5	79.1 - 79.5
Protein content (%)	11.5 - 12.0	10.5 -10.9	10.1 - 10.6	11.1 - 11.5	11.28 - 11.37
Wet Gluten (%)	25.3 - 26.3	23.5 - 24.5	22.6 - 23.2	24.8 - 24.93	24.9 - 25.2
Index	77 - 81	78 - 82	86 - 88	80.8 - 81.4	79.1 - 79.5
Moisture content (%)	10.1 - 11	10.3 - 11.1	11.7 - 12.1	10.9 - 10.9	10.5 - 10.6
Degree of Cleaning (%)	97.5 - 98.1	97.7 - 98.2	97.6 - 98.2	98.3 - 98.4	97.8 - 97.8

Source: Author's source

Wheat Tempering

Of the utmost importance in flour milling is tempering, or conditioning. Tempering implies the precise addition of water to the cleaned grain and allowing the dampened grain to rest in a mass flow 'temper' bin for an optimum amount of time. The water is typically added in a machine called a tempering mixer, or dampener. The objective of tempering the grain is to moisten the outer coat, or bran layers, and the starchy inner part of the grain. Moistening the bran allows this layer to remain intact during subsequent milling while allowing the inner part of the grain, or endosperm, to be reduced more easily into flour. The ideal amount of moisture and temper time varies with different varieties of grain as well as other variables.

Two periods for tempering, the first soaking was 13.5 hours, while the second was 6.5 hours going to the first mixture which (70% from Russian wheat has12.5% protein and 30% Ukrainian wheat 11.5% protein) and the second was 14.5 hours, while the second was 7.5 hours going to the second dose (60% Russian wheat 12.5 % protein and 40% Russian wheat 11.5% protein)as shown in Table 2.

Item	70% RUS 12.5 + 30% UKR 11.5		60%Rus12.5 +40%Rus 11.5	
	1st wheat	2nd wheat	1st wheat	2nd wheat
Moisture %	14.5	15.9	14.7	16.3
No of hours Tempering(h)	13.5	6.5	14.5	7.5
Water in l/h	589.4	208	673.7	238.9

Source: Author's source

Measurements and determinations - Natural properties

The three axial dimensions of seed are namely length "L," (longest intercept), width "W," (equatorial width perpendicular to L) and thickness "T," (breadth perpendicular to L and W). They were measured by a manual Vernier-caliper with accuracy of 0.02 mm for randomly selected 100 seeds. Mean dimensions of wheat seeds, the arithmetic mean diameter (D a), mm, geometric mean diameter (D g), mm, surface area (A s), mm 2, volume (V), mm3 and sphericity (φ), % of grains were calculated as:

-Arithmetic mean diameter (Da), mm:

$$Da = \frac{(x+y+z)}{3} \quad \ldots\ldots(1)$$

-Geometric mean diameter (Dg), mm:

$$Dg = (x.y.z)^{1/3} \quad \ldots\ldots(2)$$

-Surface area (A s), mm2:

$$As = \pi.Dg^2 \quad \ldots\ldots(3)$$

-Volume (V), mm^3:

$$V = \frac{\pi}{6}(x.y.z) \quad \ldots\ldots(4)$$

-Sphericity (φ), %:

$$\varphi = \frac{(x.y.z)^{1/3}}{x} = \frac{Dg}{x} \quad \ldots\ldots(5)$$

-Area of flat surface, mm

$$Af = \frac{\pi}{4}(x.y) \quad \ldots\ldots(6)$$

-Area of transverse surface, mm

$$At = \frac{\pi}{4}(x.z) \quad \ldots\ldots(7)$$

-Aspect ratio, decimal:

$$Ar = \frac{x}{y} * 100 \quad \ldots\ldots(8)$$

Where: x: length of grains (mm), y: width of grains (mm) and z: thickness of grains (mm)

Source: Author's source

Wheat Tempering:

