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Characteristics of durum wheat used for pasta

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Abstract

Durum wheat is an important species of wheat. It is a cereal with the same genus and with origin alike to bread wheat. A tetraploid with genomes related to wheat. Durum wheat has a diverse environment compared with bread wheat and well adapted in semiarid regions. Global production of durum is 6–8% to the production of bread wheat production. It has high protein content with hard grain texture vitreous and amber-colored. A special niche of durum is used as a food crop for making couscous, pasta, burghul and other various traditional dishes. The main of durum breeding include higher protein content with disease Resistance, more grain weight, higher grain vitreous, low screenings, higher semolina yield and color, improved pasta-making features with stronger dough characteristics. Durum is a self-pollinated crop and hence pedigree breeding is the most recommended method for its breeding. The prevailing diseases of durum are crown rot, *Fusarium* head blight, stripe, leaf, and stem rusts. Nitrogen nutrition is an important aspect of durum cultivation as grain quality and protein content reflect the price for farmers and ultimately increased its market value. The future of durum appears to be very good due to an increase in the production of pasta.

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Introduction

Durum wheat (*Triticum durum*) is one of the world's most important, nutritive crops that belong to the family *poaceae*. In 2018-19, the world production of durum wheat was almost 800 million metric tonnes (Worden, G. C. 2004).

The biggest producers of durum wheat are the European Union, Australia, the USA, Canada while Italy is producing about 4 million tonnes making the biggest contribution i.e., 41% of EU production and 10% of the world (Nosworthy *et al.*, 2017). The main durum cultivating areas are North America (including Mexico), the former Soviet Union, North Africa, Southern Europe, Middle East and India. In the world, durum is grown and cultivated over 13 million hectares and almost 30 million tonnes is produced every year. Among the world wheat production, durum constitutes only 5-8%. Durum wheat is tetraploid species of wheat having 28 chromosomes.

The grain of durum wheat is very vitreous, hard and amber-colored having high protein content. Durum wheat is utilized for the production of a variety of food products for example pasta, semolina, desserts, couscous and burghul wheat (Kadkol and Karayigit *et al.*, 2020). In durum wheat, there are various types of quality parameters that are of considerable importance in the case of milling and its products. The description of those parameters is given below:

Test weight and thousand kernel weight

The widely used specification in wheat grading is test weight (TW), which is affected by the shape and size of the grain because it is internationally recognized as an index of wheat milling potential and soundness of wheat. Two factors are responsible for lowering the TW, one is grain shriveling due to terminal drought and the second one is grain weathering caused by rain at the time of harvest. The high-protein, shriveled grain reduces the milling performance of semolina. Because small kernels have a lower percentage of endosperm, that is milled into semolina. In the case of durum wheat, the value of test weight should be greater than 76 kilogram/hectoliter. The thousand kernel weight (TKW) is also the quality parameter for determining the weight of grains (Grundas *et al.*, 2016 *et al.*, 2015).

When durum wheat is milled into semolina the most important factor is test weight. The measurement of the weight of the given volume is termed test weight. The test weight of weak wheat is 55-60 kg/hl and that of strong wheat is 80-83 kg/hl. There is another method also that is the measurement of weight of 1000 kernel of wheat.

The 1000 kernel weight of durum wheat is 30 to 40 g. Pomeranz quotes Geddes who reported that if the test weight of wheat is higher than the endosperm percentage will also be higher and semolina yield will also be higher. If the kernel of wheat is undamaged by the environment, fully matured, free from diseases and plump then the test weight is greater (Sharma *et al.*, 2021).

Hard vitreous kernels

The kernel of durum wheat should be vitreous and translucent to give good semolina production and to lessen the pasta issues like white specks, poor cooking quality and weak strands, these issues occur when grain vitreousness is low i.e., less than 50%. Starchy or non-vitreous kernels upon milling tend to give usual flour than semolina because non-vitreous kernels are soft and usual flour will produce white specks in the pasta. If the grain protein content is high then hard vitreous kernel are not considered because millers of durum wheat use finer granulations in the milling process of durum wheat (Grundas *et al.*, 2016).

