EFFECT OF WHEAT GENOTYPE ON YIELD AND PROXIMATE COMPOSITION

A THESIS
BY
SHUVO SAHA

MASTER OF SCIENCE
IN
BIOCHEMISTRY

DEPARTMENT OF BIOCHEMISTRY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

BANGLADESH

JUNE, 2016

EFFECT OF WHEAT GENOTYPE ON YIELD AND PROXIMATE COMPOSITION

A THESIS
BY
SHUVO SAHA
REGISTRATION NO: 15-06928

A Thesis

Submitted to the Department of Biochemistry Sher-E-Bangla Agricultural University, Dhaka in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE

IN

BIOCHEMISTRY

SEMSTER: JANUARY-JUNE, 2016

DEPARTMENT OF BIOCHEMISTRY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207
BANGLADESH

JUNE, 2016

EFFECT OF WHEAT GENOTYPE ON YIELD AND PROXIMATE COMPOSITION

A THESIS
BY
SHUVO SAHA
REGISTRATION NO: 15-06928

Approved as to style and content by

……	……..
Supervisor	**Co-Supervisor**
MD. NURUDDIN MIAH	**DR. KAMAL UDDIN AHMED**
Professor	Professor
Department of Biochemistry	Department of Biochemistry
Sher-E-Bangla Agricultural University	Sher-E-Bangla Agricultural University

…….

PROF. MD. NURUDDIN MIAH

Chairman of Examination Committee
Department of Biochemistry
Sher-E-Bangla Agricultural University

DEPARTMENT OF BIOCHEMISTRY

Sher-E-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Bangladesh

PABX: +88029144270-9
Ext. 309 (Off.)
Fax: +88029112649
E-mail: bioc_sau@ymail.com

Ref: **Date:**

CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF WHEAT GENOTYPE ON YIELD AND PROXIMATE COMPOSITION"*** *submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN BIOCHEMISTRY,*** *embodies the result of a piece of bona fide research work carried out by* ***SHUVO SAHA,*** *Registration No.* ***15-06928,*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.*

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Date: June, 2016

Place: Dhaka, Bangladesh

…….

MD. NURUDDIN MIAH

Professor
Department of Biochemistry
Sher-E-Bangla Agricultural University
Supervisor

DEDICATED TO

MY BELOVED PARENTS

&

All FARMERS

OF BANGLADESH

ACKNOWLEDGEMENT

The author would like to express with utmost humble gratitude and endless praises to Omnipotent Almighty God, who enabled the author to complete the research work. The author has much pleasure to express his heartfelt respect, immense indebtedness and deep appreciation to his honorable teacher and supervisor **Prof. Md. Nuruddin Miah,** Chairmain, Department of Biochemistry, Sher-e-Bangla Agricultural University (SAU), Dhaka,Bangladesh, for his worthy guidance, valuable suggestions, encouragement and continuous supervision throughout the study work and preparation of the thesis. The author wish to express his enormous appreciation and heartiest indebtedness to her co-supervisor **Dr. Kamal Uddin Ahmed**, Professor, Department of Biochemistry, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for his guidance, valuable suggestions, instructions and kind co-operation. The author extends his gratefulness to all the teachers of the Department of Biochemistry, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for their valuable advice, suggestions and constructive criticism. The author would like to gratefully acknowledged **Dr. Md. Azizul Haque,** Chief Scientific Officer, Soil Science Division, BARI, Joydebpur, Gazipur for his kind cooperation by providing laboratory facilities for biochemical analysis, special thanks to **Krishibid Md. Hafizul Haque Khan,** Principal Scientific Officer, Post Harvest Technology Division, BARI, Joydebpur, Gazipur and the technicians of Soil science Laboratory for helping the research work.

Finally, the author wish to express his boundless gratitude to his parents and other members of his family whose sacrifices, inspiration, and continuous blessings opened the gate and paved the way for his higher studies.

June, 2016 **The Author**

ABSTRACT

An experiment was conducted to study the proximate composition of four released and two advanced line of wheat varieties (*Triticum aestivum*) which was popularly growing in Bangladesh namely BARI gom-22 (Sufi), BARI gom-23 (Bijoy), BARI gom-24 (Prodip), Sonora-64, WYCYT (E-13) and WYCYT (E-14). There was none a single variety performed best in all nutrient parameters. Among these released and advanced line of wheat varieties, highest grain weight was found in BARI gom-23 (Bijoy) (52.35g) and the lowest weight of thousand seeds was found in Sonora-64 (33.21g). BARI gom-24 performed the best among the varieties only in some nutrient parameters. In case of proximate analysis, the highest protein content was recorded from BARI gom-24 (10.04%) and the highest carbohydrate was recorded from WYCYT (E-14) (72.84%). Among the other wheat varieties, BARI gom-24 contained highest amount of fibre (13.89%). WYCYT (E-13) contained highest amount of fat (1.83%) and BARI gom-22 contained highest amount of ash (2.13%). On the other hand BARI gom-24 (prodip) contained the lowest amount of carbohydrate (67.62%) and WYCYT (E-14) contained the lowest amount of protein (9.10%). WYCYT (E-14) contained lowest amount of fibre (10.21%) and BARI gom-22 (Sufi) contained the lowest amount of fat (1.03%). Sonara-64, BAREI gom-22 (Sufi) and WYCYT (E-13) showed the best performance for the most of the minerals.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

The agricultural sector plays a very significant role in the Bangladesh economy as well socially and culturally. Agriculture accounts for about 20% of the country's Gross Domestic Product (GDP). Wheat is one of the leading cereal crops grown around the world in diverse environments. Wheat is a cereal plant of the genus Triticum, especially, *T. aestivum*, of the family Graminae. In Bangladesh wheat ranks next to rice and its popularity is increasing consistently as it has great importance in human nutrition and industrial uses. It can be processed into various types of food. The total area and production of wheat in Bangladesh are about 4,29,607 ha and 13,02,998 metric tons, respectively (BBS, 2014). The average yield of wheat in this country is quite low as compared to that of other wheat growing countries of Asia like China, India, Pakistan, etc. Wheat Research Centre (WRC) and Bangladesh Agricultural Research Institute (BARI) have released 30 improved wheat varieties but many of them were not adequately adopted by farmers. There can be a range of reasons including inadequate knowledge, lack of specifically adapted varieties and inadequate extension efforts. Wheat is grown under a wide range of climatic and soil conditions. It however, grows well in clayey loam soils. In Bangladesh it is a crop of Rabi season, requires dry weather and bright sunlight. Well distributed rainfall between 40 and 110 cm is congenial for its growth. Depending on variety and weather conditions, 100-120 days are required from sowing to harvest.

In Bangladesh, wheat can be a good supplement of rice and it might play a vital role in the national economy. Wheat is a rich source of carbohydrate. It also contain protein, fat, ash, fiber, and vitamins as well as mineral such as sodium, potassium, calcium, magnesium, iron, phosphorus, copper, zinc and manganese (Kumar *et al*., 2011). Usually, wheat flour is produced by milling whole wheat kernel. Wheat flour has distinguished characteristics from other cereals due to its unique dough forming properties (Wrigley, 2004). Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles etc. Wheat is also used as animal feed, for ethanol production, wheat based raw material for cosmetics, wheat protein in meat substitutes

and to make wheat straw composites. Wheat bran is a good source of dietary fiber which helping in the prevention and treatment of some digestive disorders. The quality of wheat flours can be measured by several parameters including protein, moisture, gluten and by sedimentation, enzyme activity and rheological properties (Hruskova and Famera, 2003). Higher protein content (10-14.5%) indicate the harder and stronger the flour and lower protein content (6-10%) indicate the softer the flour. High protein flour is used to produce crusty and chewy breads and low protein flour is used to produce bakery product such as cake, biscuit, puffins and pie crusts etc. It is accepted that the increase in total protein content is due to the increase in gluten content (Chowdhury *et al.,* 2012). Moisture content is one of the important factors to determine the quality of flour and its shelf life. Normal moisture content range in wheat flour is 11-14% (Syeda *et al*., 2012). If moisture content rises above normal range flour is susceptible to fungi and mold growth as a result of increased enzyme activity, insect infestation and flavor change. Higher lipolysis and proteolytic enzyme activities are related to higher moisture content which further lead to loss in nutrients mainly protein and fat. The amount of ash is a measure of total amount of mineral present in wheat flour. Ash content indicates the milling performance which is indirectly shows the amount of bran contamination in flour. Mineral content also depend on various factors such as soil, climate, variety and cultural practices. Ash content in flour can affect color which imparting a darker color to finished products. Some specialty products requiring particularly white flour call for low ash content while whole wheat flour have high ash content.