-Water in L/h = water in % * Capacity kg/ h

-Water in%=100*(f_2-f_1)/100-f_2

1-Tempering wheat (70% Rus 12.5 + 30% Ukr 11.5)

$$\text{Water in 1st \%} = \frac{100 * (14.5 - 10.9)}{100 - 14.5} = 4.21\ \%$$

Water in 1st L/h = 4.21 % * 14 t/h *1000 kg / h = 589.4 L/h

$$\text{Water in 2nd } \% = \frac{100 * (15.9 - 14.5)}{100 - 15.9} = 1.66\,\%$$

2-Tempering wheat (60% Rus 12.5 + 40% Rus) 11.5)

$$\text{Water in 1st } \% = \frac{100 * (14.7 - 10.6)}{100 - 14.8} = 4.8\,\%$$

Water in 1st L/h = 4.8 % * 14 t/h *1000 kg / h = 673.7 L/h

$$\text{Water in 2nd } \% = \frac{100 * (16.3 - 14.7)}{100 - 16.3} = 1.9\,\%$$

Water in 2nd L/h = 1.9 % * 12.5 t/h *1000 kg / h = 238.9 L/h

3. Results

The properties of mixed wheat seeds with tempering.

As shown from Fig (1) to Fig (6), the Physical properties showed the average values of length, width, and thickness for Raw wheat, 1st, and 2nd wheat tempering of first mix wheat seeds were (5.9,5.93, and 5.92 mm), (3.07, 3.15, and 3.18), and (3.01, 3.07, and 3.1) respectively. For volume, the average values were 28.53, 30 and 30.54 mm^3 respectively. Geometric mean diameter and arithmetic mean diameter were (3.78, 3.85, and 3.87), (3.99, 4.05, and 4.06) mm respectively. Sphericity values were 64.2, 64.9, and 65.4% respectively. Also, the surface area for tow mixed wheat were 45, 46.6, and 47.1 mm^2. The values for area of flat surface were 14.2, 14.66 and 14.77 mm respectively. The values of area of transverse were 7.25, 7.59, and 7.74 mm and aspect ratio 52, 53.1, and 53.7 respectively. the average values of 1000 kernel weight for were (38.3,39.5, and 39.7g). For the same indicators with second mix wheat seeds, the average of length, width, and thickness for Raw wheat, 1st, and 2nd wheat tempering were (5.86, 5.87 and 5.88 mm), (3.03, 3.1 and 3.13mm), and (2.92, 3 and 3.2mm) respectively. For volume, the average values were 27.13, 28.56, and 30.82 mm^3 respectively. Geometric mean diameter and arithmetic mean diameter were (3.72, 3.78 and 3.88), (3.93, 3.99, and 4.07) mm respectively. Sphericity values were 63.5, 64.5, and 66.1% respectively. Also, the surface area for tow mixed wheat were 43.5, 45.1, and 47.4 mm^2. The values for area of flat surface were 13.9, 14.3, and 14.4 mm respectively. The values of area of transverse 6.95, 7.3, and 7.86 mm and aspect ratio 51.7, 52.8, and 53.2 respectively. the average values of 1000 kernel weight for were (38.2,39.4, and 39.7g).

For the first mix of wheat seeds, the percentage increase of length, width, and thickness for 1st ,2nd wheat were (13,14%), (2,3%), and (5,6%) respectively. Also, the values for the same indicators with the second mix of wheat seeds were (3,1%), (6,7%), and (2,9%) respectively. Geometric and arithmetic mean diameters for two mixed wheat seeds were (2,5%), (3,5%), (1,2%), and (2,4%) respectively. The area of flat and transverse surface values for the first mix were (6,6%), (7,10%), for the second mix were (7,6%), and (9,17%). The percentage increase of volume, sphericity, and aspect ratio, and surface area of first mixed wheat seeds were (8,10%), (12,14%), (18,20%), and (13,19%) respectively, also for second mixed, the values of same indicators were (9,16%), (2,6%), (5,10%), and (6,10%) respec-tively.1000 kernel weight for first, and second mixed wheat in 1st and 2nd were (3,3%) and (3,4%),

