Milling Damaged Starch (MDS) in wheat flour: Formation, Structure, Functionality and its Effects on Baking Quality: An Article

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ABSTRACT

In this article, the Milling Damaged Starch (MDS) in discussed in terms of formation, structure, functionality and its effects on the quality of baking products. The MDS is different from native starch regarding granular structure, crystalinity and molecular degradation. Such a diversity is responsible for the different functionality of MDS. So ,gelatinization ,pasting properties , in vitro enzymatic digestibility of wheat flour containing high level of MDS vary considerably as compared with their counter parts properties in wheat flour containing low MDS. This article discusses all the aforementioned information.

Keywords: Damaged starch, structure, gelatinization, functionality, baking quality.

INTRODUCTION

Due to forces (friction, shear, collision and impingement) applied on wheat kernels during milling , breaking of starch granules occurs , resulting in formation of Milling Damaged Starch (Suki *et al.*, 2016, Zhang *et al.*, 2019).

The MDS level in wheat flour affects considerably the baking quality of bread. Such an effect can be attributed to the elevation of both water absorption capacity (WAC) and rate of enzymatic hydrolysis in MDS as compared to the native starch. In other words, moderate MDS level could be improve dough quality, on contrary to high MDS level which leads to starch dough as found by Barrera *et al.*, (2013) and Wang *et al.*, (2017)

Recently, numerous researches have targeted at uncovering the diversity in structure, physicochemical and functionality of MDS (Hackenberg *et al* 2016, Ooms *et al*, 2018). Meanwhile, Wang & Zheng (2020) published an extensive review on MDS in terms of generation, measurement, functionality along with its effect on starch–based food systems. The present article summarizes the effect of milling conditions on MDS and thereby its effect on the quality of baking products.

Factors affecting formation of MDS

Quality of wheat kernels, flour coarseness and milling conditions are the main three factors affecting formation of MDS. Harder wheat grains possess higher MDS than the soft ones. This can be attributed to the requirement of stronger milling force to destroy the tightly structure of starch grains belonging to harder grains. Consequently, the damaged severity increases (Makowska *et al.*, 2014, Abo-Dief, 2020).

Wheat flour contains starch in a range of 78-82%. The level of MDS depends on hardness of the kernel as well as grinding severity as reported by Scanlon *et al.*, (1988).Obviously, more grinding energy is required for hard grains to mill endosperm into flour (Posner & Hibbs, 2005, Abo-Dief *et al* ., 2019)

It is noteworthy that MDS content affects the quality of flour. Wet gluten along with MDS play a pivotal role in determining dough and thereby bread quality. According to Wang & Zheng (2020), higher level of MDS and lowest gluten content (by hard milling) causes a dilution of gluten network and consequently reduces its ability to holding more water. The wide variation in the amount of MDS in wheat flour can be attributed to the tempering conditions and process of reduction during milling. Notwithstanding, it was reported that the flour physical properties including colour, particle size and MDS are influenced by each of the following factors: wheat quality, milling system (Barak *et al.*, 2014, Rahil *et al.*, 2015, Sakhare *et al.*, 2015).

Leon *et al* (2006) found that Properties of bread during storage is controlled by higher level

of MDS. This effect is a result of lowering starch-gelatinization enthalpy (ΔH) and higher melting enthalpy of amylase-lipid complex.

Compared to dry milling, wet milling could better ensure starch granular integrity as a result of absorption the heat generated through milling. Such an effect is due to the excessive water addition. Accordingly, hindering the temperature elevation and decline MDS (Ahmad & Rajab, 2018).

Abo Dief (2020) found that prolonging the period of tempering to 36 hr at 12C° resulted in a decline in the level of MDS for Australian and Russian wheat. This can be attributed to the lower tempering temperature which lower water penetration within the wheat grain and thereby required longer time until the endosperm becomes moist. So, the starch granules become more resistant to pressure and shear forces applied by milling rollers as a result of extending tempering period to 36 hr.