The CIMMYT has worked closely with the Bangladesh wheat programs and has played a vital role in popularizing wheat cultivation in Bangladesh. The CIMMYT provided an enormous elite wheat germplasm from which promising types could be selected to suit the Bangladesh environment. Many wheat scientists attended in-service training at CIMMYT on issues such as wheat improvement, production agronomy, wheat quality and station management.

The CIMMYT wheat scientists visit research stations and farmers' fields. This collaboration was a key factor in quickly turning Bangladesh into a wheat-growing country. In addition to collaboration with CIMMYT, the Canadian International Development Agency (CIDA), Australian Government Overseas Aid Program (Aus-AID), United States Agency for International Development (USAID) and the Ford Foundation provided grants for facility improvement and manpower development of the WRC, BARI, in Bangladesh (Pandit *et al*.

2011). Even though most of the wheat varieties developed by the researcher in Bangladesh are high yielding varieties, but due to slow increase of cultivation area and production those wheat varieties did not keep pace sufficiently to match with the increasing demand of wheat created by increased population. The changing habit of cereal consumption also helped to increase demand for wheat compare to rice (WRC, 2009). Under the changed of global conditions, we already experienced that food may not be affordable through import from other countries. As plant responses to high temperature or other environmental conditions varies with plant species, varieties, locations and phonological stages, it is essential to observe the performance of advanced genotypes of wheat in respect of phonological traits. Depending on global food policy and production, it may need to maximize wheat production rather than economic yield.

Therefore, the yield potentiality of newly developed wheat varieties and promising lines is needed to investigate in order to explore the varietals potentiality in maximizing wheat yield and to assist breeding program in selecting lines with higher yield potentials.

Objectives

In order to fulfill the above mentioned aim, experiments have been undertaken with the following objectives:

1. To evaluate the physical and chemical composition of different varieties and advanced line of wheat
2. To compare the physic-chemical parameters and nutrition quality of different varieties and advanced line of wheat
3. To identify nutritionally potential wheat varieties for the welfare of human being

CHAPTER II

REVIEW OF LITERATURE

Wheat (*Triticum aestivum*) belongs to the grass family graminae and strictly speaking the fruit of wheat is a caryopsis but often called kernel or grain (Delcour & Hoseney, 2010).

Wheat (Triticum aestivum) is a leading cereal crop which is mainly utilized for human consumption and livestock feed. A wheat kernel comprises three principal fractions – bran, germ and endosperm. The outer layers are all parts of the bran. The bran fraction is a by-product of milling and has food and nonfood applications (Curti *et al*., 2013).

Wheat is grown under a wide range of climatic and soil conditions. It grows well in clay-loam soils. In Bangladesh it is a crop of Rabi season, requires dry weather and bright sunlight. Well distributed rainfall between 40 and 110 cm is congenial for its growth. Depending on variety and weather conditions, 100-120 days are required from sowing to harvest (BARI, 2009)

The global wheat production was 699.4 million metric tons estimated in the year of 2011-2012 (FAO, 2012)

Grain Weight

Thousand grain weight of any crop depends on its size. Usually grain weight increases with the increase of grain size. A good number of literatures are available on the variability of this trait.

Sharma (2000) evaluated four wheat varieties and reported that 1000 grain weight and grain hardness ranged from 33.0 to 41.8g

Kaur *et al*. (2000) compared two wheat varieties and found that variety PBW-138 had higher 1000 grain weight (44.90g) and density (1.31g/ml) as compared to variety WH-542 (33.90g and 1.23g/ml, respectively)

Dhingra and Jood (2004) observed the physical characteristics of wheat and reported that 1000 grain weight was 40.84g and grain hardness 8.23kg/ grain. The grain color varied between light yellow to golden yellow.

Singh *et al*. (2006) worked on 47 commercial wheat varieties and reported that 1000 kernel weight, grain length and width ratio in the range of 30.3 to 56.5g, 6.0 to 8.0mm and 2.9 to 3.7mm,

Nitika *et al*. (2008) worked on five varieties of organic and inorganic wheat and found that inorganically grown varieties had higher 1000 kernel weight (41.7g)

Anand *et al.* (2013) compared two Indian wheat varieties and found that variety HD-2733 had higher total grain weight (42.47g) as compared to variety HD-2687 (35.21g)

Sood *et al.* (2010) found that 1000 grain weight and grain color in raw, sprouted and puffed wheat was 37.4, 37.6 and 37.2g, respectively

Suhasini *et al*. (2004) studied on malting characteristics of a few Indian wheat varieties and found wide variation with respect to 1000 kernel weight (33.4 -53.8g), volume (24.7 - 38.0 ml) and grain hardness (12.6-24.9kg/cm2**).**

Moisture

Berbert *et al*. (1996) carried out some nutritional analysis on wheat and reported that Moisture content is commonly required for any flour specification sheet, with 13.5 percent ideal for soft wheat and 14 percent ideal for hard wheat.

Nasir *et al*. (2003) stated that 9 and 10% moisture content is suitable for storage stability and longer shelf life of wheat flour.

Buschmuller *et al*. (2008) observed that Wheat or flour with high moisture content (greater than 14.5 percent) attracts mold, bacteria, and insects, all of which cause deterioration during storage. Wheat or flour with low moisture content is more stable during storage.

Syeda *et al*. (2012) carried out an experiment on Microbial and Physico-chemical contamination in the wheat flour. They found that moisture content is one of the important factors to determine the quality of flour and its shelf life. Normal moisture content range in wheat flour is 11-14%.
Brady Carter PhD (2016) in his work reported that moisture content is commonly required for any flour specification sheet, with 13.5 percent ideal for soft wheat and 14 percent ideal for hard wheat.

Hoseney, (1994).found that moisture content of 9% or lower restricts infestation but at about 14% or slightly above, fungal growth takes place.
Yadav *et al.* (2010) conducted an experiment on different wheat varieties and reported that it contains 8.4% moisture.

Ash

Ash is the residue that remains after the complete combustion of the organic compounds of a food product. The estimation of the asf content in cereals enables the classification of flours.

Gupta *et al*. (1992) found that ash in flour can affect color, imparting a darker color to finished products. Some specialty products requiring particularly white flour call for low ash content while other products, such as whole wheat flour, have high ash content.

Ahmed *et al.* (2005) reported that reported that the ash content of different varieties of wheat were variable and range from 0.52% to 0.68%.

Khan and Zeb (2007) worked on seven different varieties of wheat and reported that it contains 1.44 to 2.10% ash.

Rahman and Kader (2011) tried to find out the comparative nutritive values and physiochemical properties of five new varieties of wheat seeds. They found that the ash content of the wheat varieties ranged from 1.8% to 2.16 %.

Ndife *et al*. (2011) reported that wheat contained fewer amounts of ash (1.5%)

Carbohydrate

It is well known that starch¸ total sugar and fibre are the main constituents of carbohydrate.

Kaur *et al*. (2000) compared four wheat varieties viz. WH-542, Sonak, WH-533 and UP- 2338 for carbohydrate composition and found that the reducing and non- reducing sugars were in the range of 36 to 46 and 152 to 247mg/100g flour.

Madan *et al*. (2003) observed carbohydrates and protein content of developing grain of wheat cultivars and found a progressive decrease of total sugars, reducing sugars and non reducing sugars content in the developing grain. Starch content increased throughout the grain development.

Singh *et al.* (2006) evaluated sixteen wheat varieties and found the total soluble sugars, reducing sugars, non-reducing sugar and starch content in the range of 2.2 to 3.4mg, 0.63 to 0.94mg, 1.5 to 2.4mg and 64.3 to 73.0mg/100g,

Naik *et al*. (2007) compared three types of wheat and found that triticale type wheat had higher total sugars (5.7%), non-reducing sugars (4.5%) and starch content (64.2%) as compared to durum and bread types wheat (5.6, 4.3, 62.9 and 5.6, 4.4, 62.7 percent).

