Lab Manual No.5

Laboratory Manual on Protocols for Evaluation of Wheat Quality

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Foreword

Wheat is the major source of energy and nutrition for larger part of the population in the world. India is the 2nd largest wheat producer in the world and is the lively hood of hundreds of millions of farmers and consumers in the country. There are large numbers of wheat based products such as fermented pan bread, flat breads including chapati, biscuits, noodles and pasta products. Therefore India has to compete in domestic and international market for wheat based products. This can be accomplished by developing varieties specific to each end-use product. This needs better understanding of chemical constituents of the grain associated with the end-product quality. This will enhance the competitiveness in the wheat based industry and the profitability of farmers.

The current understanding of the role of these constituents in determining the quality of each product has led to the tremendous improvement in the quality of each cereal along with higher yield potential. Excellent progress has been made in understanding the molecular basis of grain quality traits. This has further enhanced the efficiency of breeding in selecting desirable segregants using molecular marker approach. Microlevel tests requiring small quantity of flours have been identified for predicting quality of early segregating generations and hence very useful in breeding for quality. The publication "Protocols for Evaluation of Wheat Quality" in its present form covers detailed aspects of the chemical, rheological and baking quality testing procedures. This will enhance knowledge of wheat workers in theoretical and practical aspects associated with the physical, chemical, rheological and baking quality traits of wheat grain, flour and its products. This will help in recording data on various quality traits uniformly across laboratories under AICRP on wheat and barley and private sector working in wheat improvement and also the baking industry.

It is a pleasure to see the contents of the manual which cover main aspects of wheat quality parameters. The authors deserve appreciation for giving valuable information on wheat quality methodologies. It is hoped that the publication "Protocols for Evaluation of Wheat Quality" will serve as the reference material for testing wheat quality across laboratories under AICRP on wheat and barley and baking industry.

(Gyanendra Singh)

Director, ICAR-IIWBR, Karnal

Dated the 18st September, 2023
Karnal

Preface

Wheat is the staple food and is one of the main sources of calories and nutrition to most of the Indian population. Quality analysis of wheat is required not only for the selection of product specific varieties, but also to meet the trade requirements of both the domestic and international markets. The demand for the traditional and new convenient processed wheat products is continuously increasing, particularly in economically emerging countries. Industrial food processing requires wheat quality attributes that often cannot be met by wheat for traditional foods. Therefore, improving the quality of new wheat cultivars to satisfy the demands of the industry is now one of the main priorities of wheat breeding programmes. The ability to supply wheat that meets local demand for specific end-use quality requirements will thus become more and more crucial. Also, with the surplus production of wheat, India is exporting it to many countries. To compete in the international market, India has to maintain the quality of its wheat produce.

This publication is a guide to the different methods used for the quality evaluation of wheat grains, flour and products. Wheat and flour specifications often require specialized testing to determine how flour will perform during processing. The physical characteristics of grain shape, size, colour, weight and hardness are important as they are indicative of potential processing quality. Information on several chemical (protein content, sedimentation test, falling number and gluten index) and rheological tests including Mixograph, Farinograph, Aleograph is given to evaluate dough and gluten strength properties and baking quality.The finished product formulations and processes described are laboratory testing protocols that are used to evaluate flour quality. They are model systems that may be used to predict commercial production for common uses of wheat flour worldwide. For some methods, micro level tests are also described which can be used to screen thousands of samples of early generations in breeding programmes. The publication will also benefit wheat based industry for assessing the quality of different lots and the flour produced and also help in understanding the quality of the wheat to be purchased from mandis and also farmer's field.

The compilation of these methods was considered necessary to make available the methodologies in the form of manual accessible to all the scientists working in wheat quality and also useful to industry. This will help in recording data on various quality traits uniformly across laboratories under AICRP on wheat and barley and also identification of superior varieties.

Authors

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PHYSICAL METHODS

GRAIN APPEARANCE SCORE

Three characters of the grain viz. size, shape and colour are taken into consideration for scoring the grain appearance. Bold grains with attractive shape, amber golden colour and lustre of the grain are major criteria for scoring. The maximum score awarded is 10 for excellent quality. Grains with all these characters fetch higher price in the market. These characters help the purchaser of the grain in preliminary surveying of the market.

THOUSAND GRAIN WEIGHT

Seed Counter

Grain or kernel weight is the mass of a given number of kernels and is a useful measure of grain size. Several techniques have been developed to determine grain weight, and the most common technique involves the counting of 1000 grains and weighing them and then expressing the result as the 1000-grain weight (TGW). Grain weight is considered to be a function of kernel size and its density. TGW is one of the important scales in seed quality that influences germination, seed vigor, seedling establishment and yield. TGW is positively correlated with the agronomic yield and flour yield. While test weight determines the milling quality of all wheats, kernel weight is decisively superior in predicting the milling quality of hard grains. Both, test weight and grain weight pronounce for the same quality character i.e. milling quality but their relationship has not been conclusively studied. The electronic counter is used for counting 1000 grain weight in gram. Wide range of variability from 22-45 g has been recorded for bread wheat while for durum wheat, the weight varies from 35-55 g.

TEST WEIGHT

Test weight is the weight of a specific volume of grain and is an indication of bulk density of the grain. Test weight usually determines the plumpness of the grain. It is also known as bushel weight or hectoliter weight (Kg/hl). Kernel size and shape have an important bearing on test weight. Uniform, cheeky, dense grains fitting well with each other thereby reducing the inter kernel spacing produce more test weight. It is one of the widely used and simplest criteria of wheat quality and is of primary importance in trade. Test weight is a rough index for the flour yield and several studies have shown positive correlation between them. Immature and shrivelled wheats are usually low in test weight and give correspondingly poor yields of flour.

Method

The Quality group of the IIWBR has been successful in devising an instrument where around 90 g of seed is sufficient to record the value. This is a low cost device which measures the test weight with rapidity and

greater precision.

- Close the slit of the hopper and keep the cylinder slit open.
- Fill the hopper with around 90 g grain.
- Open the hopper slit and allow the grain to drop in the cylinder.
- Close the cylinder slit to remove extra grains.
- Weigh the grain from the cylinder.

Indigenous Test weight Instrument

Results

The quantity of the weighed grains is taken as kg/hl. Indian wheats generally have test weight within 75 – 80 Kg/hl. Flour yield increases and flour ash decreases with the increase in test weight. A flour yield upto 70% and flour ash of 0.4% is normally obtained for a wheat with 75 Kg/hl. Test weight is initially impacted by genetic differences in the structure of the kernel. However, it is also affected by moisture content, method of drying, physical damage to the kernel (broken kernels and scuffed surfaces), foreign material in the sample, kernel size, stress during the growing season, and microbiological damage.

Grain hardness

Grain hardness (GH) is an important parameter, which is used as grading factor to determine wheat types and also to define end-product quality. It has a profound effect on milling, baking as well as end-use qualities of bread wheat. There are two distinct classes of wheat as soft and hard. Hard wheats tend to have more starch damage in flours suitable for bread making; while soft wheats have lower starch damage and finer flour particle size suitable for biscuit quality.

Principle

The SKCS 4100 (Perten) singulates individual kernels, weighs them and crushes between a toothed rotor and a progressively narrowing crescent gap. As a kernel is crushed, the force between the rotor and crescent and the conductivity between the rotor and the electrically isolated crescent are measured. This information is processed to provide weight, size, moisture and hardness information on an individual kernel basis.

SKCS 4100 (Perten)

Method

- A sample of wheat kernels is prepared by removing broken kernels, weed seeds, and other foreign material.
- The sample is poured into the access hopper of the single-kernel characterization system instrument.

- The SKCS instrument analyzes 50 kernels individually and records the results on a computer graph.

Results

Averages and standard deviations of these parameters are reported as SKCS results in terms of values: kernel weight is expressed in milligrams (mg); kernel diameter is expressed in millimetres (mm); moisture content is expressed as a percentage; and kernel hardness is expressed as an index of –20 to 120. Based on the hardness index (HI), the grains with HI < 45 are classified as soft, 45 – 75 as medium hard and > 75 as hard.