Grain size

The grains that fall through a 2mm screen in milling are termed undersized grains. When there is a high proportion of undersized grains, they become undesirable for milling because it lessens the semolina yield and produces non-uniform particle size. These affect pasta quality and produce white specks in pasta because of uneven hydration (Grundas *et al.*, 2016 *et al.*, 2015).

Grain hardness

The key determinant of milling performance for the production of semolina is grain hardness. The grain texture of wheat grain can be determined by proteins and these are known as puroindolines, friabilin and grain-softness protein. These all are related and friabilin is a puroindoline. But genes of puroindoline are not present in durum wheat, the absence of these is cause for the hard texture of durum wheat (Karayigit *et al.*, 2020).

Semolina yield

The durum wheat milling performance is better predicted by test weight than kernel weight. Purity parameters can be analyzed with the number of brown specks per unit area and ash content in semolina. The mill with higher extraction rates gives semolina with high ash content because semolina is contaminated with bran and this lowers the yellowness and brightness of semolina (Grundas *et al.*, 2016).

Gluten strength

Edwards *et al.* noted various ranges in strength of gluten among groupings of HMW-GS and said that specific allelic patterns indicate the ability for good performance but no guarantee for that performance.

The exact cause of strength of gluten and firm pasta's optimum level is not clear. The gluten strength of durum is determined by the gluten index test (Karayigit *et al.*, 2020). In the manufacturing process of pasta, gluten strength is very important because it influences the texture of the pasta and also has a role in the cooking quality of pasta (Grundas *et al.*, 2016). Farinograph properties are strongly influenced by gluten strength, this has a relationship to enhance the cooking quality of pasta (Samaan *et al.*, 2006).

Composition of durum wheat

The composition of durum wheat grain is:

Germ (embryo) 2 to 4%

Endosperm 75 to 80%

Aleurone layer 5 to 8%

Pericarp 7 to 8% (Abecassis *et al.*, 1987).

The chemical composition of durum wheat grain contains protein, lipids, starch, carotenoids, xanthophylls, etc. that affect the quality of durum products and are discussed here.

Starch

Starch is a very important reserve and it is present in the form of the semi-crystalline granule. Amylopectin and amylose are the major components of the starch. The amounts of amylopectin and amylose are 72 to 75% and 25 to 28% respectively in durum wheat. The diameter of these small granules is up to 10mm (mean diameter is 5mm) and the diameter of large granules is 20mm (Goesaert *et al.*, 2005). Starch is composed of only one building block is glucose (Sharma *et al.*, 2021, 2010). Amylose retrogrades with cooling, stirring of pasta and pasta's viscosity rises to reach the final value (Karayigit *et al.*, 2020). The sticky texture in pasta is contributed to the synthesis of a continuous starch phase linked with disrupted starch granules which are swollen on the surface of pasta (Zweifel *et al.*, 2003).

Protein

Durum wheat contains about 12-16% of protein. Protein has its five subclasses like polymeric glutenin (16%), monomeric gliadin (33%), globulins (3%), albumins (15%) and the residue 33%. Proteins are made up of amino acids and every amino acid has a hydrocarbon group, amino group and carboxyl acid group. In the proteins, the amino acid group and carboxyl acid group are joined with each other by peptide bonds (Sharma *et al.*, 2021, 2010). In USDA World Wheat Collection the protein content of 12,600 varieties was analyzed and resulted as 7%-22% (dry weight) d.w. (Zilic *et al.*, 2011).