Manu *et al.* (2008) stated that wheat contained high amount of total soluble sugars (4.96%), reducing sugars (0.52%), non-reducing sugars (4.45%) and starch content (69.47%)
Nitika *et al*. (2008) reported that the content of total soluble sugars, reducing sugars, non-reducing sugars and starch in five varieties of wheat were found to vary from 4.43 to 5.01, 0.52 to 0.58, 3.87 to 4.45 and 65.7 to 67.9%

Rahman and Kader (2011) compared five wheat varieties and showed that the variety BARI GAM-24 contained highest amount of reducing sugar (8.60mg/gm) while variety BAW-1064 and Sufi contained the lowest amount of reducing sugars (6.33mg/gm). Starch content of BARI GAM-24 variety was also highest (69.50%) as compared to other four varieties (68.50, 68.00, 67.95 and 67.50 %,)

Kumar *et al.* (2011) reported that wheat contains 1.7% total sugars, 66.8% starch and 68.5% carbohydrates

Protein

After starch, the largest chemical component of kernel is protein. Protein from the structural elements of cell and tissue in the human body and are considered as the basis of life, but they are also essential components in different food system.

Belderok *et al.* (2000) conducted that apart from carbohydrates, the mealy endosperm contains fats (1,5%) and proteins (13%): albumins, glubulins and the major proteins of the gluten complex- glutenins and gliadins.- proteins that will form the gluten at dough making.
The germ lies at one end of the grain. It is rich in proteins (25%). The mineral level is also rather high (4,5%). Wheat germ is available as a separate entity because it is an important source of vitamin E. Wheat germ has only one half the glutamine and proline of flour, but the levels of alanine, arginine, asparagine, glycine, lysine and threonine are double (Cornell 2003).

Duska *et al*. (2001) concluded that the quality of gluten is not only measured by the quantity of protein but also measured by the degree of extensibility and elasticity of dough

Rahman and Kader (2011) tried to find out the comparative nutritive values and physiochemical properties of five new varieties of wheat seeds. They stated that total protein content of wheat varieties ranged from 9.10% to 10.01%.

Gamal *et al*. (2012) found 10.5% crude protein in wheat flour
Branlard *et al.* (2001) studied on 162 bread wheat varieties and observed that grain protein content varied from 8.30 to 17.6% and grain hardness varied from very soft to very hard.

Qazi *et al.* (2003) worked on two varities of wheat and tried to find out the proximate composition. They found that it contains 9.20 and 10.68 percent protein.

Gluten proteins are present in the mature wheat grain endosperm where they form a continuous matrix around the starch granules. Gluten contains hundreds of protein components which are present either as monomers or, linked by inter- and intra- chain disulphide bonds (cysteine oxidized form), as oligo- polymers (Wrigley and Bietz, 1988).

Grain proteins of wheat can also be divided into structural/metabolic (non-gluten) and storage protein (gluten) (Shewry et al, 2003).

Shewry *et al*. (1995) observed that wheat kernel contain 10-15% proteins which is mostly present in the endosperm, many protein in the mature seed have either metabolic or structural role, still the vast majority of seed proteins are storage proteins that function as a nitrogen reserves for germinating embryo
Rehman *et al.* (2005) observed that whole wheat flour contains10.58 percent crude protein

Ikhtiar & Alam (2007) observed some selected varieties of wheat from Sindh and Punjab. They found the net protein in the range of 9.15- 13.80%

Gulzar *et al*. (2010) reported that different wheat varieties contained 10.30 to 11.72% crude Protein. Percentage of wet and dry gluten ranged from 24.30 to 30.06% and 8.40 to 10.40%

Fibre

Dietary fibre measurement is essential for the assessment of potential therapeutic and preventing effect of fibre intake. It has been shown that wheat is among cereal containing lower level of fibre (Anderson *et al*.1988)

Rahman and Kader (2011) tried to find out the fibre content of different Bangladeshi wheat. They stated that BARI gom 23 contains higher level of fibre.

Gear *et al*. (1981) stated that dietary fibre is the common name for all carbohydrate components occurring in foods that are non-digestible in the human small intestine. These components include non-starch polysaccharides, resistant starch, and resistant oligosaccharides with three or more monomeric units, and other non-digestible. Dietary fibre components consist of two major classes: (1) water soluble polymers (SDF), such as pectins and gums, and (2) water insoluble materials (IDF), in which cellulose, hemicelluloses and lignin are included

Wheat bran (WB) is subdivided into three distinct layers, viz testa, aleurone and pericarp. WB is composed of about 53% dietary fibre (xylans, lignin, cellulose, and galactan, fructans). Other components include vitamins and minerals and bioactive compounds such as alkylresorcinols, ferulic acid, flavonoids, carotenoids, lignans and sterols (Apprich *et al.* 2013)

Nitika *et al.* (2008) observed that crude fibre content of different wheat varieties are range from 1.71 to 1.82.

Sangwan and Dahiya (2013) worked on different wheat varuties to find out the crude fibre content. They observed that crude fibre of different wheat varieties are ranged from 1.75% to 2.07%

Fat

As mentioned before grains of cereals do not contain large amount of oil. The oil is located in the germ and bran fraction. The oil content of the wheat kernel comes mainly from germ.

Belderok *et al,* (2000) observed that the endosperm mainly contains food reserves, which are needed for growth of the seedling. Apart from carbohydrates, the mealy endosperm contains fats (1,5%)

Rahman and Kader (2011) compared five wheat varieties and showed that highest total mean fat content are present in BAW 1064 and BAW 1059.

Imtiaz *et al*. (2011) studied the proximate composition of wheat and reported that wheat contains 1.63% of fat.

Gamal *et al*. (2012) found 1.0% fat in wheat flour.

Minerals

Unlike other nutrients, minerals cannot be synthesized by living organism; so that they are all important in the human and animal diet. The main functions of minerals are structural components of body organs and tissues, constituents of body fluids and tissues electrolytes and catalysts in enzyme and hormone systems.

Gopalan *et al.* (2000) reported 48mg calcium, 355mg phosphorus, 4.9mg iron, 132mg magnesium and 2.7mg/100g zinc content in whole wheat flour

Minerals found in wheat bran (WB) include iron (Fe), zinc (Zn), manganese (Mn), magnesium (Mg) and phosphorus (P). (Aivaz & Mosharraf, 2013)

Qazi *et al.* (2003) analyzed two varieties of whole wheat for mineral content and found 4.00 and 4.32 mg/100g iron and 245 and 330.45 mg/100g phosphorus

There was a high correlation between grain-Fe and grain-Zn concentrations in the studied wheat lines. While there was significant genotype × environmental interactions obtained for Fe and Zn grain concentrations, there was still a strong genetic component to Fe and Zn accumulation in the grain (Welch and Graham 2002).

Ryan *et al*. (2004) reported minor variations in mineral concentration of different wheat varieties. They determined calcium; iron and zinc content in wheat and found the values 52.10, 6.69 and 2.50 mg/100g, respectively.

Gamal *et al.* (2012) reported higher amount of calcium, iron, phosphorus, zinc, magnesium and manganese in wheat bran (76.0, 10.6, 101.30, 7.3, 61.10, and 11.5 mg/100g) and lower in wheat flour (15.0, 1.30, 108.0, 0.6, 20.0 and 0.6 mg/100g, respectively). The calcium content of raw, germinated and fermented wheat was 151, 120 and 101mg/100g and magnesium was 8.64, 8.57 and 8.50mg/100g, respectively

Nabila *et al.* (2012) found that the calcium, iron and zinc contents of wheat were 33.66, 3.21 and 2.1mg/100g, respectively.

Anand *et al.* (2013) analyzed two varieties of whole wheat for mineral content and found 4.6 and 4.9 mg/100g iron and 37.7 and 40.8 mg/100g calcium while Saleh *et al.* (2013) found that the calcium and iron content of wheat were 30mg/100g and 3.5mg/100g, respectively.

A wide range of wheat germplasm is being studied at CIMMYT with respect to the concentration of Fe and Zn in the whole grain and environmental interactions on their concentrations (Welch and Graham 2002). According to a range of reports and survey studies, the average concentration of Zn in whole grain of wheat in various countries is between 20 to 35 $mg.kg^{-1}$ (Cakmak *et al*. 2004).