FLOUR RECOVERY

Wheat samples are milled to evaluate wheat milling properties, including flour extraction and the amount of non-flour components produced, such as bran and shorts. Flour recovery is the yield of flour obtained from wheat in the milling process. A 100% extraction (or straight-run) is whole meal flour containing all of the grain; lower extraction rates are the whiter flours from which progressively more of the bran and germ are excluded. Even though about 85% of the grain by weight is endosperm, the extraction rate varies between genotypes. Recovery of flour from bread wheat and semolina from durum wheat are heritable traits. Small samples of wheat can be milled on a number of different laboratory mills to produce flour. This flour is used to evaluate different flour and product quality parameters. The most common laboratory mills are the Brabender Quadrumat Flour Mills and the Buhler Laboratory Flour Mill and Chopin laboratary mill.

Principle

The moisture is added to the grain, before milling, to optimize milling efficiency (tempering). This softens the starchy endosperm portion of the wheat kernel, which is to be separated out in the milling process to produce the white flour. The addition of moisture also stiffens the bran and ultimately reduces the energy input required to shatter the kernel, while at the same time avoiding the shattering of bran and germ particles to be separated out in this milling process by sieving or sifting.

The Quadrumat Senior (Brabender) uses two 4-roll units: a break head and a grinding or middlings reduction head. A bipartite plan sifter with two sifter sections stacked one above the other separates the fractions according to their granulation - either as one collective flour or as two separate flours. The moistened grain is first passed through the series of break rollers, then sieved to separate out the fine particles that make up white flour. Rest are intermediate particles of endosperm (otherwise known as product middling or farina) and coarse particles of bran and germ. The middling then makes multiple passes through the reduction rolls, and is again sieved after each pass to maximize extraction of white flour from the endosperm, while removing coarser bran and germ particles.

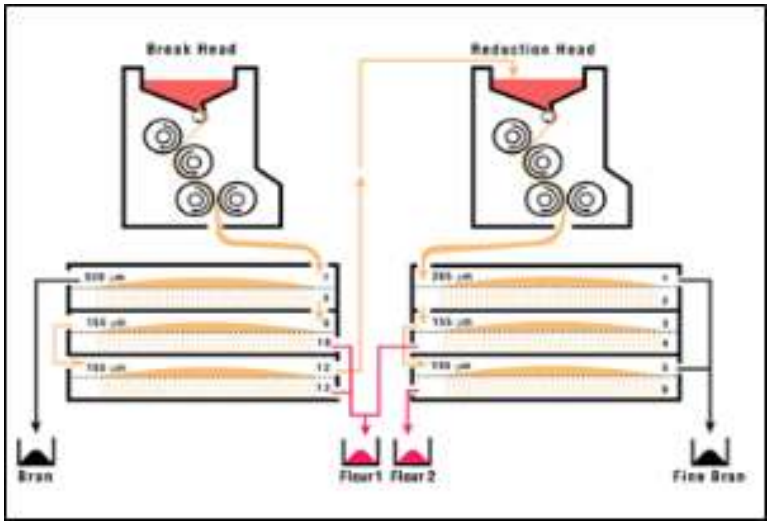
Method

- A sample of wheat is cleaned and the moisture content is determined.
- Water is added to condition (temper to 14% moisture) the wheat overnight prior to milling. Soft wheats require less water and less time than hard wheats ***(Annexure I)***.
- The tempered wheat sample (maximum 1000 g) is run through the mill the following day.
- It takes around 20 minutes to mill 1000 g grains.
- The mill fractions, such as flour, bran, and shorts are weighed and recorded.

Result

Laboratory flour mill results are generally expressed as the weight of flour, bran, and shorts. Flour extraction is reported as a percentage of flour compared to the total output of other mill products; however extraction could be reported as the percentage of flour from the sample of wheat milled. White flour is generated when the extraction rate is 75% or less. If the extraction rate exceeds 80%, the flour will contain bran particles, and if the flour extraction approaches 100%, whole meal flour is obtained. Flour extraction rate has marked effect on its nutritional content. Studies indicated that flour extraction rate affects the protein content, farinographic water absorption and gluten strength. (With an increase in extraction rate, the protein content, fibre, sugar, lipids and mineral matter increases, whereas the starch decreases)

Brabender Quadrumat senior Mill



The Milling process

Chopin Laboratory Mill CD1

DAMAGED AND INFECTED KERNELS

DAMAGED AND INFECTED KERNELS

This parameter merits consideration in grain trade as it reduces the grading value of a given wheat lot. Such types of grain adversely affect the overall quality of end product. Besides poor recovery of flour, they tend to induce early staling in the product by shortening its shelf life. Damaged and infected kernels have no market value except that it can be used as a feed.

YELLOW BERRY

Yellow berry refers to the non-vitreous nature of the wheat kernel. Individual kernels may be vitreous, non-vitreous (yellow berry) or have varying proportions of each ("mottled"). Yellow berry in and of itself represents no defect of the kernel.Yellow berry is an alteration of durum wheat kernels that affects flour quality and, consequently, the quality of products like pasta.Yellow berry has a negative effect on the quantity and quality of semolina and lowers the total protein content of the grain. The pasta products made out of the yellow berry affected grains develop stickiness while cooking. Another adverse effect of yellow berry is the reduction of yellow pigment in the grain. Although varieties do differ somewhat in their predisposition to yellow berry, the over-riding cause relates to N fertility and secondarily, biotic and abiotic stresses on the wheat plant.

SPECK COUNT

Bran fragments and ground impurities are visible as specks in semolina.The presence of specks has a negative impact on the value of the semolina because they cause brown or dark flecks in pasta, reducing consumer acceptability of the product. A count of the number of visible specks is usually conducted as part of the quality control process during semolina production, and often is a primary specification that the miller must meet. The exact nature of the counting process varies, but typically a semolina sample is spread on a table, the semolina surface is flattened, and a grid of known dimension (1.0-inch square) is placed on top. The number of specks present is visually counted and expressed as the total number within a defined area. Visual identification of specks is subjective; since it is based upon observer experience. The limitations of visual speck counting make the development of a rapid objective instrumental procedure desirable for both laboratory and commercial applications. Imaging methods for detecting bran fragments in common wheat flours have been developed using white light illumination and commercialized using fluorescence methods.

CHEMICAL METHODS

MOISTURE CONTENT

The moisture content is one among important factors in grain quality since this data is used for other tests. It denotes as the quantity of water per unit mass of grain and expressed on a percentage basis (i.e. wet basis or dry basis). Flour millers adjust the moisture in wheat to a standard level before milling. Moisture content of 14% is commonly used as a conversion factor for other tests in which the results are affected by moisture content.

Principle

Moisture content is determined by heating a flour or ground wheat sample in an air oven and comparing the weight of the sample before and after heating. The amount of weight loss is the moisture content.

Method (AACC Method, 46-12, 1983)

- Weigh accurately 5 g of wheat flour in an aluminium box with a close fitting lid.
- Place the uncovered box with its lid in a well ventilated oven maintained at 100°C for 5 h.
- Remove and cool the box with the lid replaced to room temperature in a dessicator and weigh.

Results

Calculate the loss in weight due to moisture and express as percentage. NIR instrument can also be used to determine the moisture content in wheat grain and flour samples.

ASH CONTENT

The ash content of the flour can affect the colour of the final end product. Some products require particularly white flour with low ash content while other products, such as whole wheat flour, have high ash content. The ash content in wheat and flour has significance for milling. Ash content also indicates milling performance by indirectly revealing the amount of bran contamination in flour.

Principle

Ash content is determined by high temperature incineration in an electric muffle furnace. When a sample is incinerated in an ash oven, the high temperature drives out the moisture and burns away all the organic materials (starch, protein, and oil), leaving only the ash. The residue (ash) is composed of the non-combustible, inorganic minerals that are concentrated in the bran layer.

Method (AACC Method 08-11, 1983)

- Weigh 3.5 g of well mixed sample in a weighed porcelain crucible (dried overnight at 100°C).
- Place the crucibles in a muffle furnace at around 425° C. Gradually increase the temperature to 550°C for soft wheat flours or 575 – 590°C for hard wheat flours.
- Incinerate until light grey ash is obtained or to a constant weight.
- Cool in a dessicator and weigh soon after room temperature is attained.

Results

Ash content results for wheat or flour ash are expressed as a percentage of the initial sample weight. Wheat or flour ash is usually expressed on a common moisture basis of 14%.