In process of protein biosynthesis in durum wheat, it can be reported that the process of synthesis of protein and accumulation may lead to a less or more aggregated state which affects the technological properties of semolina and pasta. Various authors like Favret *et al.* and Johnson *et al.* said that the protein content must be represented as the quantity in 1 seed, not as % of the weight of seed (Ruisi *et al.*, 2021). Ram (2003) and Aghaei (1995) assumed that protein subunit (high molecular weight glutenin subunit 2* 7+8) were in correlation with improved dough strength as despite subunit null. On *Glu-B1* chromosome, the 6+8 subunit was in association with stronger gluten type than 13+16 & 7+8 but weak gluten characteristics are due to subunit 20 (*Glu-1B*). Bechere *et al* (2000) reported that it is safe to use low molecular weight glutenin patterns in association with durum wheat quality because similar high molecular weight glutenins can be linked with 2 different patterns of low molecular weight glutenins. In the programme of breeding, it is useful to discard lines with HMW-GS 20 and LMW-1 and electrophoretic analysis is combined with Sodium dodecyl sedimentation test to develop durum wheat cultivars with good firmness and viscoelasticity of cooked pasta (Gregova *et al.*, 2012).

Grain protein

The grain protein content in durum wheat is an important quality parameter that should be greater than 13%. So that after milling more than 12% protein should be present in semolina important for producing pasta with good textural properties. High-protein semolina produces physically stronger and elastic pasta (dry) than low protein semolina. High protein content in semolina has the potential to produce pasta firmer, less sticky and resistant to overcooking. There are some negative aspects also for extra high protein content like lesser TW and semolina yield that gives duller pasta. Semolina containing a low amount of protein produces fragile spaghetti having very low firmness. Durum wheat with high-protein content enables the pasta for swelling during cooking, allows retention of firmness with overcooking and lessens the cooking loss (Grundas *et al.*, 2016).

Prolamins

Durum wheat prolamins are classified based on solubility, the alcohol-soluble is called gliadin and the insoluble is called glutenin. Glutenins are responsible for gluten strength and elasticity and gliadins are for the extensibility and cohesiveness of gluten. Gliadins are joined together with disulphide bonds and are classified as α/β- and γ-gliadins, those gliadins which are non-connected are named as ω-gliadins. Gliadins may act as chain terminators and LMW-GS can work as chain extenders. These proteins comprise 80 to 85% of gluten proteins and are very important in determining viscoelastic properties of dough important in the quality of pasta (Balakireva and Zamyatnin, 2016).

Gliadins

Gliadins are known as single chain polypeptides and gliadins are classified into four classes α-, β-, γ-, and ω-gliadins based on electrophoretic mobility on sodium dodecyl sulphate-poly acrylamide gel electrophoresis (Balakireva and Zamyatnin, 2016).

Gliadin-45 type band is linked with high elastic recovery and gliadin-42 type band is with poor elastic recovery. Wasik and Bushuk said that the quantity of glutenin polypeptides correlates with spaghetti-making quality. The molecular weight of these polypeptides is medium. The cause of the relationship between gliadin 45 and gliadin 42 and viscoelastic properties of durum wheat is low molecular weight glutenin polypeptides. Payneeta reported that the low molecular weight-2 group was present in durum varieties in gliadin-45 types and the low molecular weight-1 group was in gliadin-42. It was suggested that the gliadins are causal agents of gluten quality and low molecular weight glutenins are of the strength of gluten (Du Cros, 1987).

In pasta processing during dough formation, when water is added the disulphide bonds will break and the unfolding of the gliadin molecule occurs. This unfolding results in the formation of new bonds with glutenin molecules and making the gluten network stronger (Sharma *et al.*, 2021). There is a close relationship between α- and β-gliadins. These are known as α-type gliadins. α- Gliadins are related to intolerance of gluten but glutenins & γ-gliadins are not. The sum of gliadins' Sulphur-rich and Sulphur-poor subunits ranged as 58.65%-64.43% in durum wheat (Zilic *et al.*, 2011).

Glutenins

Glutenins molecules are also classified into low molecular weight glutenin subunits and high molecular weight glutenin subunits based on sodium dodecyl sulphate polyacrylamide gel electrophoresis (Balakireva and Zamyatnin, 2016). The molecules having 30-55 kilo Dalton molecular weight (Mw) range come in the category of low molecular weight and those molecules having 100-140 kilo Dalton come in the category of high molecular weight subunits. These subunits make heterogeneous mixtures of polymers with the bonding of disulphide and peptide linkages. The molecular weight of glutenin proteins is up to tens of millions and these are considered the largest protein in nature (Zilic *et al.*, 2011).