Most of the seed-Zn is present in the embryo and aleurone layer, whereas the endosperm is very low in Zn concentration. Zn concentrations were found to be around 150 $mg.kg^{-1}$ in the embryo and aleurone layer and only 15 $mg.kg^{-1}$ in the endosperm. (Ozturk *et al*. 2006)

CHAPTER III

MATERIALS AND METHODS

3.1 Materials

Four released and two advanced line of wheat namely BARI gom-22 (Sufi), BARI gom-23 (Bijoy), BARI gom-24 (Prodip), Sonora-64, WYCYT (E-13) and WYCYT (E-14) were selected for the study. The seeds were collected from the Wheat Research Center (WRC), Dinajpur. Seeds were cleaned, sun dried and stored into plastic container in a cool place until used for the chemical analysis.

3.1.1 Brief description of varieties

BARI gom-22 (Sufi): This is a composite variety evolved by the BARI in 2005. The grain is small in size.

BARI gom-23 (Bijoy): This is a composite variety evolved by the BARI in 2005. The grain is big in size.

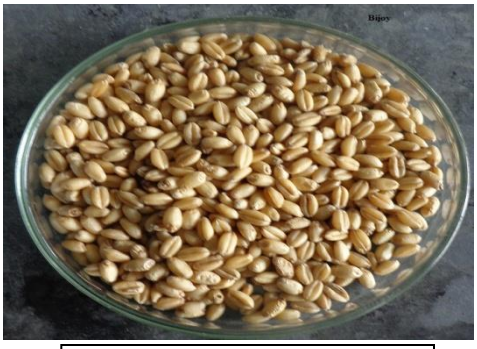
BARI gom-23 (Prodip): This is a composite variety evolved by the BARI in 2005. The grain is big in size.

Sonora-64: This is a composite variety evolved by the BARI in 1974. The grain is small in size.

WYCYT (E-14): This advanced line evolved by BARI.

WYCYT (E-14): This advanced line evolved by BARI.

BARI gom-22 (Sufi)



BARI gom-23 (Bijoy)

BARI gom-24 (Prodip)

Sonora-64

WYCYT (E-13)

WYCYT (E-14)

Figure 1: Photograph showing variations in seed coat color, seed size and shape of some selected released and advanced line of Wheat varieties (*Triticum aestivum*)

3.2 Physicochemical Properties

The nutritive value of a food grain is indicated by its composition shown by chemical analysis. The degree to which the chemical analysis indicates the nutritive value is dependent on the constitution determined. Some constituents are determined fairly easily and rapidly, while others require much more time and analytical ability. Consequently, most laboratories are faced with a choice between making a few rather simple determinations of a large number of samples or complete analysis of a limited number of samples. Before undertaking an analysis, the results of which will represent the composition of a crop or a consignment of a food grain, it is necessary to ensure that the sample taken is randomly selected so as to be truly representative of the original bulk, and is sufficient in amount.

3.2.1 Determination of 1000 grain seed weight

The mass was determined by randomly selecting 250 seed samples and weighing in an electronic balance of 0.001 g sensitivity. The weight was then converted into 1000 seed mass.

3.2.2 Determination of moisture

Moisture content of wheat sample was determined by conventional method i.e., drying in an oven at 100°C for overnight.

Procedure

Empty aluminum moisture dish was weighted (w_1) and 2.5 g sample was taken in a moisture dish and weighted (w_2). The sample was spread evenly and placed without lid in oven and dried samples overnight at 100°C. The dishes were transferred to desiccators to cool. Aluminum dish was weighed after cooling (w_3).

Calculation

$$\% \text{ Moisture} = \frac{(W2 - W1)}{(W2 - W3)} \times 100$$

3.2.3 Determination of ash

The sample is ignited at 600°C to burn off organic material. The inorganic material which does not volatilize at that temperature is called ash. The procedure was described by Ranganna (1986)

Equipments

1. Balance
2. Muffle furnace
3. Desiccators

Procedure

The temperature of the muffle furnace was fixed to 600°C and crucible was heated foe 1h and transferred into a desiccator; cooled them to room temperature and weighted (W_1). About 2g sample was put into the crucible weighted (W_2). The sample was burned in a muffle furnace at 600C for about 2h. The crucibles were transferred into the desiccator and cooled them to room temperature and weighted (W_3). It was done immediately to prevent moisture absorption. The incineration repeated until constant weight was obtained.

Calculation

Weight of the sample taken = $W_2 - W1$

Weight of the ash obtained = $W_3 - W1$

$$\% \text{ Ash} = \frac{\text{Weight of the ash}}{\text{Weight of the sample taken}} \times 100$$

$$= \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

3.3 Chemical analysis

3.3.1 Estimation of fats

Reagent and Equipments

1. Anhydrous ethyl ether
2. Soxhlet, flask and condenser
3. Hot plate

Procedure

Dried wheat flour sample was weighted out into an extraction thimble. Weight of thimble and sample were recorded in laboratory book. The thimble was placed into the soxhlet. 50-100 ml ethyl was added to the soxhlet flask then it was connected to holder and condenser. Soxhlet flask was placed on hot plate and distilled at low temperature for 16-20 hours. After extraction it was turned off and allowed to cool. When distillation was ceased, the extraction thimble was removed and allowed to air dry for 30-40 minutes the thimble was weighed out. The loss of weight was cured fat.

% Crude fat (on a dry weight basis)=

$$\frac{\text{Wt. of thimble \& sample before extraction} - \text{Wt. of thimble \& sample after extraction}}{\text{Weight of sample before extraction}} \times 100$$

The fat determined by the above procedure (Hughes, 1965) contains usual lipids including waxes pigments, certain gums and resins. A better name for these constituents would be "ether soluble extract"

3.3.2 Estimation of total protein content by Microkjeldhal method

The protein content of food stuff is obtained by estimating the nitrogen content of the material and multiplying the nitrogen value by 6.25 (according to the fact that nitrogen constitutes on average 16% of a protein molecule). This is referred to as crude protein content, since the non protein nitrogen (NPN) present in the material is not taken in consideration. The estimation of nitrogen is done by kjeldhal method (AOAC 1984) which depends upon the fact that organic nitrogen when digested with sulphuric acid in the presence of catalyst selenium oxide, mercury or copper sulfate is converted into ammonium sulphate. Ammonium liberated by making the solution alkaline is distilled into a known volume of a standard acid which is then back titrated.

The nitrogen present in the sample is converted to ammonium sulphate by digestion at (380°C) with sulphate acid in presence of a catalyst, potassium sulphate and mercuric oxide. Ammonia liberated by distilling the digest with sodium hydroxide solution is absorbed by boric acid and is titrated for quantitative estimation.

Equipments

1. Balance
2. Microkjheldhal (Mkj) digestion set
3. Mkj distillation set

Reagent

1. Digestion mixture: 100g of potassium sulphate (K_2SO_4) was thoroughly mixed with 20g of copper sulfate ($CuSO_4.5H_2O$) and 2.5g selenium dioxide (SeO_2) was added with it
2. 60% sodium hydroxide solution: 600g sodium hydroxide and 50g sodium thiosulphate were dissolved in distilled water, cooled and made the volume up to 1 liter
3. Boric acid: 40g of boric acid was dissolved in water and made up to 1 liter
4. Double indicator: 200mg each methyl red and bromocresol green was dissolved separately in 100 ml of 70% ethanol. One part of methyl red and five parts of bromocresol green were mixed before use.
5. Hydrochloric acid (0.02 N HCL) : 8.5 ml concentrated hydrochloric acid was added to 5 liter of distilled water. Standardized to 0.02 N acids by titrating it against standard sodium carbonate (0.02 N) solution.

Procedure

A known quantity of the finely ground sample (100 mg) weighted out in an Mkj digestion flask. About 2 g digestion mixture was added with it 2 ml of concentrated sulphuric acid was dispensed into the flask. Then it was digested for about 2 hrs in Mkj digestion set and was cooled the clear digest. The digest was dissolved in minimum amount of distilled water and carefully transferred to an Mkj distillation set. 10 ml of sodium hydroxide solution was added and distilled it. The distillation was collected for 5 min into 5 ml boric acid containing 2 drops of mixed indicator in a 50 ml conical flask, till the color of solution was changed. The distillate was titrated against a standard hydrochloric acid and noted the titer value (TV).

Calculation

$$N\ \% = \frac{(14.007) \times (\text{normality of the acid, } 0.02) \times (TV)}{\text{Weight of sample (mg)}} \times 100$$

Where 14.007 is the equivalent weight of nitrogen

Nitrogen % is converted into protein by multiplying with a factor 6.25 for cereals and pulses.