Muffle furnace

PROTEIN CONTENT

Protein content is a key specification for wheat and is related to many processing properties, such as water absorption and gluten strength. Protein content also can be related to finished-product attributes, such as texture and appearance. Low protein content is desired for crisp or tender products, such as snacks or cakes. High protein content is desired for products with chewy texture, such as pan bread.

Principle

The Infratec™ 1241(FOSS) is a whole grain analyser using near-infared transmittance technology to test multiple parameters (moisture, protein, etc). Near Infrared measurements of grain have shown superior performance when measuring in transmittance mode instead of reflectance mode. Transmittance mode measurements are made in a lower wavelength range, 570 – 1050 nm, whereas the primary information for reflectance measurements is obtained between 1100 – 2500 nm.

Method

- Select the programme and set the number of subsets.
- Pour around 150 g clean grains into the hopper.
- Press the analyse button and read the results from the screen.
- If the sample volume is less, select the appropriate programme, pour the grains into the cuvette of STM (Sample Transport Module), insert the cuvette into the module, press analyze and read.
- For protein estimation in flour samples, fill up the cup with flour and place it into the hopper, press analyze button and read the results.

Whole grain analyser (FOSS)

Results

The protein requirements are >12.0 %, 10.0-12.0% and <10.0 % for making good quality bread, chapatti and biscuit, respectively.

GLUTEN CONTENT

Gluten is the functional component of protein and determines many of the dough and processing characteristics of wheat flour. Gluten consists of the two specific proteins "Glutenin" and "Gliadin". Gliadins behave as a viscous liquid and glutenins behave as cohesive elastic solid when hydrated. Gluten is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten reflects protein content and is a common flour specification required by end-users in the food industry. The Glutomatic System (Perten) is the global standard for determination of gluten quantity and quality.

Principle

Wet gluten content is determined by washing the flour or whole meal sample with a salt solution to remove the starch and other solubles from the sample. The residue remaining after washing is the wet gluten. During centrifugation, the gluten is forced through a sieve. The Percentage of gluten remaining on the sieve is defined as the Gluten Index, which is an indication of gluten strength. The more residue is left in the sieve of the centrifuge, the firmer is the gluten. Firm gluten result in more stable doughs with high volume yields. Greater wet gluten content means greater bread volumes.

Method (AACC Method 38-12A, 2000)

Glutomatic System (Perten)

- A 10 g sample of wheat flour or whole meal is weighed and placed into the glutomatic washing chamber with a 88 micron polyester screen.
- 4.8 ml of salt solution (2% NaCl) is added to the meal or flour samples.
- Meal or flour samples and the salt solution are mixed to form a dough during 20 sec.
- After termination of the mixing phase, the washing automatically starts and continues for five minutes. For wheat meal, the sample is transferred to a chamber equipped with a coarse 840 micron sieve allowing bran particles to be washed out.
- Exactly 30 sec after completed washing, the undivided wet gluten piece is transferred to the special sieve cassette and centrifuged for one min at 6000 rpm in Centrifuge.
- The fraction passed through the sieves is scraped off with a spatula and weighed. The fraction remaining on the inside of the sieve is collected and added to the balance. The total wet gluten weight is obtained.
- The total wet gluten piece is dried at 150°C for four min in the Glutork 2020. After drying, the gluten is weighed on the balance.
- The amount of gluten remaining on the centrifuge sieve in relation to total wet gluten weight is the Gluten Index.

Results

- Four parameters can be determined using the Glutomatic analysis.
- Wet Gluten Content (WGC, %)
- Dry Gluten Content (DGC, %)
- Water Binding of Gluten (WGC – DGC)
- Gluten strength by Gluten Index (GI)

A high gluten index indicates strong gluten. Wet gluten content results are expressed as a percentage on a 14% moisture basis; for example, 35% for high protein, strong gluten wheat or 23% for low protein, weak gluten wheat.

FALLING NUMBER

The Falling Number System measures the alpha-amylase enzyme activity in grains and flour to detect sprout damage, optimise flour enzyme activity and guarantee soundness of traded grain. Alpha-amylase activity has direct impact on bread and pasta quality and adversely affects the malting process. A certain amount of alpha-amylase is necessary for proper baking to occur. The alpha-amylase breaks down starches to provide sugars to help fuel the fermentation process. The amount of enzyme present can have a direct bearing upon the quality of bread produced. Producing noodles from flour with a low Falling Number(FN) is difficult, with dough handling and cutting problems and product sticking to machinery. It also results in an off-colour end consumer product which will be sticky after it is boiled. The FN value has an inverse relationship with the alpha-amylase activity that means the higher the alpha-amylase activity, lower the FN value, and vice-versa.

Principle

The falling number instrument (Perten) analyzes viscosity by measuring the resistance of a flour-water paste to a falling stirrer. In the boiling water bath, the starch begins to gelatinize and the slurry becomes more viscous. The Mixing makes sure the gelatinization is homogeneous in the slurry. At this elevated temperature, the alpha-amylase enzyme starts to broken down starch and the viscosity thus decreases. The amount of starch break-down is dependent on the alpha-amylase activity and this means that higher the activity of the alpha-amylase lower the viscosity will be. The lower viscosity of the slurry, the faster the stirrer will fall to the bottom. The time taken by stirrer to fall to the bottom is called the falling Number.

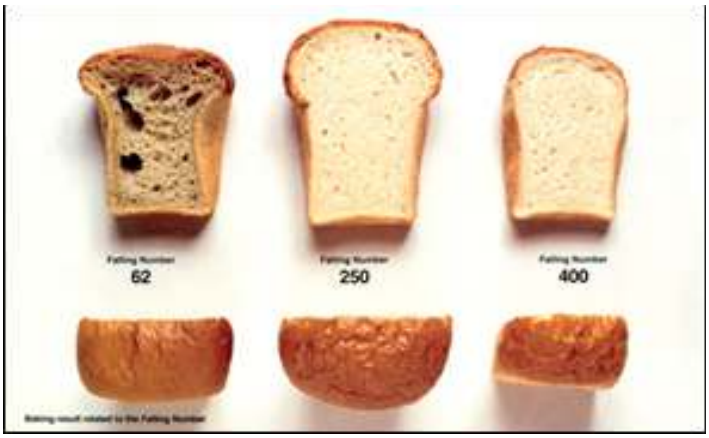
Method

- Weigh 7.0 ± 0.05 g of whole meal or flour and put into a Viscometer tube. The flour amount should be moisture corrected by measuring the actual moisture content of the sample (When grinding a wheat sample to perform a falling number test, it should be at least 300 grams to assure a representative sample).
- Add 25 ± 0.2 ml of distilled water to the tube.
- Vigorously shake the sample and water in the tube to obtain a homogeneous suspension.
- The stirrer is inserted into the viscometer tube and is put into the boiling water bath and the instrument is started. After 5 seconds the stirring begins automatically.
- The stirrer is automatically released from its top position after 60 (5 + 55) seconds and is allowed to fall down under its own weight.
- The total time in seconds from the start of the instrument until the stirrer has fallen a measured distance is registered by the instrument. This is the Falling Number.

Falling Number Instrument

Results

Falling number results are recorded as an index of enzyme activity in a wheat or flour sample and the results



are expressed in time as seconds. A high falling number (for example, above 300 seconds) indicates minimal enzyme activity and sound quality wheat or flour. A low falling number (for example, below 250 seconds) indicates substantial enzyme activity and sprout damaged wheat or flour.

The level of enzyme activity measured by the falling number test affects product quality. When the alpha-amylase activity is right, a high volume bread with firm and soft texture is achieved (FN = 250 in picture). If the activity is too high, a sticky bread crumb and low volume may result (FN = 62 in picture). If the activity is too low, a dry bread crumb with diminished volume may result (FN = 400 in picture).

SEDIMENTATION VALUE

The sedimentation test provides information on the protein quantity and the quality of ground wheat and flour samples. Positive correlations were observed between sedimentation volume and gluten strength or loaf volume attributes. The sedimentation test is used as a screening tool in wheat breeding as well as in milling applications.

Principle

The SDS sedimentation test measures the sedimentation value of the suspension of flour in SDS-lactic acid solution. The sedimentation value depends mainly on the amount and the swelling characteristics of the glutenins, since other proteins like gliadins are soluble in the SDS test solution. A number of modified SDS sedimentation tests have been developed and are widely used in predicting dough properties and bread making qualities in the early stages of wheat breeding programmes. Cultivars with different protein quality, as expressed by their gluten characteristics, should be differentiated by the SDS sedimentation test.