The ability to make disulphide bonds required for making up glutenin polymer structure is affected by differences in the number of cysteine residues, in size of glutenin subunits and polarity. The insoluble glutenin content is 26.76% of the total proteins in durum wheat. Glutenin is also the major wheat storage protein (Zilic *et al.*, 2011). In the process of pasta manufacturing, the viscosity (extensibility) of dough is increased due to the gliadin and glutenin is responsible for the elasticity (strength) of the dough (Sharma *et al.*, 2021).

Amylose and amylopectin

The amylose content (0.7 to 22.9%) is obtained by substituting the durum starch with waxy hexaploid wheat. In the blends of flour, the amylose content was decreased by increasing the percentage (%) of waxy starch as a result stickiness and firmness of cooked pasta increased whereas cooking time decreased. During cooking, soluble carbohydrate like amylose arising from the granules of starch is the reason for the stickiness of pasta. So, to enhance the stickiness on the pasta surface the carbohydrate in the form of amylopectin will be released in the manufacturing of pasta (Karayigit *et al.*, 2020).

The pasta firmness also increases by increasing the amylose content. The granules are tightly packed in high amylose starches, on swelling have resistance to deformation and rupture. This may be the explanation for the greater ability for the production of firmer pasta. Due to the rise in amylose content, the cooking loss in pasta increased and water uptake decreased. Hospers *et al* (2013) fed humans pasta of 40% amylose content in comparison with control past of amylose content 25.9% and assumed that it lowers the insulin levels & postprandial blood glucose (Karayigit *et al.*, 2020).

Gluten

The viscoelastic properties of the dough are determined by grain proteins and the protein that is involved in the network formation of dough is known as gluten. Gluten protein is measured when we wash the dough under running water. In this process, the particulate and soluble matter is washed out to give a proteinaceous mass that exhibits cohesive nature on stretching. On a dry weight basis, the gluten constitutes 75% protein and the remaining are lipids and starch. Furthermore, the prolamins that are not soluble in alcohol-water mixtures due to their presence in polymers stabilized by interchain disulphide bonds are known as glutenins and gliadins, these both form gluten. The major proteins that are present in the endosperm of grain are prolamins (Shewry *et al.*, 2002).

The HMM subunits comprise 12% total protein and it corresponds to 1 to 1.7% flour weight. The subunits are very important because they are responsible for determining dough viscoelasticity properties and are linked with high or low dough strength. The HMM subunits are present in polymers of glutenin mainly in high molecular polymers and their amounts correlate with the strength of the dough. The balance between "trains" and "loops" can also contribute to gluten elasticity such as dough extension will result in "unzipping of the trains" and "stretching of the loops". The extended chains that are formed give elastic energy to dough this tells about the increase in dough resistance in the mixing process (Shewry *et al.*, 2002). Gluten protein is responsible for the elasticity and *al dente* chewability of pasta (Sharma *et al.*, 2021). The most important parameter of the cooking quality of durum wheat is gluten viscoelasticity, this is linked with a protein termed as Ll\iW-glutenins and gamma gliadins coded at locus Gli-Bl. This protein has strong aggregative properties. This protein can differ type 42 and type 45 genotypes about 15% and 30 % respectively (Ruisi *et al.*, 2021). The viscoelastic properties of gluten are directly affected by the aggregation state of proteins.An improvement occur in the cooking quality of pasta when the maturation process goes on. It can be reported that if the metabolism of nitrogen is not involved in origin of various physico-chemical properties then the cooking quality potential will be poorer. John & Carnegie reported that disulphide bonding between proteins occur only in the drying of grain (Ruisi *et al.*, 2021).

