Quality of a product may be considered from several angles depending upon the purpose for which it is utilized. It may mean different things to different people. The millers and the bakers divide wheat into strong and weak varieties. In the strong category, gluten is highly elastic and the bread made from it is porous and digestible, whereas similar amount of weak wheat gives smaller, more dense and less attractive loaves of bread. Wheat of either very weak or strong gluten does not make good chapatis (unleavened panbaked bread). Those prepared from the former become brittle soon after cooking and that from the later become leathery. Medium strong gluten type are known to make better chapatis. Similarly, hard and soft wheats may have different meanings and may be used to describe the physical properties of endosperm, kernel vitreousness, protein content, flour strength etc. The kernel hardness influences various quality parameters such as granularity, milling conditions and starch damage. Hard wheat is used for bread making while the soft one is used for pastries, biscuits, cakes, noodles, pretzels etc.

Protein-calorie malnutrition is the most serious nutritional problem in most of the developing countries of the world. Due to lack of animal protein in human diet, the amount and the quality of cereal proteins may determine the adequacy of protein intake in the diet. With increased production of wheat to the level of self-sufficiency, the consumers and the processors in India are becoming quality conscious.

Quality of food grain is a complex phenomenon and may be influenced by several factors which may be genetic and/or environmental. Cultural practices also considerably influence the grain quality. The effect of fertilizers particularly nitrogen seems to be the most pronounced on grain quality of wheat. In this article, the work done on quality of wheat grain and its products as influenced by nitrogen and climatic factors has been reviewed.

Quality Traits: Quality of wheat is judged by the grain protein content, gluten content, vitreousness etc. Wheat is classified in the market on the basis of kernel vitreousness and protein content (which in turn is an estimate of flour strength). The relationship between crude protein content and bread making potential is so well established that the protein is generally accepted as a major indicator of physico-chemical properties of wheat flour.

Flour properties such as water absorption, mixing requirements, loaf volume etc. are all governed by its protein content. Wheat flour with high protein content is required for bread making, intermediate for chapatis, low or cookies and the lowest for preparation of cakes. Flour having high protein content possesses high sedimentation value and viscosity, high water absorption, strong mixing properties and large loaf volume desired for baking commercial bread (Barmore and Bequette, 1968). Cookie diameter (Yamazaki and Lamb, 1961), ash content (Bequette et al., 1963)
and mixing time (Finney, 1963) are also influenced by grain protein content.

Durum wheat (*Triticum durum Desf*) should have high protein content and medium strong gluten for its acceptability for varied end uses. Production of semolina in durum wheat is influenced by number of factors (Pollhame, 1981). Such type of grains yield higher semolina of uniform particle size, free from specks and grits. High percentage of protein or gluten is desired in semolina for preparations of good quality macaroni products. The acceptable limits for desired quality traits of durum and its products are given in Table 1.

**Table 1 : Quality considerations of durum wheat for export purposes**

<table>
<thead>
<tr>
<th>Property</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitreous kernels</td>
<td>80% (minimum)</td>
</tr>
<tr>
<td>Hectolitre weight/Test weight</td>
<td>75 kg</td>
</tr>
<tr>
<td>Protein content</td>
<td>11%</td>
</tr>
<tr>
<td>Moisture content (maximum)</td>
<td>14%</td>
</tr>
<tr>
<td>B-carotene content</td>
<td>&gt; 5 ppm</td>
</tr>
<tr>
<td>Sedimentation value</td>
<td>35 ml</td>
</tr>
<tr>
<td>Yellow berry</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td>Foreign material (maximum limit)</td>
<td>1%</td>
</tr>
<tr>
<td>Falling number value</td>
<td>300 seconds</td>
</tr>
</tbody>
</table>

Yellow berry (starchiness/mealy endosperm/grain mottling/non-vitreousness) is a serious physiological disorder in wheat particularly durum wheat due to which kernels assume undesirable yellowish and soft appearance. Grain quality of non-vitreous grains is poor than the vitreous grains (Fortini et al., 1975; Sharma et al., 1983; Cantamutto et al., 1987). It is caused by high starch accumulation and is associated with low protein content in grains. Proportion of storage proteins responsible for good baking quality is low in yellowish grains (Sharma et al., 1983, Ransom et al., 1989, Gianibelli et al., 1990, Raath et al., 1995). In extreme cases, yellow berry kernels are characterised by the presence of loosely held, distinct protein bodies and exposed starch granules (Sharma et al., 1983). Yellowing appeared to have major effect on protein fractions (Fortini et al., 1975; Fortini et al., 1975) and may influence the composition of amino acids (Hubbard et al., 1977, Waines et al., 1978, Sharma et al., 1983). Presence of yellow berry in durum wheat imparts poor nutritional and industrial value to its varied end products. It adversely affects milling and baking quality of durum products such as macaroni, spaghetti and semolina and imparts undesirable white spots in dried pasta. The accepted limit of yellow berry is less than 10 per cent.