Method 1

- Four samples can be analysed at the same time.
- Take four 100ml glass measuring cylinders with stoppers.
- Add 50 ml distilled water to each. Keep the 50 ml SDS/Lactic acid reagent ready in 50 ml cylinders.
- Add 6 g whole meal (5.0 g Flour) to 50 ml water (Cylinder 1) and start the stop clock. Shake rapidly for 15 sec.
- Keep the clock running continuously throughout rest of the experiment. The times for commencement of the other operations are given, in minute, in the table.

Exprimental set up of 6 g test

Cylinder No.	15 sec. shake in water	15 sec. shake in water	15 sec. shake in water 50ml S.D.S. invert 4X	Invert 4X	Invert 4X	Invert 4X	Read Sedimentation volume (ml)	
							Whole meal	Flour
1	0	2	4	6	8	10	30	50
2	0.5	2.5	4.5	6.5	8.5	10.5	30.5	50.5
3	1.0	3.0	5.0	7.0	9.0	11.0	31.0	51.0
4	1.5	3.5	5.5	7.5	9.5	11.5	31.5	51.5

The required S.D.S./lactic acid reagent may be prepared by dissolving 20g S.D.S. in one litre of distilled water, to this 20ml of stock dilute lactic acid prepared by diluting one part by volume of 88% lactic acid with 8 part by volume of distilled water, is added and the reagent shaken or otherwise agitated until homogenous.

Method 2

- Take 4 ml distilled water in clean glass tubes. Add 1 g whole meal to the tube.

- Vortex carefully and let it stand for 5 min.
- Again vortex and allow to stand for 5 min.
- Add 12 ml SDS/Lactic acid solution. Invert 10 times and keep for 10 min.
- Note the sedimentation volume carefully.

Exprimental set up of 1 g test

Results

High SDS sedimentation values are associated with stronger gluten. Sedimentation values can be in the range of 20 ml or less for low-protein wheat with weak gluten to as high as 70 ml or more for high-protein wheat with strong gluten. For making good quality bread, chapatti and biscuit, the required sedimentation values are >60 ml, 30 - 60 ml and <30 ml respectively. Using 1 g test, the values can vary between 5 and 15 ml. SDS test using 1g of the whole flour has strong correlation with sedimentation test using 6 g whole meal flour. SDS sedimentation volumes are highly heritable and can be used for selecting among the early generation progeny.

YELLOW PIGMENT CONTENT

Yellow colour in durums imparts attractive appearance to the pasta products and therefore majority of the pasta consumers prefer the yellow pigment. Xanthophills and specially β-carotene contributes to the colour production in the semolina. β-carotene also acts as a bioactive compound because of its antioxidant activity. Durum endosperm contains twice the concertration of yellow pigment than that of aestivum. Since yellow pigment is highly susceptible to oxidation, precaution has to be taken for its determination.

Reagents

- Water Saturated Butanol (WSB) : Mix equal volumes of distilled water and n- butanol in a separating funnel. Cap tightly and shake vigorously. Allow the two phases to separate. Collect the upper layer and store at room temperature.
- β-carotene standard

Method (AACC 14-50, 2000)

- Weigh 8 g sample (whole meal/flour/semolina) and add to 40 ml WSB in a glass tube with stopper.
- Shake gently and allow to stand for 16-18 hrs at room temperature in dark.
- Mix and filter completely through the filter paper (Whatman No. 1).
- Measure the optical density of the clear filtrate at 435 nm using water-saturated n-butanol as blank in a spectrophotometer.
- Calculate the amount of yellow pigments form the β-carotene standard curve.

Preparation of standard curve

- Make a standard β-carotene solution of concentration 1mg/ml in WSB.
- Make dilutions in the range of 2.5 to 15.0 µg. & read at 435nm.
- Prepare a standard curve and determine the Linear regression equation.
- Use the equation to calculate the content of yellow pigment in samples.

Micro-Method

- Take 0.2 g flour in 2 ml amber coloured micro-centrifuge tube.
- Add 1.0 ml WSB, vortex and keep for 16-18 hrs at room temperature.
- Centrifuge at 10000 rpm for 10 min.
- Read the supernatant carefully at 435nm.

Results

As described earlier yellow pigment is essentially a preferable feature of durum wheats. Range of yellow pigment is generally 4 to 8 ppm, but durums with less than 5ppm of yellow pigment are not acceptable in the international market.

PHENOL TEST

This test is basically used for testing of varietal purity qualitatively. Phenol colour reaction is also correlated to the darkening of the whole meal dough and chapatti quality. The colour of the phenol reaction is negatively correlated to the chapatti quality.

Principle

The enzyme tyrosinase (Polyphenol oxidase) present in the outer layers of wheat grain react with the phenol and oxidize it to quinones which are subsequently converted to dark coloured melanins by polymerisation and interaction with protein. Intensity of colour depends on the amount of tyrosinase enzyme. Tyrosinase activity is found to be an inherited characteristic.

Method

- Clean the grains of any damaged kernels or foreign material and put in a Petri dish.
- Add 1% phenol solution so that all the seeds are dipped in the solution.
- Keep for 2 hrs, drain the solution and dry the seeds on a filter paper sheet.
- After complete drying, grade the colour on the scale of 0 – 10.

Results

Dark colour indicates high polyphenol oxidase activity which is not suitable for good chapatti quality.

Phenol test

HIGH MOLECULAR WEIGHT-GLUTENIN SUBUNIT (HMW-GS)

ANALYSIS

Glutenins and gliadins constitute around 80% of the total seed proteins in wheat. These proteins impart the visco-elastic property to the dough which determines the end product quality. Glutenins (acid soluble) are polymeric proteins whose monomeric units are divided into high (HMW, 67-130kDa) and low (LMW, 35-45kDa) molecular weight glutenin subunits. HMW-GS represents 5-10% of total seed proteins depending upon the number of expressed genes present. Strong and extensible dough contains high proportion of specific HMW-GS and LMW-GS. Genes controlling the HMW-GS are located on the *Glu*-A1, *Glu*-B1 and *Glu*-D1 loci on the long arm of the group one chromosome. There is differential quality effect linked to glutenin subunit combination. HMW-GS 1, 2* (*Glu*-A1); 7+8, 7+9, 17+18 (*Glu*-B1); and 5+10 (*Glu*-D1), generally contribute positively to high dough strength. Electrophoretic studies have revealed appreciable polymorphism in number and mobility of HMW-GS.

Protein Extraction:

Take a single grain of wheat. Crush it in the folds of butter paper and transfer to the micro-centrifuge tube. Add 1 ml of sample buffer and vortex for 90 sec. Incubate in water bath at 80°C for 20 min. Cool and store in refrigerator.

SDS-PAGE

Solutions

1. 30% Acrylamide - bis acrylamide stock solution : 29.2 g of acrylamide and 0.8 g of N, N'- methylene bis acrylamide dissolved in 80 ml of ddw. Stirr at magnetic stirrer till it completely dissolves. Make the volume to 100 ml. Filter and Store at 4°C in a dark bottle.

2. 10% SDS - 10 g SDS dissolved in 100 ml of ddw. Keep at 37°C for complete dissolution.