The high molecular weight forms in protein with the distribution of molecular weight same as in the case of gluten obtains from mature seed reported by Miflin *et al* 1974 Pernollet said that the physical forces involving in the growth of granules of starch and in the drying of grain that may arise for disruption of the membrane of protein and for arising up new linkages in between proteins and in between other constituents and proteins (Galterio *et al.*, 1987). The wet gluten content in durum wheat ranged from 20.00% (ZP 10/I)-32.20% (ZP 7858) in durum wheat (Zilic *et al.*, 2011). SDS-sedimentation volume was in poor correlation with α-amylase activity. The SDS-sedimentation test predicts the durum wheat gluten strength & explains that sprout damage does not influence the strength of gluten (Sission *et al.*, 2020).

Carotenoid pigment

The natural carotenoid pigment content is responsible for giving the bright yellow color in durum products. The oxidative degradation of carotenoid by lipoxygenase (LOX) enzyme is also important in imparting yellow color to products. In the pasta manufacturing process, pigment loss mainly occurs. The pigment loss is related to semolina LOX enzyme activity. If durum wheat has a higher pigment content then the reaction of LOX will be hindered by beta-carotene and bleaching of semolina will be decreased. So, lower LOX activity and higher pigment content are selection parameters for giving yellow color in durum wheat products like pasta. If there exists high peroxidase activity then the pasta will show brownish color masking the yellow color (Karayigit *et al.*, 2020).

Lipids

The lipid pigments present in endosperm comprise xanthophylls. The main xanthophyll in durum wheat is lutein. Other lipids in durum wheat are sterols, hydrocarbons, phospholipids, glycolipids, fatty acids and glycerides. The short mixing times (less than 1 minute) and high-temperature drying (greater than 70°C) decrease the influences of LOX. Monoglycerides with saturated fatty acids when added in the dough the stickiness of pasta is lowered and tolerance in overcooking was maintained. Free polar lipids can join with gliadin by hydrophilic bonds and polar lipids linked with glutenins. These bonds increase the interaction of proteins that gives structural support to the gluten network. The removal of non-polar lipids and total lipids had a bad influence on the quality of pasta like an increase in cooking loss and pasta stickiness described by Matsuo (Karayigit *et al.*, 2020).

Milling of durum wheat

Cleaning, tempering, milling and purifying are the steps that are performed when durum wheat is milled into semolina. First of all, grains are cleaned from any other particles like insects, stones and other grains because these things affect the quality of semolina and can also decrease the efficiency of rolls in the grinding mill. After cleaning, the tempering process is performed. Before grinding the durum wheat grain is tempered to a moisture content of about 16% because durum wheat grain is hard. In the tempering process, the bran and endosperm separation can occur. The durum wheat after the tempering is ground on the rolls of the mill and grain opens and endosperm releases the bran portion. After grinding, the milling of endosperm is carried out into semolina and semolina is purified from the bran particles and flour. In the milling process of durum wheat grains, almost 25 to 20% portion converts into bran, 65 to 70% in semolina and 10% into flour. The semolina fraction comprises of a variety of sizes; from around 100-650 µm, 65 to 70% of this is in the size almost 250 µm (Sharma *et al*., 2021).

Gluten is present between the spaces of granules of starch. Before the breakdown of starch-protein interaction, the starch granules break in the milling process of hard wheat. In this case, the starch is termed as damaged starch. If the durum wheat grain is milled into usual flour then the damage of starch will be more. For pasta production, greater starch damage is not good so here is the reason why durum wheat kernel is milled into semolina rather than usual flour (Sharma *et al*., 2021). When the extraction of milling increases, more endosperm near the aleurone layer & bran is removed results in increasing the protein content of semolina (Samaan *et al*., 2006).

In the usual milling process, the aleurone layer and the pericarp together produces the bran streams. Semolina is produced by the endosperm (between 150 and 500 microns) but endosperm also produces flour (below 150 microns). At the cleaning stage, before milling, the major part of the germ is usually removed from the grain (Abecassis *et al*., 1987). The purpose of milling durum is to obtain much semolina with less production of flour for pasta manufacturing. Semolina has a higher selling price so it is very cost-effective (Sharma *et al*., 2021).