3.3.3 Estimation of Carbohydrate

Total carbohydrate estimation

The method was described by Raghuramulu et al. (2003). The content of the available carbohydrate was determined by the following equation:

Carbohydrate = 100 − { (Moisture+ Fat+ protein+ Ash+Oil/Fats)g/100g }

3.3.4 Estimation of minerals

Reagent for Ca and Mg determination

1% Lanthanum solution

Fifty nine gram of lanthanum oxide (La_2O_3) were added with about 50 ml of water. Slowly and cautiously, 250 ml conc. HCL was added to dissolve the La2O3. It was made to 5 liters with water.

Turbidimetric reagent

10 gm of polyvinyl pyrolidone (PVP K30) was dissolved in about 100 ml of hot water. 150 gm of ($BaCl_2$. $2H_2O$) was dissolved in about 500 ml of water. The PVP and barium chloride solutions were mixed and were made to liter with water.

Preparation of standard

1. For convenience the Cu, Fe, Zn were prepared together in water. The high concentration for these elements was as follows : 2μg Cu/ml, 10μg Fe/ml, 2μg Zn/ml.
2. The P, K, Na were prepared together in water with high concentrations as follows: 20µg P/ml, 100µg K/ml, 40µg Na/ml.
3. Ca and Mg were prepared in the same solution with concentrations as follows: 100µg Ca/ml, 40 µg Mg/ml.

Digestion solution

Nitric-perchloric solution

Conc. Perchloric acid (100ml) was added to 500 ml concentrated HNO_3 to prepare nitric-perchloric solution.

3.3.5 Digestion of wheat seed sample for determination of Ca, Mg, Na, Zn, Fe, Cu, Co and B

Digestion procedure

Weighted 500 gm dry seed sample and put into a 50 ml boiling flask. 5 ml of nitric-perchloric solution was allowed on cool hot plate and turned temperature to 375°C. It was allowed to digest for 1 hour and 30 minutes. The flask was removed from digestion chamber and cooled and 15 ml water was added. The flask was agitated and heated to dissolve the ash and filter.

Analytical procedure

By using a combination dilute-dispenser, 1 ml aliquot was taken from filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For S determination, 7 ml of aliquot from dilution 1, 9 ml of acid seed solution and 4 ml of turbidimetric solution were mixed together thoroughly. It was allowed to stand 20 minutes and not longer than 1 hour. The reading was taken in turbid meter or in colorimeter at 535 nm using a cuvette with 2 cm light path. For P, K and Na determination, 1 ml aliquot from dilution 1, 9 ml of water and 10 ml of color reagent were mixed together. It was allowed to stand about 20 minutes and reading was taken of spectrophotometer at 680 nm.

For Ca and Mg determination, 1 ml aliquot from dilution 1, 9 ml of water and 10 ml of 1% lanthanum solution were mixed together. It was analyzed by AA procedure. For Fe and Zn determination, the original filtrate was used to analyze these elements by AA procedure

3.4 Statistical analysis

The recorded data for each character from the experiments was analyzed statistically to find out the variation resulting from experimental treatments using MSTAT-C, Microsoft Excel package program and Minitab17. The mean for all the treatments were calculated and analysis of variance of characters under the study was performed by F variance test. The mean differences were evaluated by Least Significance test.

CHAPTER IV

RESULT AND DISCUSSION

Four released and two advanced line of wheat varieties were taken for the determination of physical and chemical characteristics. The seeds were stored under a suitable storage condition. The proximate composition and some other nutrient composition of wheat kernel are also reported.

Analytical studies of the whole seeds:

The proximate composition of the whole wheat seeds of different released and advanced line were presented in different tables. The data had also been estimated on moisture free basis in order to allow for better comparison of the different fraction. The data mentioned were the average of three replications and had been presented and discussed.

4.1 Seed weight

Thousand grain weight of different released and advanced line cultivars of wheat are presented and compared in table 1. Thousand grain weights were determined at 13% moisture level. It was found that seed weight varied with their size and shape. The result showed that highest weight of thousand of seed weight was found in BARI gom-23 (Bijoy) (52.35g). It was significantly higher than all other cultivars. Statistically similar results are shown by BARI gom-24 (Prodip) (51.44g). The lowest weight of thousand seeds was found in Sonora-64 (33.21g). The thousand grain weight reported by Singh et al., (2006) and Suhasini *et al*. (2004) was more or less similar with present value.

4.2 Moisture

Seed deterioration increased when moisture content is increased. It is proved that the permeable moisture content of different cereals is 10-12% at storage condition. It is an important factor for other nutrients as they vary with it. It is also necessary for insect infestation and diseases. When seeds contain above 18% moisture then insect infestation and diseases occurred. The moisture content of different released and advanced line of wheat cultivars were presented in table 1. The moisture content of different released and advanced line of wheat cultivars were varied from 7.91% to 8.87%. The result showed that highest moisture content was found in BARI gom-22 (Sufi) (8.87%), which was followed by BARI gom-23, BARI gom-24, Sonora-64, WYCYT (E-13) (8.76%, 8.59%, 8.43% and 8.06%). The lowest moisture content was found in WYCYT (E-14). The present value was more or less similar with the reported value of Yadav *et al.* (2010). The present values of moisture content become lower than the reported result of Syeda *et al*., (2012) which happened due to different levels of sun drying after harvesting.

4.3 Ash

Ash content of different released and advanced line of wheat cultivars were variable and ranged from1.58% to 2.13% (table 1). BARI gom-22 contains significantly highest amount of ash (2.10%). The lowest amount of ash content (1.57%) showed by the cultivar WYCYT (E-13) followed by the cultivar BARI gom-23 (1.58%). BARI gom-24, Sonora-64 contain similar amount of ash (1.78%, 1.72%). WYCYT (E-14) contains 1.63% of ash. The present values were significantly higher than the reported value of Ahmed et al (2005). The present value was more or less similar with the reported value of Khan and Zeb (2007). Khan and Zeb (2007) reported that it contains 1.44 to 2.10% ash.

Table 1. Weight of 1000 seeds, Moisture and Ash content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

Name of the varieties (Treatment)	Weight of 1000 seeds (gm)	Moisture (%)	Ash (%)
BARI GOM-22(Sufi)	35.24 e	8.87 a	2.13 a
BARI GOM-23 (Bijoy)	52.35 a	8.76 ab	1.58 b
BARI GOM-24 (Prodip)	51.44 b	8.59 ab	1.78 ab
Sonora-64	33.21 f	8.06 ab	1.72 ab
WYCYT (E-13)	42.46 c	8.43 ab	1.57 b
WYCYT (E-14)	39.73 d	7.91 b	1.63 b
$LSD_{(0.05)}$	0.69	0.86	0.44
CV (%)	0.89	5.59	14.06

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT

4.4 Protein

Protein is one of the major nutrients of different released and advanced line of wheat varieties. Protein content is genetically controlled. It is influenced by nitrogen fertilizer application and agronomic practices. The total protein contents were determined on moisture free basis. The amount of protein of different released and advanced line of wheat cultivars have been presented in table 2. The results showed that among the different wheat cultivars BARI gom-24 contains significantly highest amount of protein (10.04%) which was also at par with the varieties WYCYT (E-13) (10.01%), BARI gom-23 (9.83%), Sonora-64 (9.74%) and BARI gom-22 (9.67%). On the other hand WYCYT (E-14) contains significantly lowest amount of protein (9.10%). The present values were more or less similar with the values reported by Rahman and Kader (2011), Gamal *et al*. (2012) and Shewry *et al*, (1995). However these values are lower than the reported by Branlard *et al.* (2001), Ikhtiar & Alam (2007) and Gulzar *et al*. (2010). Gulzar *et al*. (2010) reported that different wheat varieties contained 10.30 to 11.72% crude Protein. This difference might be due to the nitrogen fertilizer application, ecology and agronomic practices.

4.5 Fat

It is evidenced that fat content is genetically controlled and cereal grain contains lowest amount of fat. Highest total mean fat content are present in WYCYT (E-13) (1.83%) which is significantly higher than other wheat cultivars and followed by Sonora-64 (1.72%). Statistically similar results are shown by WYCYT (E-14), BARI gom-23 and BARI gom-24 (1.57%, 1.52% and 1.46%). On the other hand BARI gom-22 contains significantly lowest amount of fat (1.03%). These results were more or less similar with the result reported by Belderok et al., (2000), Rahman and Kader (2011) and Gamal *et al*. (2012).