3. Stacking gel buffer (pH 6.8) 0.5 M Tris-HCl.

4. Separating gel buffer (pH 8.8) 1.5 M Tris-HCl.

5. Electrophoresis buffer (pH 8.3) (Tris-glycine buffer) Tris base 25 mM; Glycine 192 mM; SDS 0.1%

6. Sample buffer (2X) - Tris-HCl (62 mM, pH 6.8); SDS 2%; Glycerol 10%; BME 5%; BPB 0.1%

7. Fixing solution - 50% Methanol; 10% glacial aceteic acid

Solution	12% separating gel (40ml)	5% stacking gel (8ml)
30% Acrylamide stock	16.0 ml	1.3ml
Separating/Stacking gel buffer	10.0 ml	2.0ml
10% SDS	0.2 ml	80µl
10% APS	0.4 ml	80µl
TEMED	20 µl	10
Distilled water	13.38 ml	4.53ml

Constituen ts of Gel

8. Staining solution - 50% methanol; 10% glacial acetic acid; 0.1% CBB - R250

9. Destaining solution - 10% methanol; 7% glacial acetic acid

10. 10 % Ammonium per sulphate : 0.1g/ml (Prepare fresh just before use)

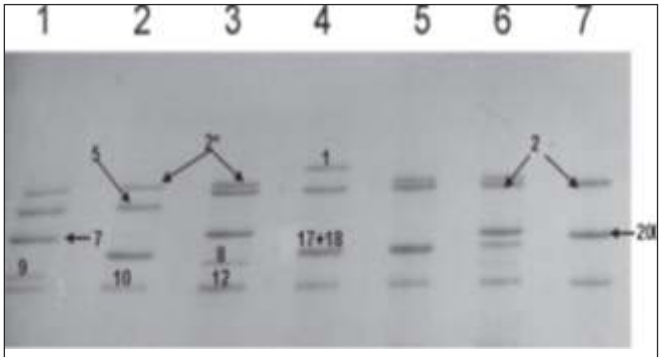
- APS and TEMED are added just before pouring of the gel solution as TEMED initiates the cross-linking of the gel.
- Carefully clean the glass plates with warm soapy water. Rinse them thoroughly with ddw. Dry and wipe them with ethanol.
- Assemble the gel plates with the spacers and the clamp. Now pour the separating gel solution prepared, between the glass plates. Overlay it with water and allow it to polymerize for 30 – 40 min at 37°C.
- Remove the overlay solution. Now pour 5% stacking gel prepared. Insert the comb and let the gel again polymerize.
- Remove the comb, clean the wells with a syringe and assemble the gel plates in the electrophoresis chamber, filled with the electrophoresis buffer. Pre run it at 80V for 15min.

Sample preparation:

- Centrifuge the extracted samples at 10,000 rpm for 10min.
- Load the samples with the help of micropipette.
- Run at constant voltage of 80 Volts till the sample is in stacking gel and after that the voltage is raised to 100 volts. Allow the gel to run till the dye reaches 0.5 cm from the lower edge of the gel.
- After completion of electrophoresis, gel is taken out in a tray containing the fixing solution and left in it for 30 min.
- Leave the gel in staining solution overnight.
- Next day, the gel is taken out and kept in destaining solution on 2-3 times till the bands are clear.

Results

After complete destaining, take a picture of the gel on a white light transilluminator. Read the banding pattern for each sample.



SDS-PAGE profile of HMW glutenin subunits from wheat Genotypes indicating their subunit nomenclature. Lane 1 - PBW443;lane 2 - GW273; lane 3 - NW1014; lane 4 - K9465; lane 5 - K9644;lane 6 - NW1012; and lane 7 - C306.

Score	HMW-GS on Different Locus		
	Glu-A1	Glu-B1	Glu-D1
4	-	-	5+10
3	1	17+18	-
3	2*	7+8	-
3	-	13+16	-
2	-	7+9	2+12
2	-	-	3+12
1	Null	7	4+12
1	-	6+8	-
1	-	20	-

Reference Table for HMW-GS Score

MICRONUTRIENT ANALYSIS

Wheat Sampling Protocol

- Collect a representative sample from bulk harvest, or if grains are harvested from a small plot, collect randomly selected heads before the main harvest. Place the samples in clean, new, properly labelled paper envelopes to avoid contamination from dust and soil.
- Thresh heads by hand and store the seed in clean, new paper envelopes. Pass the grains through an air cleaner to remove all foreign material.
- Sample Split the clean grains to obtain the required amount of sample, and manually remove any visible soil particles. Place the resulting sample in new, clean brown paper bags.
- For atomic absorption spectroscopic (AAS) analysis, grind around 5 grams of grains in a non-contaminating grinding mill (Cyclotec Mill, Foss) and collect ground whole wheat flour. Package the samples in clean, new, properly labelled, paper coin envelopes and store in a dry location until ready for analysis.

A. MICROWAVE DIGESTION BASED AAS (DESTRUCTIVE METHOD)

The method prepares wheat flour samples for the quantitative determination of the concentration of copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn), using nitric acid ($HN0_3$) in conjunction with microwave heating in closed Teflon vessels. Digested analyte concentrations can be determined by atomic absorption spectrometry (AAS). Digestion is facilitated by the application of microwave power and elemental volatilization is avoided using closed digestion vessels.

Requirements

1. Analytical balance
2. Microwave digestion system and Teflon double wall digestion vessels (Anton Paar)
3. Pipette dispensers
4. Volumetric flasks of 25 ml capacity
5. AAS system (ECIL)

Microwave Digestion System

Reagents

1. Deionized water
2. Nitric acid (12N)
3. Standard solutions (Cu, Fe, Mn and Zn)

Procedure

- Weigh 500 mg wheat flour and place in Teflon digestion vessel. Include a method blank.
- Using pipette dispenser, add 7 mL trace metal grade concentrated HNO_3 to each vessel inside a fume hood.
- Place digestion vessel in outer body shell, cap, and allow the sample and reagents to predigest for 30 minutes.

- Close vessel relief valve and place the vessels in the microwave oven and set the program.
- At completion, remove the vessel from the microwave oven and place in a fumehood to cool down.
- In the fume hood, vent the vessel by rotating the release valve one half revolution. Vent until the vessel is completely depressurized. Remove the cap and rinse the cap into the vessel with deionized water.

Atomic Absorption Spectrophotometer

- Quantitatively transfer the contents of the digestion vessel into a volumetric flask, dilute to 25-mL volume.
- Elemental analysis of the flour digest can be made using AAS. Calibrate the instrument using calibration solutions. Determine the analyte concentrations of a method blank, unknown samples, and record concentrations in ppm.

Results

The concentration of unknown sample is calculated by plotting against the absorption values obtained from the standard curve of the same element.

Element (ppm) = (µg/ml*100) / sample weight (g)

Precautions

1. Teflon digestion vessel liners should be cleaned using double distilled water.

2. Check pipette dispensing volume and calibrate using an analytical balance.

3. When adding reagent to vessels always wear protective clothing (i.e., eye protection, lab coat, disposable gloves and shoes). Always handle reagents and opening of vessels in an acid fume hood.

X-Supreme 8000

B. XRF BASED NON DESTRUCTIVE METHOD

The Oxford Instruments X-Supreme 8000 uses X-ray fluorescence spectrum of the photon released. It is possible to quantify the levels of elements based on the intensity of released photons with intensity directly proportional to elemental abundance. It is a non-destructive method for the analysis of elements in whole cereal grains and does not require any hazardous chemicals.

Procedure

- The instrument is to be switched on and left to 'warm up' for 90 min.
- Samples used for analyses were harvested as mentioned in the sampling section and it has to be ensured that no contamination is present.

- A minimum of 3 g sample grain (in duplicate) are loaded in the aluminium cups with plastic inserts (4 µm film) and a total of 10 samples can be evaluated at a time.
- The appropriate program with the required instrumental parameters for the elements to be assessed is selected.
- The results obtained are in ppm.

Precautions

It is recommended that the machine should be calibrated with the results obtained with ICP-OES or AAS analysis to ensure accurate reference values and a strong calibration.

RHEOLOGICAL METHODS

Rheological tests measure the mechanical properties (viscosity, elasticity, consistency, extensibility etc.) of dough under various deformation conditions. Most of these tests are used to predict the baking performance and behavior of dough during processing before baking. The conviction that the rheological properties of dough affect its behavior during processing, has led to the design of methods and instruments for measuring rheological or similar properties. Descriptive rheological measurements are done by Mixograph, Farinograph, Alveograph and Extensograph.

MIXOGRAPH

Measures flour water absorption and dough mixing characteristics. The Mixograph Test quickly analyzes small quantities of flour for dough gluten strength. Wheat breeders use mixograph results to screen early generation lines for dough gluten strength. Flour water absorption measured by the mixograph often serves as bake absorption in bread baking tests.

Principle

The Mixograph test measures and records the resistance of a dough to mixing with pins. Peak Time is the dough development time, beginning the moment the mixer and the recorder are started and continuing until the dough reaches maximum consistency. This indicates optimum mixing time and is expressed in minutes. Mixing Tolerance is the resistance of the dough to breakdown during continued mixing and affects the shape of the curve. This indicates tolerance to over mixing and is expressed as a numerical score based on comparison to a control. Weak gluten flour has a shorter peak time and less mixing tolerance than strong gluten flour.