In wheat milling, a specific characteristic obtains from the presence of crease in grain. This is not possible to reach the bran present inside the crease because the aleurone layer and pericarp cannot be separated. So, millers of durum wheat have to open the kernel then the stepwise removal of endosperm from the bran takes place instead of starting from outside and going inwards. This process is carried out with the help of break rolls that produces a shearing and crushing action. The bran cannot be separated only from sieving in mill streams of durum wheat and cannot be scratched up like in normal flour and bread wheat technology. The milling process of durum wheat should use corrugated rolls and the semolina separation is carried out at every step. Then the purification process of semolina should be done based on their density using purifiers and of their size using sifters (Abecassis *et al*., 1987).

In bread wheat milling, purifiers are not used. The important role of purifiers is striking between milling of 2 kinds of wheat. In durum wheat products, color is a crucial parameter in the case of quality. The color of pasta or mill product is measured through the brown index and yellow index colorimetric determinations. The low brown index and high yellow index shows higher quality. In streams of semolina, the yellow index of flour remains constant while the yellow index decreases for central to peripheral areas (Abecassis *et al*., 1987). In both the flour and semolina, the brown index is lower in the central streams and vice versa. The protein content is also lowest in the central streams and vice versa. In the case of flours, the peripheral flours have lower gluten content despite higher protein content. The firmness of gluten increases from central to peripheral in both flours and semolina (Abecassis *et al*., 1987).

It is particularly higher in the case of central (3.55 mm) flours and of intermediates (3.21 mm). In the case of gluten recovery, it is lower in peripheral ones than in central in both flours and semolina. Gasiorowski and Obuchowski explained that in the milling of durum wheat the starch granules are influenced by the occurrence of stresses because these are sensitive to mechanical action and are damaged. The granules of starch that are damaged absorb greater water (Boggini *et al*., 2012).

Granulation of semolina

The particle size of semolina has an effect on water absorption in pasta dough and on the drying process of pasta so it is very important in the pasta manufacturing process. This is obvious that it affects pasta quality. It is necessary to have a small range in size of a particle because small particles absorb more water than other ones. The white specks in pasta are due to the bigger particles. The usual size of semolina for the production of short pasta like macaroni finer than 350 µm and long pasta like spaghetti is finer than 630 µm. Semolina flour is utilized for the production of noodles and coarsely milled semolina greater than 630 µm is for the production of Couscous. If semolina with a very small particle size is utilized for the production of pasta the starch will leach out into cooking water and mushy pasta will be produced. The reason is that in these small particles, the granules are more damaged (Sharma *et al.*, 2021).

Dough

The dough formation process involves the gluten network formation and in this protein-containing semolina particles exude proteinaceous fibrils, these make a cohesive dough. During the process of extrusion and mixing several changes occur and this is termed as dough development. At the molecular level, various changes occur like the interaction of glutenin, gliadin and gluten formation (Viscoelastic matrix). The irreversible protein-protein cross-linked are made when the hydrated gluten is subjected to heating. At a temperature below 55°C the starch acts as an inert filler & cannot absorb more water (Karayigit *et al.*, 2020).

During the heating process, the starch becomes rubbery, loses its rigidness & can absorb water. As the granules swell, the viscosity increases and soluble material is released from the granule. If the temperature reaches above 55°C, gluten becomes stiff, rough and makes a gel. This type of gluten exhibits broken gel fragments in pasta and pasta strands will be weaker. So, the maximum temperature is maintained below 55°C during the dough making process. The dough of pasta absorbs almost 31 to 35% water. Edwards *et al.,* by the use of reconstitution, reported that low molecular weight-2 protein is associated with the strengthening of the dough more than low molecular weight-1 protein (Karayigit *et al.*, 2020). Cubadda determined that the dough development is affected by particle size distribution with the regulation of hydration during the stage of mixing. Improper hydration is dangerous to dough development because with an increase in the hydration the dough strength will be decreased (Samaan *et al.*, 2006).