**Effect of Nitrogen:** Nitrogen is an important constituent of plant proteins and is the most frequently deficient element. Protein content of wheat flour is the principal factor determining its baking properties (Bequette et al., 1963). Demand for nitrogen is the greatest during periods of rapid growth and declines towards maturity. Application of nitrogen is known to increase the protein content of grains (Johnson et al., 1973, Bates and Reynish, 1976, Haas et al., 1976, Eppendorfer, 1978, Baghutt and Puri, 1979, Dhaliwal et al., 1981, Ferri et al. (1989); Sombrero and Monneveux, 1989, Bakshi et al., 1992, Fares et al., 1993). However, the first effect of nitrogen is to increase the yield if moisture and other growth factors are adequate. Increase in yield is often associated with corresponding decrease in protein content (Schlehuber and Tucker, 1959). As long as increased nitrogen application increase the yield, increase in yield is more than the protein content. When it is absorbed by the plants in excess of its vegetative needs, increase in protein content of grain and straw occurs (Hunter et al., 1958, Sander and Peterson, 1968, Terman et al., 1969). Nitrogen application mainly increase the gliadin and glutenin fractions (Brunetti et al., 1976). Grain protein content was associated positively with the leaf nitrogen content but negatively with stem nitrogen content. Several workers have reported that the protein content and resistance to yellow berry increased with increasing nitrogen levels (Rao and Bhardwaj, 1981, Sharma et al., 1983, Ferri et al., 1989; Sombrero and Monneveux, 1989, Bakshi et al., 1992, Sayar et al., 1992, Gupta et al., 1997).

Nitrogen increased mainly crude protein, crude fibre and ash content and decreased the starch and phosphorus content (Singh and Lamb, 1960, Agarwal, 1976). Similar increases were reported by Abrol And Uprety (1969). Gupta and Das (1954) also reported increase in protein content with nitrogen application. However, ash content was not affected by nitrogen application (Gupta and Das, 1954). With increase in level of nitrogen, there was increase in the protein percent-
age and its recovery, gluten per cent and its yield, flour recovery, sedimentation value, Pelschenke value, water absorption by dough and phosphorus and potassium uptake by grain, whereas, flour recovery, phosphorus and potassium content in grain declined (Singh et al., 1974). Similar effect of nitrogen on protein content was reported by Hucklesby et al. (1971) and Johnson et al. (1973).

Dose: Application of 105 kg N/ha reduced the incidence of yellow berry (Orphanos and Krentos, 1980). Ryan et al., (1997) reported that 120 kg N/ha decreased the yellow berry incidence. With increase in nitrogen dose from 0-160 kg/ha, there was significant increase in grain protein content while yellow berry decreased significantly (Rao and Bhardwaj, 1982). Application of 120-150 kg N alongwith 60-75 P₂O₅/ha recorded significantly higher grain protein, B carotene content and sedimentation value and lower incidence of yellow berry as compared to lower doses of these nutrients (Kumar, 1997). Elsewhere also, incidence of yellow berry decreased with increasing application of nitrogen upto 180 kg/ha (Dhaliwal et al., 1981, Fares et al., 1993) Similarly increasing the dose of nitrogen from 0-250 kg/ha increased the grain protein content of durum wheat from 11.2-14.7 per cent (Massantini, 1974). However, Robinson et al. (1979) observed that 270 kg N/ha was required for acceptable control of yellow berry.

Increasing nitrogen rates increased the gluten strength (Sombrero and Monneveux, 1989, Bakshi et al., 1992, Fares et al., 1993), sedimentation value (Stickler et al., 1964, Bakshi et al., 1992, Fares et al., 1993), alveographic index (Fares et al., 1993) and loaf volume (McNeal et al., 1963). Increases in grain protein, gluten content, Pelschenke value and water absorption by dough with increasing doses of nitrogen from 0-150 kg/ha were reported (Massantini, 1974). Pasta quality improved (Oporouh and Cernescu, 1975) whereas the ash content and lysine content decreased with application of nitrogen (Allensandroni et al., 1976).