Method

- A sample of 10 g of flour on a 14% moisture basis is weighed and placed in a mixograph bowl.
- Water is added to the flour and the bowl is inserted into the mixograph.
- The flour and water are mixed together to form a dough.
- As the dough is mixed, the mixograph records a curve on graph paper/ computer screen.

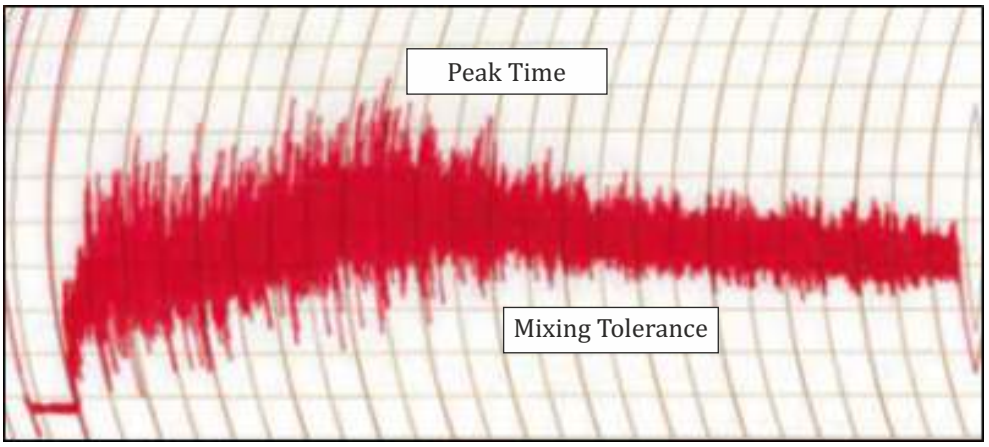
Results

The mixograph curve suggests mixing time requirement, tolerance and optimum water absorption. Depending on the dough strength of the flour, the curve will reach a maximum; either as a well-defined peak or as a plateau. After further mixing, a decrease in the mixing curve is recorded and the breakdown starts. Dough breakdown behavior is reflected in the tail of the curve when mixing continues beyond the mixing peak and is commonly referred to as mixing tolerance. A dough with good mixing tolerance will have a broader "window of opportunity" for a baker to stop the dough at

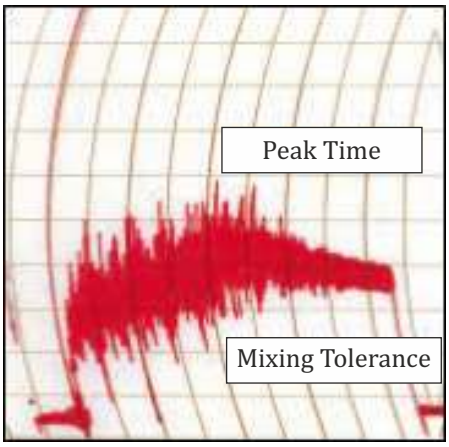
Mixograph

optimum development. Good dough mixing tolerance would also indicate that bread dough should be elastic after mixing. The point of optimum dough development is at the maximum in the mixing curve or slightly after the peak. The rate of breakdown shows the stability of the dough and its sensitivity to mechanical treatment.

For desirable bread-type flour with adequate flour protein, a mixogram should indicate high water absorption, moderate mixing times (3-6 minutes), strong gluten strength, and good dough mixing tolerance. Mixogram mixing time is largely a function of protein content and gluten strength. As protein increases, mixing time will decrease. Extremely long mixing time is considered undesirable because the power and time requirements would not be economical for a commercial bakery.



Strong gluten Flour



Weak gluten Flour

ALVEOGRAPH

The Alveograph enables determination of the tenacity, extensibility, elasticity and baking strength of flour. The Alveograph test measures and records the force required to blow and break a bubble of dough. A stronger dough requires more force to blow and break the bubble. A bigger bubble means the dough can stretch to a very thin membrane before breaking and has higher extensibility. The Alveograph Test provides results that are common specifications used by flour millers and processors to ensure a more consistent process and product.

Principle

The alveograph determines the gluten strength of a dough by measuring the force required to blow and break a bubble of dough. The Alveograph is composed of three indissociable elements: the mixer, equipped with a pressure sensor and an extraction passage. The mixer enables dough formation and extraction for dough ball preparation for use in the alveographic test. The Alveograph section measures the tri-dimensional extension of a dough specimen which changes shape into a bubble under the effect of air pressure. This means of extension reproduces the deformation of the dough under the influence of gaseous pressure. The Alveolink enables choosing of the tests which are to be carried out. It processes the data, curve displays and parameters for the different tests carried out.

Method

- Prepare the sample flours and measure the moisture content.
- Calibrate the instrument for the required pressure (60/92).
- A sample of 250 g of flour is mixed with a salt solution (2.5% NaCl) as per the moisture content to forms a dough for 8 minutes.
- Five 4.5 cm circular dough patties are formed and then rested in the alveograph in a temperature-regulated compartment at 25°C for approximately 20 min.

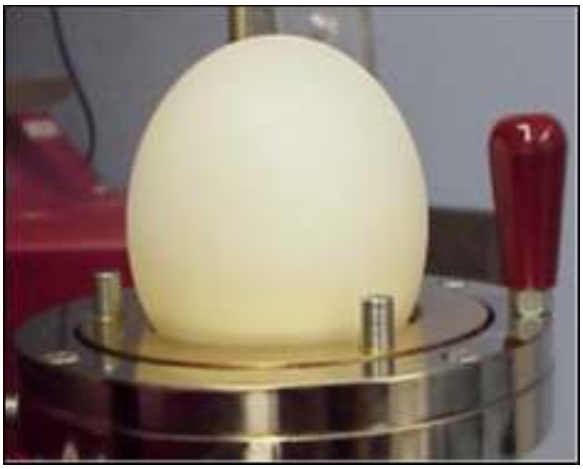
Alveograph

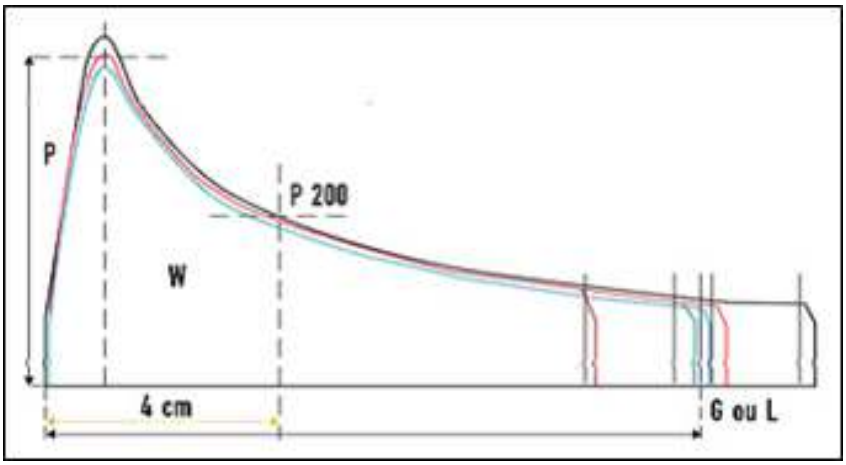
- Each dough patty is tested individually for the inflation. The alveograph blows air into a dough patty, which expands into a bubble that eventually breaks.
- The pressure inside the bubble is recorded as a curve on the Alveolink screen.

Results

The curves obtained with the Alveograph device are interpreted by usingthe following parameters:

- P value is the force required to blow the bubble of dough. It is indicated by the maximum height of the curve and is expressed in millimeters (mm).
- L value is the extensibility of the dough before the bubble breaks. It is indicated by the length of the





curve and is expressed in millimeters (mm).

- P/L Ratio is the balance between dough strength and extensibility.
- W value is the area under the curve. It is a combination of dough strength (P value) and extensibility (L value) and is expressed in joules.
- Weak gluten flour has lower P values than strong gluten flour.
- For better bread making potential of the flour it should have > 300 W value and < 0.8 (P/L ratio).