Structure of MDS

Granules of MDS are rough, distored and deformed. The greater MDS level is, the rougher and more irregular and distroed starch granule is (Barrera *et al.*, 2013, Sakhare & Inamdar, 2014, Wu *et al.*, 2018).

Scanning electron microscopic (SEM) examination was used by Abo-Dief (2020) to illustrate the effect of tempering conditions (tempering and time) along with milling systems on the appearance and size of starch granules. The photographs showed that the hard milling gave more damaged starch, cracked flatted or less rouned for the flour of the two cultivars (Australian and Russian) than that of normal milling (Figure 1 and 2). Also, the tempering at 12C° had generally some effects for different tempering times being less pronounced on the appearance of starch granules. Such n effect can be explained on the basis that the amorphous amylose, like a flexible mechanical plasticizer, could absorb excessive shock and cushion the destruction of amylopectin crystalinity via external forces in starch granules, and thereby alleviating the particle size reduction (Liu *et al.*, 2018).

Functionality of MDS

Generally, a decreasing of tendency in both gelatinization temperature and enthalpy (ΔH) could be traced as a results of high MDS level (Shi *et al.*, 2016). This phenomenon can be attributed to the increased disorder in crystalinity structure of starch, which in turn reduces the energy required for gelatinization. Obviously, moisture content plays a pivotal role in gelatinization of MDS (Liu *et al.*, 2018).The MDS often has lower viscosity, which results in fragile surface of broken MDS when they get swollen during gelatinization (Tan *et al.*, 2015)

Regarding water hydration property of MDS, the higher the milling severity is m, the greater the MDS solubility is (Dhital *et al.*, 2010 & Liu *et al.*, 2017). The point of interest is that the MDS has augmented rate of *in vitro* digestibility, on contrary to native starch. It was reported that higher MDS could be result in greater digestibility percentage.

Effect of MDS on baking quality

The MDS plays a key role in determining the quality of baking products. For instance, texture of these products is influenced by MDS (Liu *et al.*, 2019)

Bread produced from flour has high MDS level gives loves of low specific volume (Hackenberg *et al.*, 2016). Due to the high water capacity of MDS, enzymatic hydrolysis is reported in addition to lowering the formation of fermentable sugar and consequently dimishing the amount of gas generated during fermentation (Hackenberg *et al.*, 2016). In other words, MDS may cause disruption of gluten network. Such an effect lead to poor ability of dough to hold gas. Moreover, it was found that MDS has effect on colour of the baked products and accordingly affects the appeal of consumers (Vouris *et al.*, 2018).

Use of wheat flour containing high MDS was found to diminish the diameter of cookies. This can be explained based on the MDS which leads to stiff dough (Barak *et al.*, 2014, Mancebo, *et al.*, 2015)

In a conclusion, MDS plays a pivotal role in determining quality of wheat flour and subsequently the baking products made from it (Abo-Dief, 2020, Wang & Zheng, 2020).