4.6 Crude fibre

The amount of crude fibre was also determined on moisture free basis. The crude fibre content different released and advanced line of wheat cultivars is varied from 10.21% to 13.89%. the significantly highest amount of crude fibre contents were found in BARI gom-24 (13.89%) which was at par with the varieties BARI gom-23, WYCYT (E-13) and Sonora-64 (13.09%,13.67% and 12.21%). Significantly lowest amount of crude fibre content was found in WYCYT (E-14) (10.21%). BARI gom-22 contains 11.75% of crude fibre. The present value of fibre were more or less similar with the reported value of Sangwan and Dahiya (2013) and Nitika *et al.* (2008).

4.7 Carbohydrate

Carbohydrate is the major nutrient component of the wheat kernel. Generally starch, reducing sugar and crude fibre are considered the main components of carbohydrate. The result of carbohydrate contents of different released and advanced line of wheat cultivars are presented in table 2. It was observed that WYCYT (E-14) gave significantly highest amount of carbohydrate (72.84%) which was at par with the variety BARI gom-22 (70.13%). Statistically similar result was found in BARI gom-23, Sonora-64 and WYCYT (E-13) (69.27%, 69.72% and 67.95%). BARI gom-24 contains significantly lowest amount of carbohydrate (67.62%). These present result were more and less similar with the result reported by Singh *et al.* (2006), Nitika *et al*. (2008) and Rahman and Kader (2011) but higher than the values reported by Naik *et al*. (2007) Manu *et al.* (2008) and Kumar *et al.* (2011). Agronomic practices, environmental factors as well as variation among the varieties might be influenced the carbohydrate contents.

Table 2. Proximate analysis of Protein, Fat, Crude Fibre and Carbohydrate of different released and advanced line of Wheat varieties (*Triticum aestivum)*

Name of the varieties (Treatment)	Protein (%)	Fat (%)	Crude Fibre (%)	Carbohydrate (%)
BARI GOM-22(Sufi)	9.67 ab	1.03 c	11.75 c	70.13 b
BARI GOM-23 (Bijoy)	9.83 ab	1.52 ab	13.09 ab	69.27 cd
BARI GOM-24 (Prodip)	10.04 a	1.46 b	13.89 a	67.62 e
Sonora-64	9.74 ab	1.72 ab	12.21 b	69.72 cd
WYCYT (E-13)	10.01 a	1.83 a	13.67 ab	67.95 d
WYCYT (E-14)	9.1 b	1.57 ab	10.21 d	72.84 a
$LSD_{(0.05)}$	0.80	0.32	0.44	1.37
CV (%)	4.54	11.30	11.90	1.01

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT

4.8 Minerals

Different major and minor minerals were analyzed in this work. The amount of different major minerals was stated in table 3 and the amount of different minor minerals of wheat varieties was stated in table 4

Calcium (Ca)

It is well known that wheat germ contain minerals. In case of calcium content of different released and advanced line of wheat varieties was ranged from 0.51% to 0.60%. Sonora-64 contained the highest amount of Ca (0.60%) which found significantly higher than other varieties and followed by BARI gom-24 (0.59%) and BARI gom-23 (0.57%). WYCYT (E-14) contained the lowest amount of Ca which was lower than other cultivars. These values were much higher than the values reported by Gopalan *et al.* (2000).

Magnesium (Mg)

Magnesium is the major minerals for human nutrition. Magnesium content of different released and advanced line of wheat cultivars are presented in table 3. Magnesium content of different varieties is ranged from 0.26% to 0.31%. The highest amount of magnesium content was found in Sonora-64 (0.31%) which was significantly higher than other cultivars. This was followed by BARI gom-24 (0.30%) and WYCYT (E-13) (0.29%). The cultivar WYCYT (E-14) contained significantly lower amount of magnesium (0.26%). This result was more or less similar with the result reported by Gopalan *et al.* (2000). This present values were found lower than the values reported by Gamal *et al.* (2012).

Potassium (K)

Six wheat varieties contained a wide range of K which was 0.13% to 0.23% reported in table 3. The highest amount of potassium found in BARI gom-22 (0.23%) which was significantly higher than other varieties or cultivars. This was followed by Sonora-64 (0.19%) and BARI gom-23 (0.18%). The lowest amount of potassium was found in BARI gom-24 (0.12%) which was significantly lower than other varieties. The present value of potassium found more or less similar with the values reported by (Aivaz & Mosharraf, 2013).

Table 3. Proximate analysis of major minerals content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

Name of the varieties (Treatment)	Ca (%)	Mg (%)	K (%)
BARI GOM-22(Sufi)	0.56 a	0.28 a	0.23 a
BARI GOM-23 (Bijoy)	0.57 a	0.26 a	0.18 ab
BARI GOM-24 (Prodip)	0.59 a	0.3 a	0.12 b
Sonora-64	0.6 a	0.31 a	0.19 ab
WYCYT (E-13)	0.52 a	0.29 a	0.13 ab
WYCYT (E-14)	0.51 a	0.26 a	0.15 ab
$LSD_{(0.05)}$	0.21	0.18	0.09
CV (%)	20.39	35.60	31.33

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT

Copper (Cu)

The analysis of different released and advanced line of wheat cultivars showed a varied ranged of Cu from 11.22ppm to 14.26ppm (table 4). Sonora-64 contained significantly higher amount of Cu (14.26ppm) which was significantly higher than other varieties and followed by WYCYT (E-13), BARI gom-22 and BARI gom-23 (13.62ppm, 12.76ppm, 12.64ppm). Significantly lowest amount of copper found in BARI gom-24 (11.22ppm). This present values was more or less similar with the values reported by Saleh *et al.* (2013)

Iron (Fe)

Iron contained by different released and advanced line of wheat cultivars also showed a varied range from 239.10ppm to 279.24ppm which is presented in table 4. The present values was more or less similar with the values reported by Qazi *et al.* (2003) but lower than the Anand *et al.* (2013). Significantly highest amount of iron was found in Sonora-64 (279.24ppm) followed by WYCYT (E-13), BARI gom-22 (267.56ppm, 254.70ppm). the variety BARI gom-24 contaied significantly lowest amount of Fe (239.10ppm). the different levels of iron in soil, fertilizer and variation among the varieties might be influenced the iron content.

Boron (B)

Different released and advanced line of wheat cultivars contained relatively lower amount of boron. The analysis of different released and advanced line of wheat cultivars showed a varied ranged of B from 12.00ppm to 16.87ppm (table 4). Significantly highest amount of B (16.87ppm) was found in WYCYT (E-13) followed by BARI gom-22 (16.80ppm). statistically similar result (14.72ppm and 14.37ppm)) was found in BARI gom-23 and WYCYT (E-14). The lowest amount of B was found in BARI gom-24 (12.00ppm) which is significantly lower than other cultivars.

Zinc (Zn)

The zinc content of different released and advanced line of wheat cultivars varied from 33.26ppm to 42.78ppm. The analyzed values were lower than the values reported by Gopalan *et al.* (2000) but found more or less similar with the values reported by Welch and Graham (2002). Significantly highest amount of Zn content found in Sonora-64 (42.78ppm) followed by BARI gom-22 (38.28ppm). The amount of Zn content in WYCYT (E-13) (34.62ppm) and BARI gom-23 (34.25ppm) are almost similar. Significantly lowest amount of Zn content (33.26ppm) was found in WYCYT (E-14).