Time and Stage of Application: Time of nitrogen application affects the kernel protein content and incidence of yellow berry (McNeal et al., 1963). Availability of nitrogen to wheat during various phases of its growth and development is an important factor influencing the yield and quality of grain. Robinson et al. (1979) postulated that high demand for non-protein nitrogen required for glutenin production occurred after boot stage. Dexter and Dronzek (1975 a,b) also observed that level of non-protein nitrogen in grains was low after anthesis when glutenins were at the highest rate of production. Nitrogen applied late in the season increased the grain protein content (Reeves, 1954). Nitrogen applied at bloom stage is also reported to increase the grain protein content (Finney et al., 1957). Application of nitrogen at boot stage resulted in significantly higher protein content and reduction in yellow berry percentage (Robinson et al., 1979). Brunetti et al. (1976) indicated that nitrate reductase activity at earing stage was a measure of available nitrogen for protein synthesis. Proportion of vitreous grains increased with late application of 40-60 kg N/ha at ear formation stage (Jurgen and Knittel, 1985). With increase in protein content due to nitrogen application, concentration of lysine and tryptophan decreased. Mosconi and Bozzini (1973) reported that availability of nitrogen during ripening stimulated the synthesis of storage proteins, produced vitreous grains and decreased the incidence of yellow berry.

Top dressing of nitrogen at heading gave higher protein content and gluten content than its basal application (Blum et al., 1980). Application of 270 kg N/ha in 3 equal splits at pre-planting, tillering and boot stage increased the grain size, grain density, grain protein content and reduced the yellow berry incidence as compared to its application in single dose (Robinson et al., 1979). Grain yellow berry content of 18.9 per cent recorded without nitrogen application was reduced to 5.1 per cent with application of 96 kg N/ha at sowing and to 3.7 per cent with nitrogen applied in 2 equal splits at sowing and tillering and further to 3.2 per cent when nitrogen was applied in 5 equal splits at sowing, 3 leaf stage, shooting, heading and after pollination (Parodi et al., 1982). Application of 15-30 kg N/ha as urea at heading, anthesis and post anthesis decreased the yellow berry percentage in grains from 80 to 7 per cent depending upon the rate of nitrogen and stage of its application (Gianibelli et al., 1990). Similarly, split application of one-fourth nitrogen at each of the boot and anthesis stage increased the protein
content and reduced the yellow berry incidence in grains (Dhaliwal et al., 1981).

**Method of Application**: Several workers have reported the effectiveness of urea solution applied as spray in increasing the grain protein content of wheat (Finney et al., 1957; Smith, 1962; Sadaphal and Das, 1966). Elimination of mottling by spraying urea is important as it is related to increase in protein content as well as improvement in appearance and lustre of grains. Urea concentration higher than 3 per cent resulted in complete elimination of mottling (Sadaphal and Das, 1966; Jurgen and Knittel, 1985); however, increase in concentration more than 6 per cent reduced the beneficial effect of spraying urea possibly due to phytotoxicity of higher concentration (Jurgen and Knittel, 1985). Spraying after bloom was more efficient than at blooming or heading (Robinson et al., 1979; Dhaliwal et al., 1981). Single spray at flowering increased the protein content by over 4 per cent (Finney et al., 1957; Smith, 1962); however, frequent sprayings of urea solution caused reduction in plant activity as a result of burning of leaves (Finney et al., 1957).

**Effect of Environment and Cultural Practices**: Finney and Meyer (1952) reported that high temperature during fruiting affected most of the flour properties. Inferior baking quality resulted when high temperature and low humidity conditions existed for the last 15 days of ripening (Finney and Fryer, 1958). Proper conditions for rapid translocation of protein from stem and leaves to grains late in the growing season seemed essential for maximum grain protein content (McNeal and Davis, 1966).

Grain nitrogen content is not the only factor determining yellow berry content of grain (Leonard and Martin, 1963). Marked differences among varieties were observed for prevalence of yellow berry indicating the role of genetic composition (Rao and Bhardwaj, 1981, Gupta et al., 1996; Gupta et al., 1997). Excessive soil moisture at heading and seed maturation period accentuated yellow berry (Robinson et al., 1977) probably by leaching of nitrogen from root zone or by slowing down the process of plant maturation. Late sown wheat showed higher percentage of protein and B carotene (Augustine, 1993, Kumar et al., 1994).

Sowing of wheat on 30 November resulted in significantly higher protein content, B carotene and sedimentation value and lower yellow berry incidence than 1 November sowing at Hisar (Kumar, 1997). Higher incidence of yellow berry was observed in early and deeper sowing (Mahdi et al., 1996).

Adequate availability of nitrogen and proper conditions for rapid translocation of protein from stems and leaves to grain late in the growing season seem essential for maximum grain protein content. Application of nitrogen at later vegetative stages is found to have less effect on vegetative growth and more in increasing the protein content. Spray application of urea has been found effective in increasing protein content in the grains. Environmental factors particularly during later reproductive phase influence the grain quality of wheat.

**REFERENCES**