Farinograph

The starch damage & gassing power is increased due to the reduction in particle size of semolina granules results in decreased development time & increased Farinograph water absorption (Karayigit *et al.*, 2020). Brabender Farinograph stability, dough development time and water absorption affected by milling technique. The main and first parameter associated with Farinograph is damaged starch and the second one is the content of protein. In research, it was reported that particularly at low protein content Farinograph stability and development time decreased. The Farinograph development time increased with the slow reduction of hard wheat into flour. The dough properties are weakened due to excessive water absorptions. When the protein content is high, the gluten protein absorbs the water released by damaged starch, stabling the consistency of the dough and masking the weakening effect of released water (Dexter *et al.*, 1994).

Mixograph

The development time of mixograph is strongly linked to the firmness of pasta (Karayigit *et al.*, 2020). The longer particles of semolina would take longer time for hydration which would delay the formation of gluten and result in delaying the time required for maximum consistency of dough. By increasing the damaged starch the mixogram peak time is reduced. Before achieving the maximum consistency of dough the flour particles should be completely hydrated. In a study, it has resulted that peak hight was highest with semolina (6.1cm) and durum flour (7.6cm) (Deng, 2017).

Alveograph

The ICC process recommends that based on 15% flour moisture content the 50% constant water addition is needed. The dough becomes stiffer when the starch damage (absorption of water) of flour increases, the height of the Alveograph curve increases, the area under the curve increases and the length decreases. In a study, it has resulted that for the lowest protein samples the curves remained higher and shorter but for those of higher protein samples the height and length were also restored (Dexter *et al.*, 1994). The Alveograph shows the strength of gluten (Karayigit *et al.*, 2020).

Products of durum wheat

Durum wheat is used in the formation of various products like bulghur, frekeh, bread, bread rolls, couscous, durum pastries, etc. But the most important product that is made from durum wheat in the whole world is pasta (Karayigit *et al.*, 2020).

Pasta

Pasta is healthful, nutritious, low-glycemic-index food & it has high levels of lutein that is vitamin A precursor and antioxidant (Ranieri, 2000). Pasta is made with various shapes and types namely penne pasta, noodles, spaghetti, spiral, twister, seashell, elbow, butterfly, flower, etc. (Giacco *et al.*, 2016).

Pasta quality

The important and necessary quality parameters of pasta are as:

Wholesomeness

Yellow color

Low stickiness

"*Al dente*" trait

(Biernacka *et al.*, 2020)

The high color in pasta does not depend on the yellow pigment in semolina but it is affected by the activity of enzyme lipoxygenase in semolina during the processing of pasta. The mechanical texture is described by a variety of terms like bulkiness, chewiness, stickiness, elasticity and firmness (Wrigley *et al.*, 2015).

The ash in semolina gives a dark colour to pasta therefore the grain of durum wheat should not contain high levels of ash. The pasta should be yellow due to the naturally occurring carotenoid pigments because in pasta manufacturing artificial dyes are not used. If gluten and protein components are in lower amounts the pasta will be fragile and brittle subjected to cracking during transport and drying and of low quality. Two components i.e., mineral content and ash content are very important for quality analysis of durum wheat because these components tell whether the wheat is suitable for pasta processing or not (Rachon *et al.*, 2012).

The *al dente* texture is dependent on a soft but external coherent zone and firm core that provides some level of cut resistance (Zweifel *et al.*, 2003). It is very important for the manufacturing of high-quality pasta that the size of semolina granules is not too small or too big. There is another important need for high-quality pasta is that the activity of lipoxygenase should be very low because it will oxidize the carotenoid pigment i.e., lutein and colorless pasta will be produced. The semolina requires less water for dough formation because this less water in starting will ease the drying process and the water should be removed in the drying process (Sharma *et al.*, 2021, 2010). The cooked pasta represents a difference in the distribution of moisture, the water content decreases from 90-39g/100g (Zweifel *et al.*, 2003).