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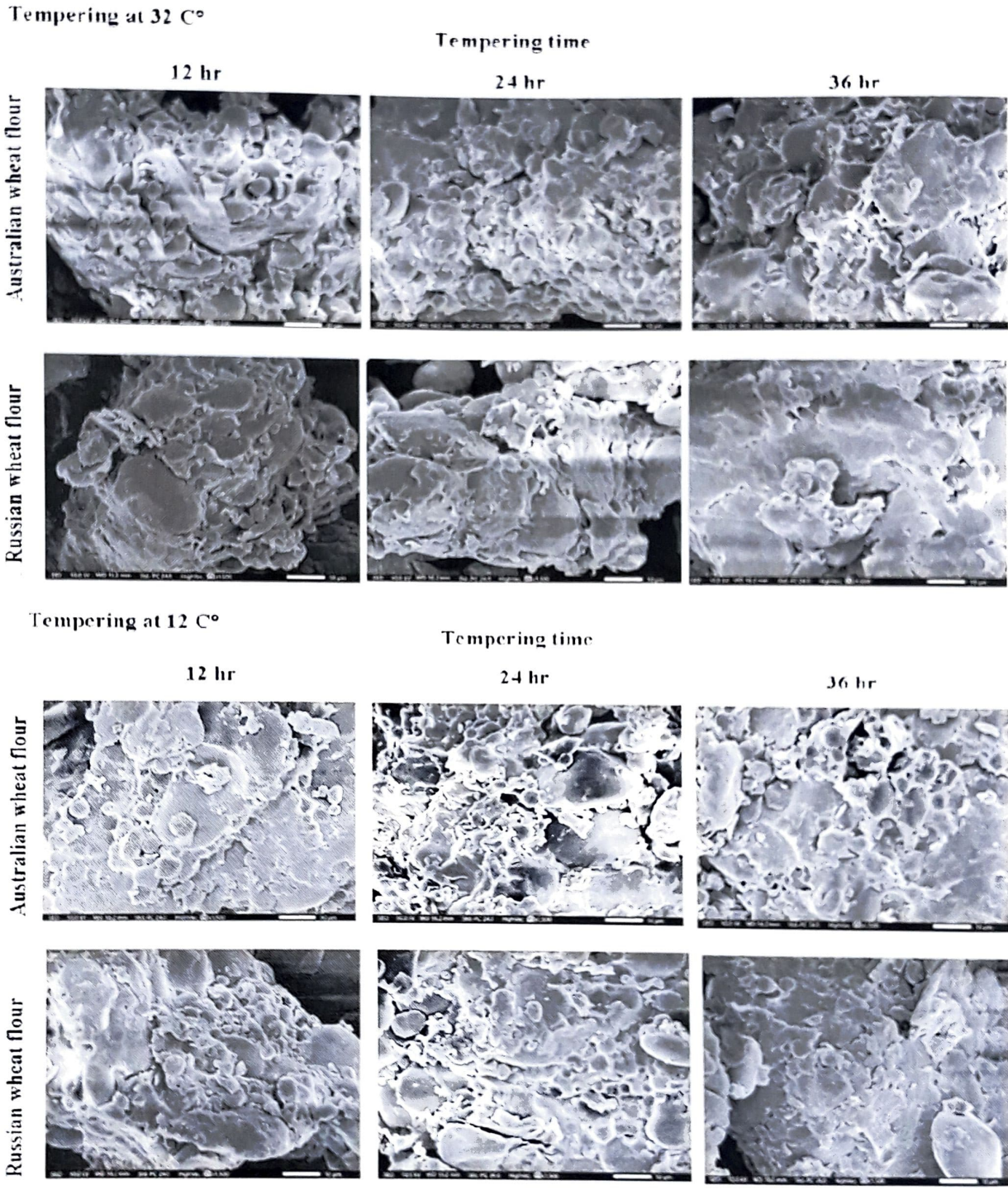

Fig. 1: Effect of tempering conditions and hard milling system on starch appearance for Australia and Russian wheat flour

References: Abo-Dief (2020)