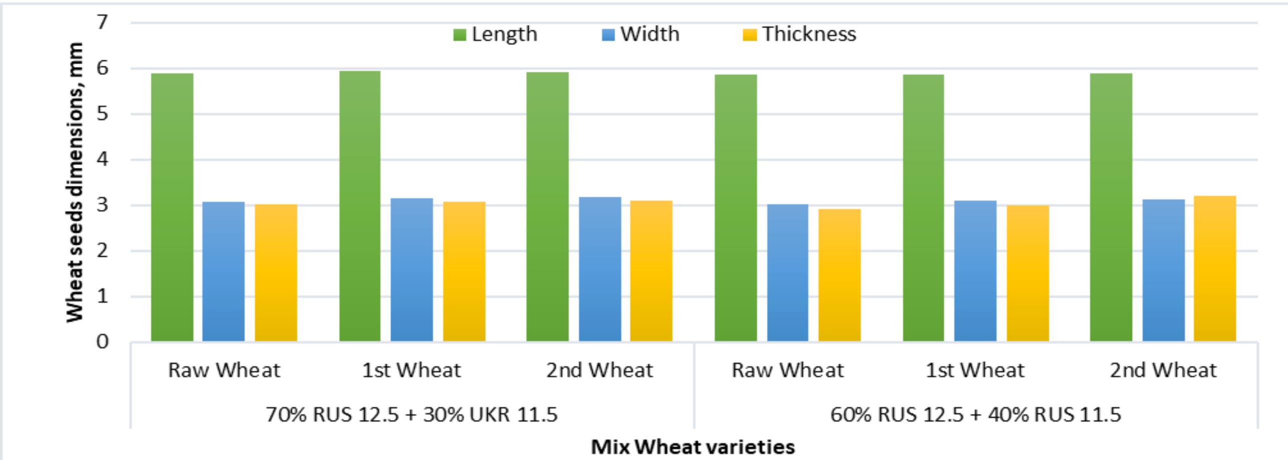

Fig 1. Relationship between principle dimensions of wheat seed and mixed wheat varieties in first and second stage of tempering. Source: Author's source

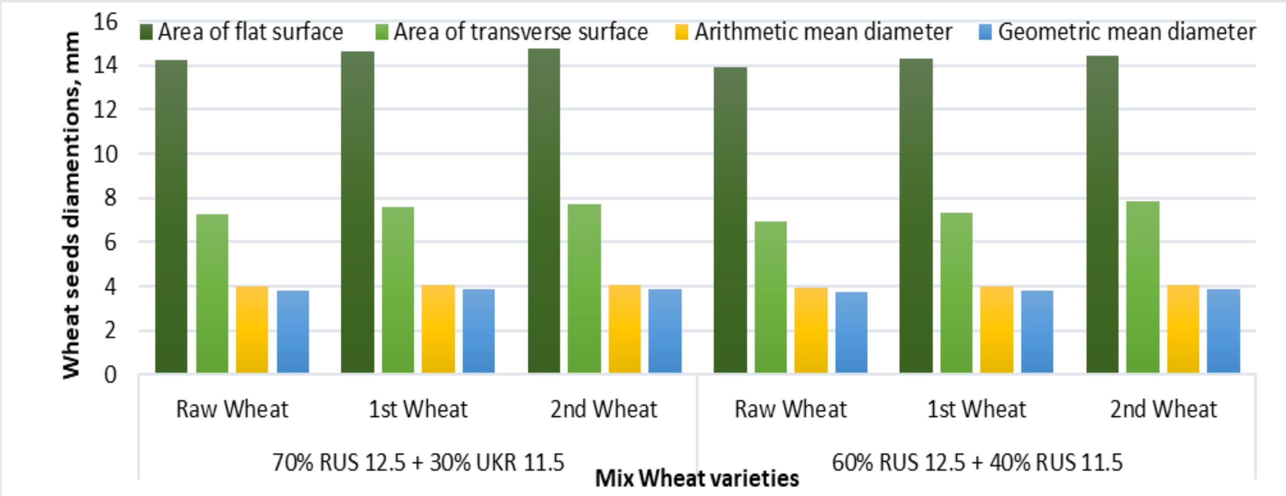

Fig 2. Relationship between wheat seed dimensions and mixed wheat in first and second stage of tempering