Effect of drying temperature on pasta quality

At high-temperature drying, differences in firmness are apparent but at low-temperature drying differences in quality are apparent in surface parameters linked with firmness and stickiness. The presence of enzyme α-amylase in grain would lead to higher sugar levels & leads to arise in pasta redness during high-temperature drying. Semolina α-amylase activity is not related to cooked pasta resilience, firmness and stickiness (Karayigit *et al.*, 2020).

Durum waxy wheat was not found suitable for pasta production due to its softening effect. Extraction rate of semolina has no particular influence on the cooking quality of pasta. On the other hand, the particle size distribution of semolina has a significant role in the making of pasta due to its influence on hydration rate (Samaan *et al.*, 2006).

Color

The yellowness in pasta is increased by the inactivation of endogenous lipoxygenase enzyme that prevents the bleaching of carotenoid pigment. Whereas pasta dried at high temperature at low product moisture content then it gives red-brown color: synthesis of melanoidins is associated with Maillard reaction. In a study, it was analyzed that all samples of pasta dried at 80°C and 100°C showed an increase in yellowness during the high-temperature drying process (Zweifel *et al.*, 2003).

Texture analysis of pasta

For the measurement of pasta quality, two parameters are important, one is sensory tests like stickiness and firmness and the second is water uptake ability during cooking. During the process of cooking the network of gluten must be at a medium strength to give the required cooking quality. The reason behind this fact is that the too strong gluten network will produce fragile pasta and too weak gluten network will produce mushy pasta on drying. The high protein content is an important parameter to enhance the cooking quality because high protein content gives resistance to overcooking. High-quality pasta needs more big subunits of glutenin than smaller ones. Low gliadin contents and high glutenin contents are linked with high pasta hardness (Sharma *et al.*, 2021).

Reducing sugar content

In the process of spaghetti manufacturing, the increase in reducing sugar content occurs during the process of extrusion due to shearing. In the spaghetti manufacturing process, the activity of α-amylase is limited due to less moisture content of pasta dough and instant moisture loss in spaghetti at the initial drying stages (Sission *et al.*, 2020).

Breaking strength

The breaking strength of pasta is affected by drying temperature because if the drying temperature is low the pasta will become weak after one week as compared to pasta dried at high temperature (Sission *et al.*, 2020).

Cooking score

The cooking score is determined in the sense of firmness and resilience & it is affected by storage time and drying procedure. The temperature for drying of pasta should be 70^{O}C for obtaining good cooking quality. High-temperature drying has a good effect on pasta firmness and resilience (Sission *et al.*, 2020).

Stickiness

Pasta's stickiness will be less if it is dried at 70°C than at 39°C. Storage time does not influence stickiness (Sission *et al.*, 2020). The quantitative information about the cooked pasta is obtained by an adhesion test. It resulted that the pasta dried at 100^{O}C proved to be firmer in comparison with the pasta dried at low temperature. The pasta samples reduced the stickiness except dried at 80°C. High-temperature drying leads to low stickiness and high firmness of cooked pasta (Zweifel *et al.*, 2003).

Conclusion

Durum wheat provides us essential nutrients like protein, iron and zinc in higher amounts. Therefore, durum wheat in nutritional perspective is very important. The different characteristics of durum wheat with different perspectives for pasta formation have been studied. Like undersized grains in milling gives non-uniform particle size and it reduces the quality of pasta. The vitreousness and translucency of durum wheat kernel gives good semolina production and lessens the quality issues of pasta. Likewise the higher test weight of durum produces higher semolina. The stickiness in pasta is due to the higher amount of starch and amylose content. Similarly, the high firmness of pasta is due to the high amylose and protein content. Pasta's extensibility and elasticity is related with high amount of gluten in durum wheat. The high amount of carotenoid pigment imparts bright yellow color to durum products i.e. pasta. This study gives clear understanding for characteristics of durum wheat related to high quality pasta production parameters. Nevertheless, further research will be done in future with new perspectives.

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