PRODUCT EVALUATION METHODS

Wheat is a unique gift to mankind as a strong visco-elastic dough can be prepared from the wheat flour which can further be used to prepare a large number of products like bread, biscuit, chapatti, pasta, etc. In this section, finished product formulations and processes are described for laboratory testing protocols that are used to evaluate flour quality. They are model systems that may be used to predict commercial production for common uses of wheat flour worldwide.

PAN BREAD

The Pan Bread Test provides end-users with information on flour quality characteristics. Bakers need flours that perform consistently, especially in high-speed commercial operations. Consumers desire a consistent product that meets expectations for volume, colour, and texture. The following standard recipe is generally used for testing the wheat varieties for their bread making qualities.

Requirements

Analytical balance, Dough mixer, Fermentation chamber, Baking moulds, Proofing chamber, Rotary oven, Loaf volume meter, Knife

Composition

Flour	100 g
Dry yeast	2.5 g
Sugar	5.0 g
Salt	2.0 g
Shortening Ghee	3.0 g
(Saturated fat) Water	60 ml

Bread

Method (AACC Method 10-11, 1962)

- Mix all the above ingredients except ghee and knead together in a dough mixer for 90 seconds to form a dough.
- Leave the dough for 1 h 40 min at 30-32°C for fermentation.
- After fermentation, again knead the dough with ghee in the dough mixer for 40 sec, mould in desired shape and place in oiled baking mould.
- Place the baking moulds with dough inside the proofing chamber which is maintained at 35.5°C with 92% humidity. Leave the loaves for 50 min.
- At the above temperature, amylase enzyme become more active which leads to formation of maltose, the main food source for yeast enzymes. Evolution of CO_2 leads to steady increase in loaf volume.
- After proofing, the loaves are baked in a rotary oven maintained at 220°C for 12 min. Volume of the baked loaves is immediately measured by the loaf volume meter. The final evaluation of bread is done after 18 h, taking its loaf score in consideration.

Loaf score

Pan bread is evaluated for processing characteristics, external and internal characteristics, and texture. The results are expressed as a numerical score **(Annexure II)**.

a) Volume: Measurements are made by displacement of rape seed. High volumes are preferred.

b) External appearance: Observations are made of general appearance and crust colour. A good loaf should have an attractive golden brown crust, good shape and freedom from torn crust.

c) Crumb texture: The crumb texture of the surface exposed by cutting the loaf is assessed by stroking with fingers. Silkiness is preferred to roughness.

d) Crumb cell structure: Ideally the cell should be thin walled, elliptical in shape and of uniform size which should be neither too large nor too small.

e) Crumb resilience: This is assessed by pressing the cut surface of the loaf with the fingers. A soft crumb which exhibits elastic recovery after depression is desirable.

BISCUIT (Sugar Snap Cookie)

The Sugar Snap Cookie Test is used worldwide to evaluate the performance of wheat flour for use in a wide range of confectionery products. Flour with low protein and weak gluten, which produces cookies with a high cookie spread and numerous cracks on the surface, usually performs well for these products.

Requirements

Cookie dough micro mixer, Electric mixer, Aluminium cookie sheet, Metal gauge strips, Rolling pin, Cookie cutter, Small plastic spatula, Baking oven, Vernier Calliper

Reagents

Solution A

Dissolve 79.8 g sodium bicarbonate ($NaHCO_3$) in distilled water and make to 1 litre.

Solution B

Dissolve 101.6 g ammonium chloride (NH_4Cl) and 88.8 g NaCl in distilled water and make to

1 litre. If sealed tightly, reagents can be stored for several months.

Biscuit paste

Sodium Hydrogen Carbonate	10.4 g
Milk powder	31.2 g
Sugar	624 g
Ghee	312 g

Sift together all ingredients except ghee eight times. Cream these ingredients together with ghee using an electric mixer on a low speed for 1 minute, then scrape; on high speed for 30 seconds, then scrape. Keep the mixture covered at 4°C for longer duration.

Method (AACC Method 10-52, 2000)

- A sample of 37.6 g of biscuit paste is weighed out and combined with 4.0 ml solution A, 2.0 solution B and 2.0 ml water in a cookie dough mixing bowl and mixed for 5 min.
- 39.2 g flour is added and mixed for 25-30 sec to form a dough.
- The dough is rolled out to a consistent thickness, cut into circles with cookie cutter and placed on a greased cookie sheet.
- The cookies are baked at 205°C for 11 min.
- The cookies are allowed to cool on the cookie sheet for 5 min before removing to a cooling rack.

Calculations

Sugar snap cookies are evaluated for cookie spread (diameter) and top grain appearance. The results are expressed as a numerical score based on comparison to a control sample. After the cookies have cooled to room temperature, lay two cookies edge-to-edge and measure width. Rotate them one quarter turn and re-measure. Repeat twice more. Cookie width is the mean of four measurements multiplied by appropriate

correction factor. For thickness measurement, cookies were stacked on top of another and thickness is measured. Turn and again restack cookies in different order and re-measure thickness. Cookie thickness is the mean of two measurements. Spread factor is calculated by dividing mean width by mean thickness in cm.

Biscuit

Results

Greater the spread factor of the cookies, better is the flour quality for making confectionary products.

FLAT BREAD (Chapatti)

Flat bread includes a diverse range of products, including tortillas in Mexico, chapatti in India, and shaobin in China. The Flat Bread test provides information to manufacturers on processing performance of flour. Consumers desire a consistent product that meets expectations for colour and texture of cooked chapatti.

Requirements

Rolling Pin, Gas stove, Griddle, Kitchen balance, Scale to measure puffing height, Muslin cloth

Method

- 100 ml water is taken in a measuring cylinder and is added slowly to 100 g whole wheat flour and kneaded manually to obtain a dough of uniform consistency. Additional water is added if required. Amount of water used is recorded.
- The dough is covered with a moist muslin cloth and allowed to rest for half an hour.
- Dough is divided into two parts of 40 g each and the balls are rolled into chapatti of around 15 cm diameter and 1.5 mm thickness and again weighed.
- The chapatti is cooked on both sides on a hot griddle and then puffed on a wire mesh. The puffing height is measured while chapatti is still on the flame with a special scale designed by the Quality & Basic Science division of IIWBR, Karnal. The puffed chapatti is immediately weighed.
- One puffed chapati is immediately kept covered in a cloth for four h and then evaluated for its chapati quality score. The other chapati is also evaluated for chapati quality score immediately after puffing.

Chapatti

Result

Chapattis are scored (0–10) subjectively for the parameters like appearance, colour, taste, aroma, pliability, puffing height as per the table **(Annexure III)**.

PASTA

Composition

Semolina 100 grams

Water 31.5 grams

Method (Adapted from AACC Method 66-41, 2000)

1. A sample of semolina is weighed and placed in a mixing bowl.

2. Semolina is mixed at low speed as water is added over a 30 sec period and then mixed at high speed for 4 min to form dough.

3. The dough is transferred to the extruder and extruded into pasta product.

4. The extruded pasta product is cut to length and dried.

Results

- Extruded pasta is evaluated for processing performance, texture, color, external characteristics, and cooking qualities. The results are expressed as a numerical score based on comparison to a control sample.
- Processing performance is determined for dough strength and extensibility.
- External characteristics are determined for surface smoothness and appearance including color, clarity, specks, and cracks.
- Cooked pasta is evaluated by sensory analysis for cooking qualities, such as firm bite ("al dente", non-stickiness, flavor, and mouthfeel).
- Texture can be determined with an instrument test; for example, the TA.XT2 Texture Analyzer (similar to Asian Noodle Texture Test)

La Parmigiana(Pasta Maker)

Pasta

Quality evaluation of Macaroni

Apparatus

1. Oil or Prestone constant-temperature bath adjusted to maintain cooking water temperature at 95-96°C. With mineral oil, bath should be held at 105-106°C; with undiluted Prestone, temperature of 101.0-101.5°C is required.

2. Tall-form lipless beakers, 500 ml.

3. Buchner funnels or tared weighing basket of nichrome gauze, approximately 3 inches high and of 3 inches diameter.

4. Recording tenderness tester.

5. Volumeter, consisting of 50 ml Erlenmayer-flask fitted with ground glass joint and measuring tube graduated 0.05 ml each from 0 to 10 ml .

Procedure

Tenderness of cooked product:

1. Place 250 ml water (at 95°C) in 500ml tall-form lipless beaker in bath and cover beaker with watch glass, and let stand until water temperature reaches 95.5-96.0°C.