Table 4. Proximate analysis of minor minerals content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

Name of the varieties (Treatment)	B (ppm)	Cu (ppm)	Zn (ppm)	Fe (ppm)
BARI GOM-22(Sufi)	16.8 a	12.76 bc	38.28 b	254.7 c
BARI GOM-23 (Bijoy)	14.72 b	12.64 c	34.25 cd	245.37 e
BARI GOM-24 (Prodip)	12 d	11.22 d	33.66 de	239.1 f
Sonora-64	13.2 c	14.26 a	42.78 a	279.24 a
WYCYT (E-13)	16.87 a	13.62 ab	34.62 c	267.56 b
WYCYT (E-14)	14.37 b	12.82 bc	33.26 e	247.21 d
$LSD_{(0.05)}$	0.96	0.85	0.83	1.62
CV (%)	3.63	3.66	1.26	0.35

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT

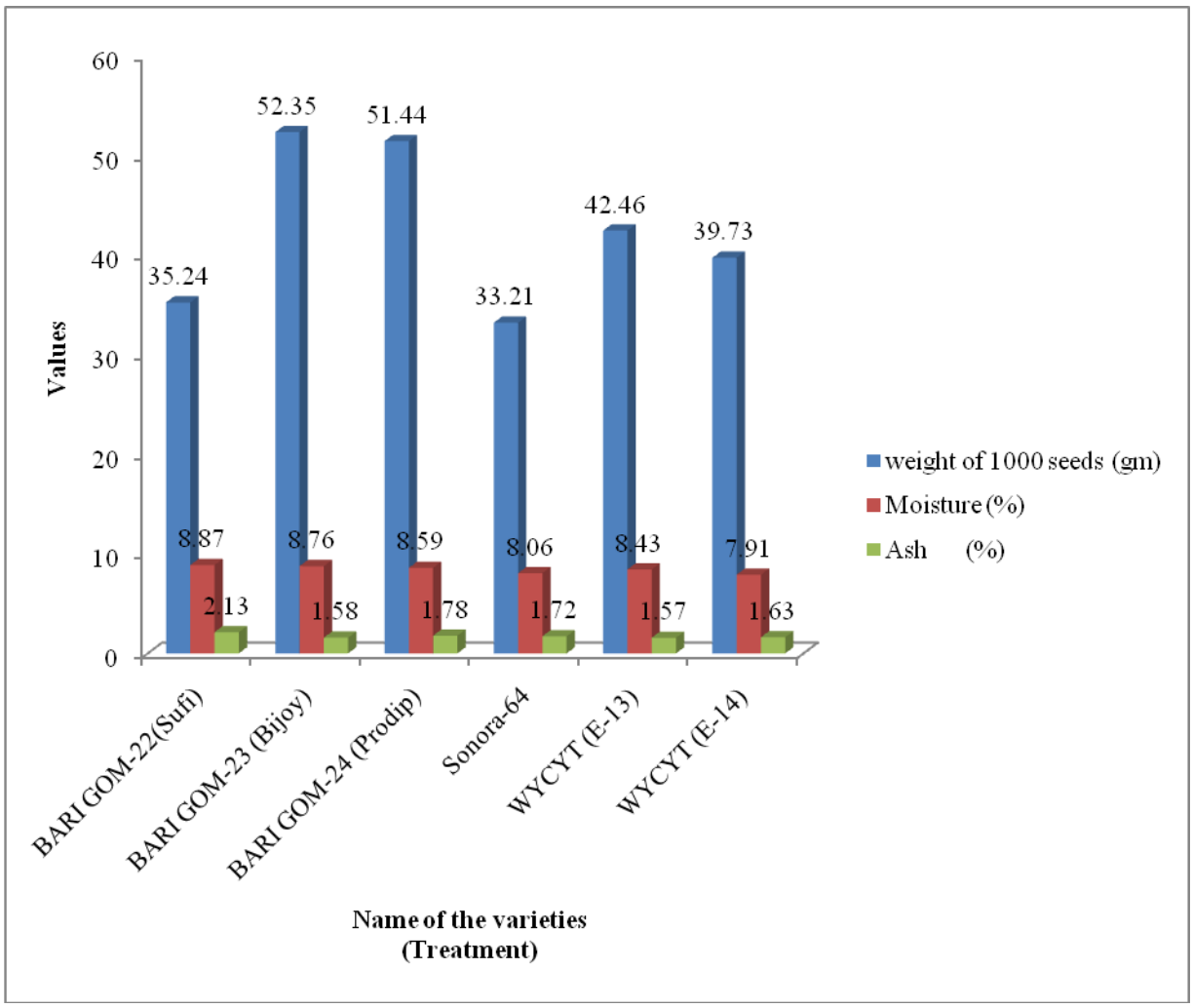


Figure 2. Weight of 1000 seeds, Moisture and Ash content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

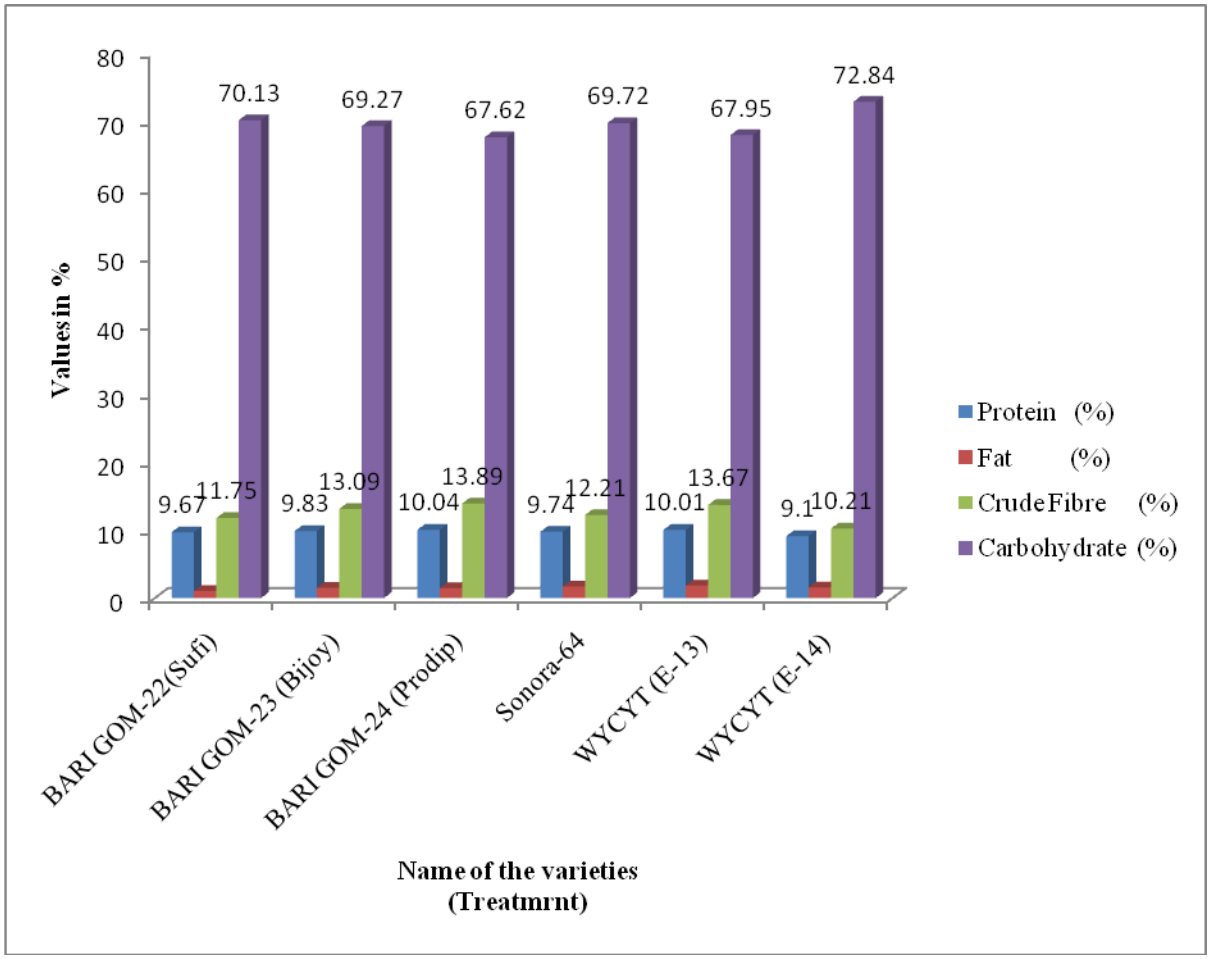


Figure 3. Proximate analysis of Protein, Fat, Crude Fibre and Carbohydrate of different released and advanced line of Wheat varieties (*Triticum aestivum)*