Source: Author's source

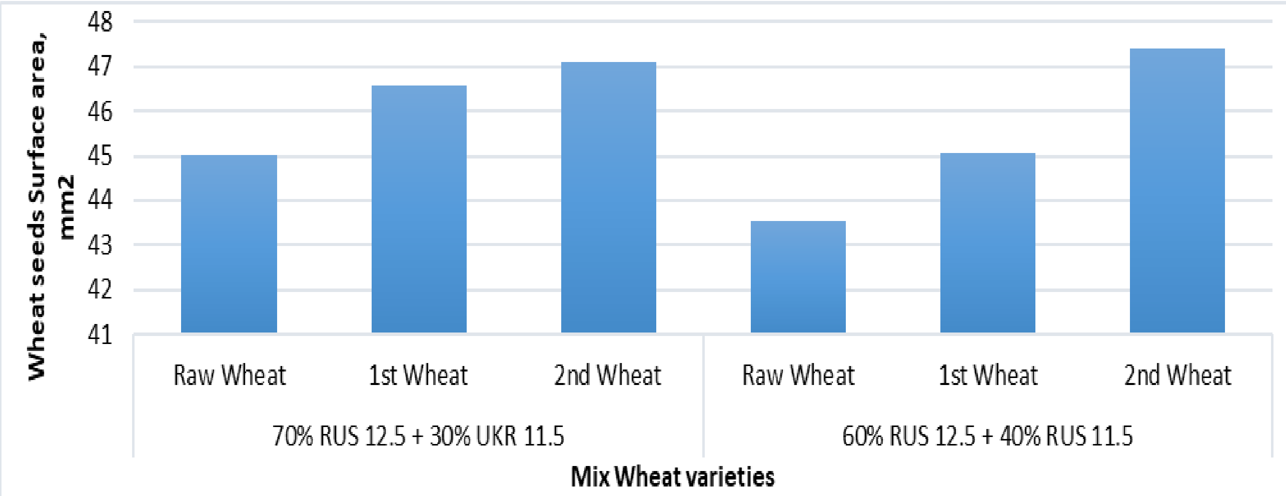

Fig 3. Relationship between volume of wheat seeds and mixed wheat in first and second stage of tempering

Source: Author's source

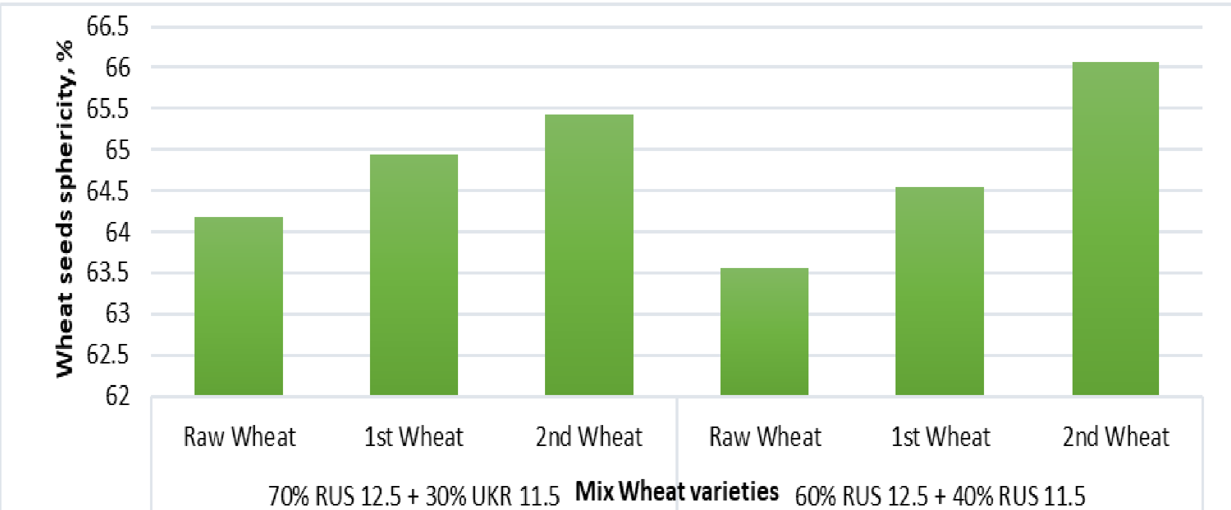

Fig 4. Relationship between sphericity of wheat seeds and mixed wheat varieties in first and second stage of tempering. Source: Author's source