2. Put 25 g broken macaroni sample (1-4 inches or use elbow macaroni) and stir with glass rod.

3. Cook for 30 min with brief stirring at 10 min intervals.

4. Drain macraroni in tared weighing basket for 2 min and weigh, wash three times with cold water, and store under water until ready for testing regarding tenderness. Retain original water in which macaroni was cooked, for disintegration test.

5. For measurement of tenderness, select samples at random and withdraw from water by gripping ends with forceps.

6. Absorb surface moisture from each strand by placing upon filter paper.

7. Locate strand under plunger of tenderness tester and lower plunger until it rests freely upon sample.

8. Apply load at constant rate of approximately 12 g per sec until recorded curve shows definite evidence that "break" or "yield" point has been passed.

9. Make five such tests. In most cases all five records can be made upon a single chart.

10. Evaluate graphic records obtained, and calculate single figure tenderness score from following values:

(a) Time to "break"- time in second from beginning of application of load until the "break" or "yield" point is reached.

b) Time in second from beginning of application of load until sample has been compressed to arbitrary thickness (selected to fall somewhat below "break" point in majority of samples). For macaroni 3/16 inches in diameter, value of 0.115 inches is suggested.

(c) The smaller angle made between a prolongation of liner portion of curve and upper horizontal line of chart.

(d) Ratio of a to b.

11. Tenderness score is computed by formula:

Score = time to break (a) + angle (c) + 10 X ratio (d).

12. Values obtained are be comparable only when material of similar size and section is tested, since any variation in arbitrary thickness selected for value b will affect absolute magnitude of results.

Volume increase on cooking:

1. Fill volumeter to zero mark with high-boiling petroleum naphtha or kerosene.

2. Introduce 10 g uncooked macaroni, broken into small pieces, through top of tube, tap apparatus gently to dislodge air bubbles, and read increase in volume. Multiply results by 10 and record as dry volume per 100 g.

3. In a similar manner, determine volume of cooked macaroni and calculate increase in volume.

Water absorption during cooking:

Determine increase in weight upon cooking and express as %.

Resistance to disintegration (residue):

1. Evaporate drainings from sample cooked as directed under "Tenderness of cooked sample," above, to dryness on steam bath in weighed beaker or dish, dry at 130°C for 1 hour and weigh.

2. If presence of added salt is indicated, residue must be ashed, chlorides determined and correction made.

Note: It has been shown (Ref.1) that a very close relationship exists between wet weight and volume, and volume can therefore be calculated by formula:

Volume of cooked macaroni = (1.0085 x wet weight of cooked sample) - 8.81

References

1. Binnington, D.S., Johannson, H., and Geddes, W.F. Quantitative methods for evaluating the quality of macaroni products. Cereal Chem. 15149 (1939).

2. Giorn. Risicoltura 25:251 (1935).

Annexure I

CONDITIONING THE WHEAT – CALCULATION FOR THE QUANTITY OF WATER TO ADD

- Required moisture content

For Brabender Quadrumat Flour Mills

Refined flour: 14.5%

For Chopin Laboratory Mill

Semolina: 16.5%

Refined flour: 16.5%

To make a run with wheat having a moisture content A % (A % < 16.5 %), for milling test, does not mean that it will be necessary to add:

16.5 % - A %

For example 16.5 % - 10 = 6.5 % moisture or 6.5 ml per 100 g of wheat.

In fact, the composition of the product is written:

Dry matter (%) + initial moisture content A (%) = 100

If one wishes to increase the moisture content % of the product to 16.5 %, the amount of water to add must take into account the amount of dry matter to dampen in order to arrive at the correct final moisture content.

The amount of water is given by the following equation:

- For example : to condition wheat to a 10 – 16.5 % moisture content:
- Quantity of water to add per 100 g:

$X = (16.5 - 10)\ X\ 1.2 = 6.5\ X\ 1.2 = 7.8\ ml$

Annexure II

Parameters for Evaluation of Bread

1. Volume (ml)	Score		
<300	4.00	620	16.00
301- 400	5.00	625	16.25
405	5.25	630	16.50
410	5.50	635	16.75
415	5.75	640	17.00
420	6.00	645	17.25
425	6.25	650	17.50
430	6.50	655	17.75
435	6.75	660	18.00
440	7.00	665	18.25
445	7.25	670	18.50
450	7.50	675	18.75
455	7.75	680	19.00
460	8.00	685	19.25
465	8.25	690	19.50
470	8.50	2.Stickiness	Score
475	8.75	Non-sticky	2.0
480	9.00	Partial	1.0
485	9.25	Sticky	0.0
490	9.50	3. Appearance	
495	9.75	Excellent	2.0
500	10.00	Good	1.5
505	10.25	Fair	1.0
510	10.50	Non-Attractive	0.0
515	10.75	4. Crust colour	
520	11.00	Excellent	2.0
525	11.25	Good	1.5
530	11.50	Fair	1.0
535	11.75	Non-Attractive	0.0
540	12.00	5. Crumb colour	
545	12.25	Excellent	3.0
550	12.50	Good	2.0
555	12.75	Fair	1.0
1. Volume (ml)	**Score**		
560	13.00	Non-Attractive	0.0
565	13.25	6. Texture	
570	13.50	Excellent	4.0
575	13.75	Good	3.0
580	14.00	Fair	2.0
585	14.25	Non-Attractive	0.0
590	14.50	7. Taste and Aroma	
595	14.75	Excellent	2.0
600	15.00	Good	1.5
605	15.25	Fair	1.0
610	15.50	Bad	0.0
615	15.75		
Total score – 34.5	**Score to be reduced to a maximum of 10**		

Annexure III

Parameters for evaluation of wheat for chapatti quality score

1.	**Water uptake**		**Max – 20**	**Min – 10**
	<60	10		
	60-62	12		
	63-65	14		
	66-68	16		
	69-71	18		
	72-75	20		
	Dough stickiness (Before maturation)		**Max – 10**	**Min – 5**
	Partial sticky	10		
	Non-Sticky	5		
2.	**Colour of dough (Before maturation)**		**Max – 15**	**Min – 5**
	Creamish	15		
	Whitish	10		
	Brownish	5		
3.	**Dough stickiness (After maturation)**		**Max – 10**	**Min – 0**
	Partial sticky	10		
	Non-Sticky	5		
	Sticky	0		
4.	**Colour of dough (After maturation)**		**Max – 15**	**Min – 5**
	Creamish	15		
	Whitish	10		
	Brownish	5		
5.	**Puffing height (cm)**		**Max – 20**	**Min – 10**
	<5	10		
	5-5.5	12		
	5.6- 6.0	14		
	6.1-6.5	16		
	6.6-7.0	18		
	7.1-7.5	20		
6.	**% Loss of water just after baking**		**Max – 20**	**Min – 10**
	9.0-10.5	20		
	10.6-12.0	18		
	12.1-13.5	16		
	13.6-15.0	14		
	15.1-16.5	12		
	16.6-18.0	10		
7.	**Appearance**		**Max – 25**	**Min – 15**
	Very good	25		
	Good	20		
	Fair	15		
8.	**Colour**		**Max – 25**	**Min – 15**
	Very good	25		
	Good	20		
	Fair	15		
9.	Aroma		**Max – 10**	**Min – 5**

Very good	10		
Good	8		
Fair	5		
10. Pliability		**Max – 20**	**Min – 10**
Very soft	20		
Soft	15		
Leathery	10		
11. Taste		**Max – 10**	**Min – 5**
Very good	10		
Good	8		
Fair	5		
12. % Loss of water 4hr after baking (Open condition)		**Max – 20**	**Min – 10**
4-6	20		
7-8	18		
9-10	16		
11-12	14		
13-14	12		
15-16	10		
13. % Loss of water 4hr after baking (Closed condition)		**Max – 20**	**Min – 10**
0-2	20		
3-4	18		
5-6	16		
7-8	14		
9-10	12		
11-12	10		
14. Pliability 4hr after baking (Open condition)		**Max – 20**	**Min – 10**
Very soft	20		
Soft	15		
Leathery	10		
15. Pliability 4hr after baking (Closed condition)		**Max – 20**	**Min – 10**
Very soft	20		
Soft	15		
Leathery	10		

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