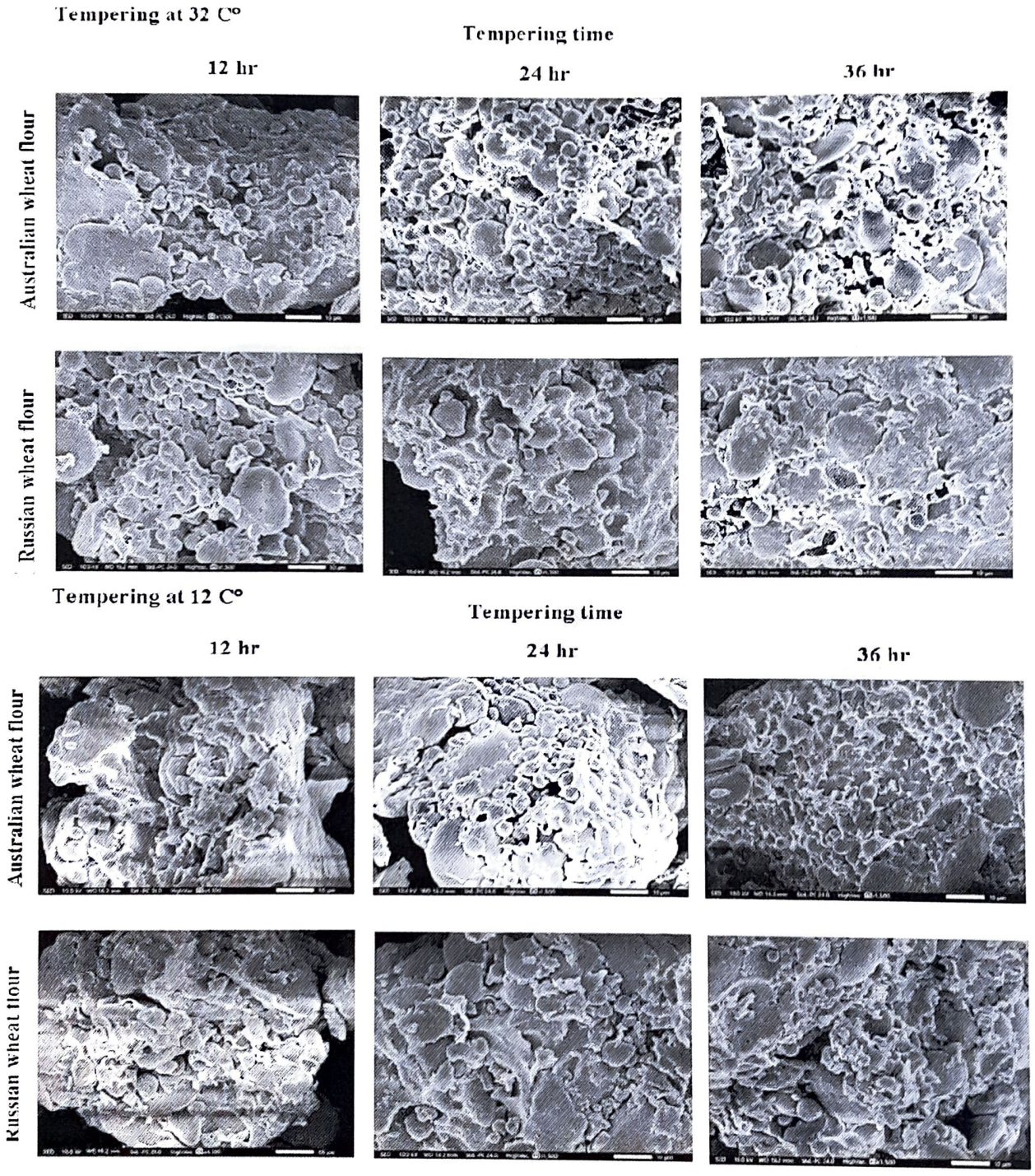

Fig. 2: Effect of tempering conditions and normal milling system on starch appearance for Australian and Russian wheat flour

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نشا الطحن المحطم فى دقيق القمح: التكوين، التركيب، الوظيفة والتأثير على جودة الخبيز : مقال

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فى هذا المقال تم مناقشة نشا الطحن المحطم وذلك من منظور التكوين، التركيب، الوظيفة بالإضافة إلى تأثيراته على جودة منتجات الخبيز. يتباين نشا الطحن المحطم عن نظيره العادى (السليم أو غير المحطم) من حيث البناء الحبيبى، البللورية و التكسير الجزيئي. وتعتبر هذه الاختلافات مسئولة عن الصفات الوظيفية المختلفة لنشا الطحن المحطم .بناء على ما تقدم فإن عملية الجلتنة، صفات العجينة، الهضم الإنزيمي تحت ظروف المعمل تتباين بشكل واضح فى حالة دقيق القمح الذى يحتوى على نسبة عالية من نشا الطحن المحطم وذلك مقارنة بنظيره المحتوى على نسبة أقل من هذا النشا. يناقش هذا المقال كل المعلومات المذكورة أيضا.