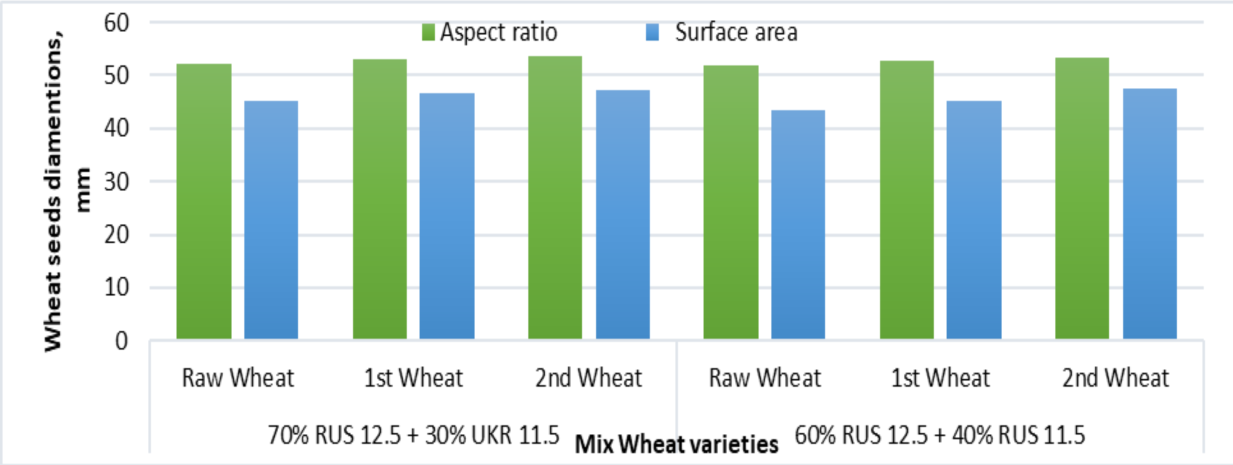

Fig 5.. Relationship between aspect ratio, and surface area of wheat seeds and mixed wheat varieties in first and second stage of tempering. Source: Author's source

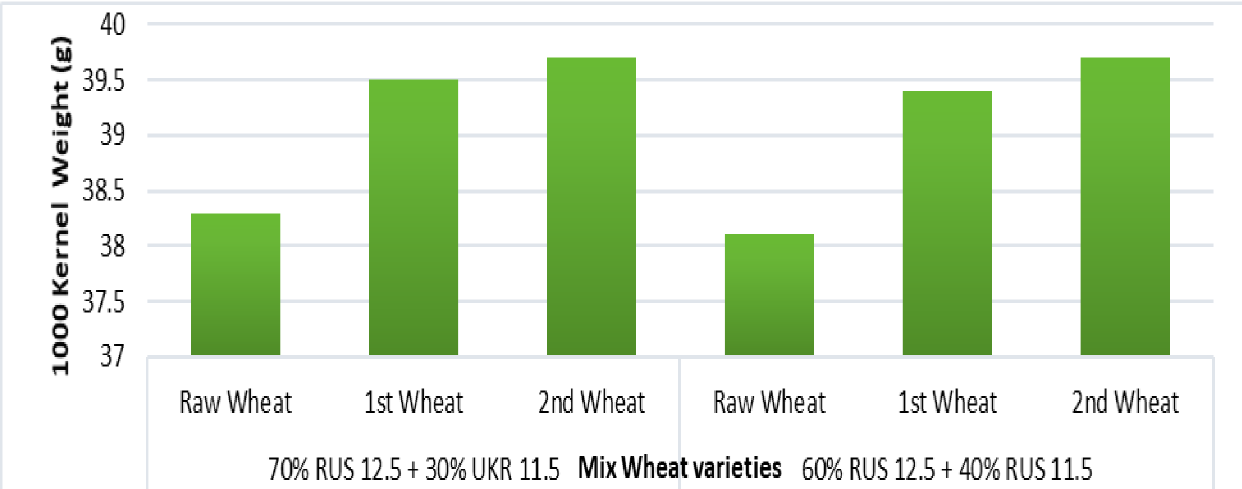

Fig 6. Relationship between 1000 kernel weight of wheat seeds and mixed wheat varieties in first and second stage of tempering. Source: Author's source

4. Conclusions

The results showed that during the initial tempering phase of the two mixtures, the values of length increased by (13,14%), width increased by (2, 3%), thickness increased by (5, 6%), volume increased by (8, 10%), geometric mean diameter increased by (2, 5), arithmetic mean diameter increased by (1, 2), sphericity increased by (12, 14%), area of flat surface increased by (6, 6%) and 1000 kernel weight increased by (3, 3%). During the second tempering stage, the results of length increased by (3, 1%), width increased by (6, 7%), thickness increased by (2,9%), volume increased by (9,16%), geometric mean diameter increased by (3, 5), arithmetic mean diameter increased by (2, 4), sphericity increased by (2, 6%), area of flat surface increased by (7,6%) and 1000 kernel weight increased by (3, 4) %.

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