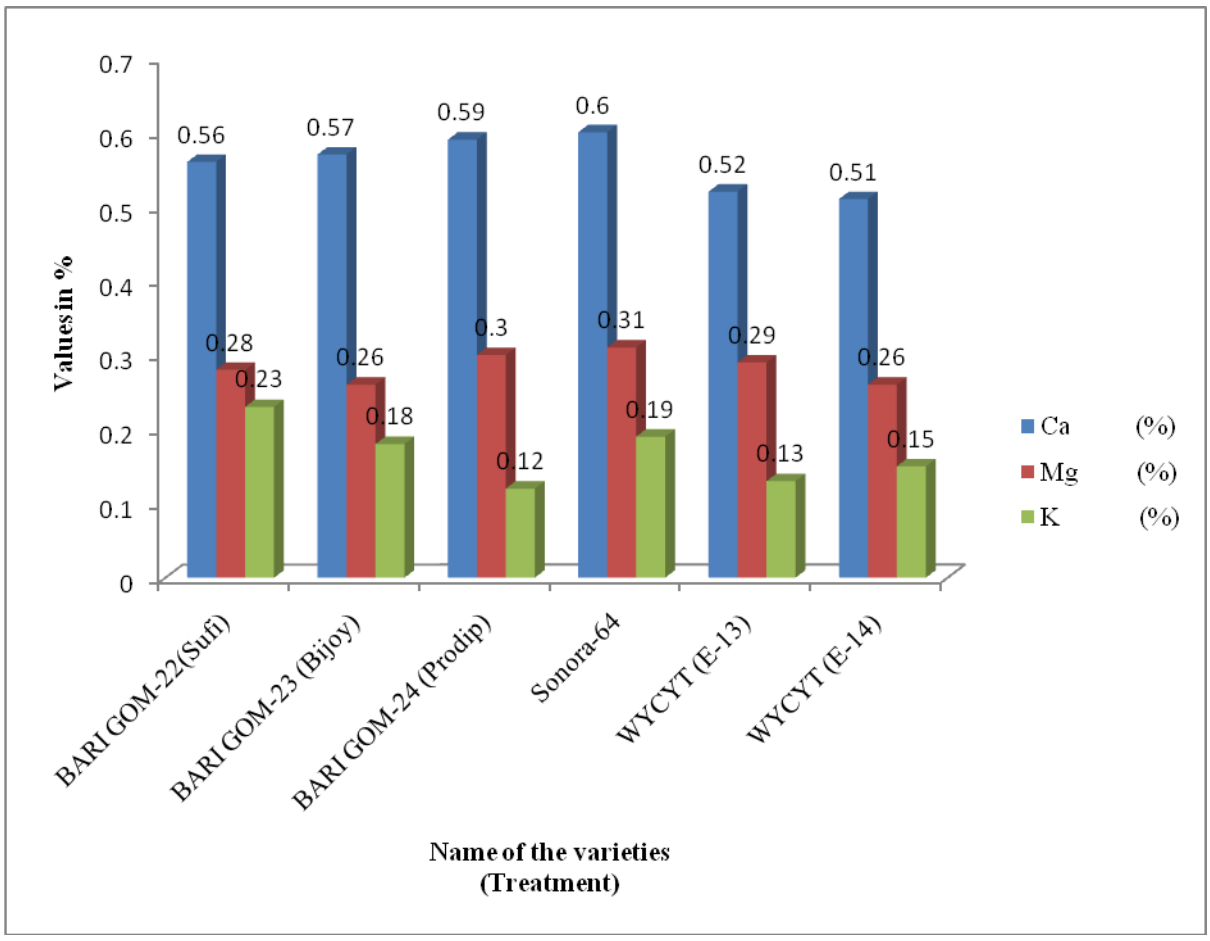


Figure 4. Proximate analysis of major minerals content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

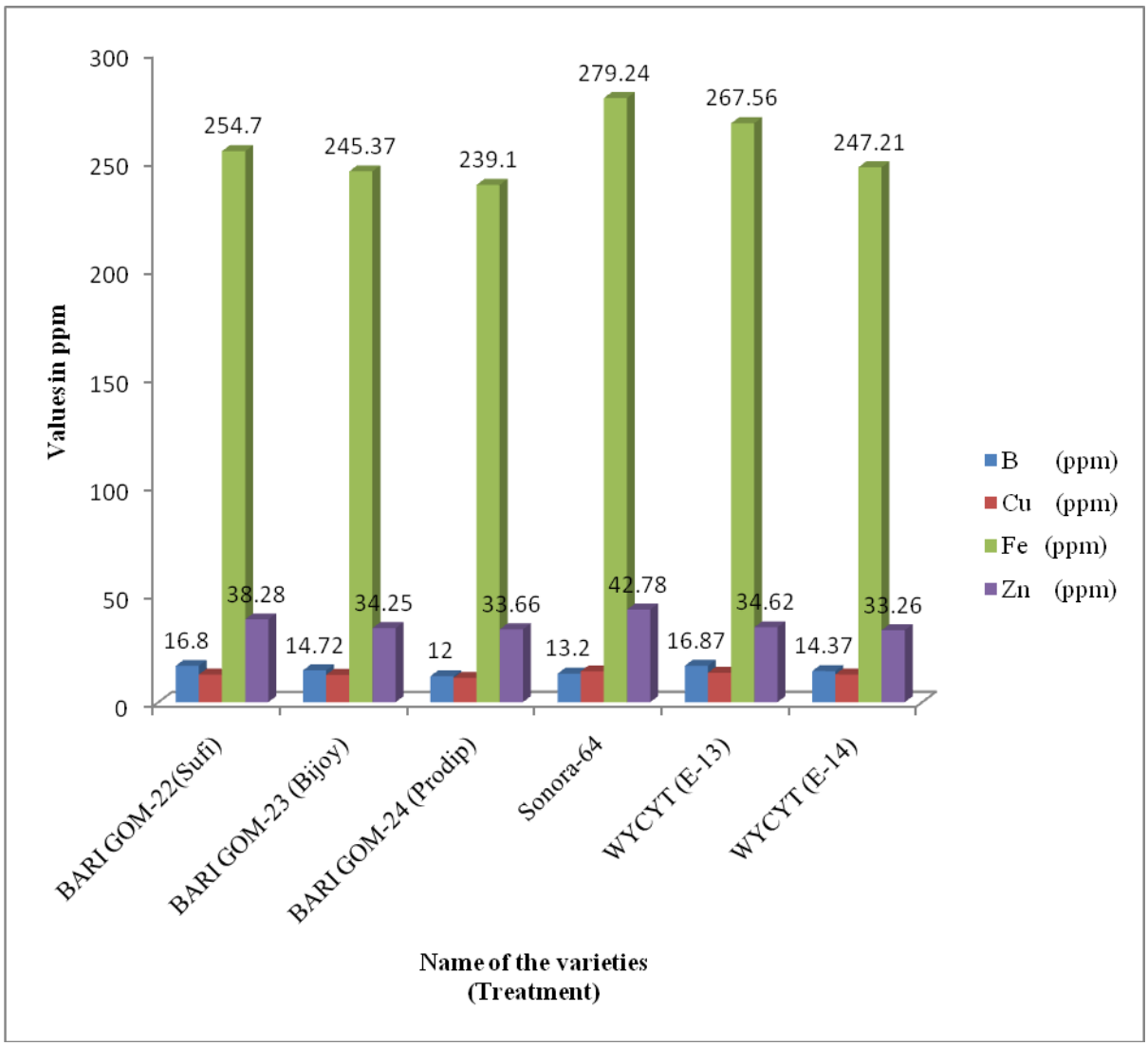


Figure 5. Proximate analysis of minor minerals content of different released and advanced line of Wheat varieties (*Triticum aestivum)*

CHAPTER V

SUMMARY AND CONCLUSION

The work was conducted on six released and advanced line of wheat varieties. The work was conducted for the evolution of the physiochemical parameters of the kernel. From my research work we observed that that highest weight of thousand of seed weight was found in BARI gom-23 (Bijoy) (52.35g). On the other hand the lowest weight of thousand seeds was found in Sonora-64 (33.21g). The result showed that highest moisture content was found in BARI gom-22 (Sufi) (8.87%) whereas the lowest moisture content was found in WYCYT (E-14). significantly highest amount of ash (2.10%) was found in BARI gom-22 (Sufi).

Among the different released and advanced line of what cultivars BARI gom-24 (Prodip) contains significantly highest amount of protein (10.04%). The protein contents of different released and advanced line if wheat cultivars were varied from 9.10% to 10.04%. On the other hand WYCYT (E-14) contains significantly lowest amount of protein (9.10%). Highest total mean fat content are present in WYCYT (E-13) (1.83%) and BARI gom-22 contains significantly lowest amount of fat (1.03%). Significantly highest amount of crude fibre contents were found in BARI gom-24 (13.89%) on the other hand lowest amount of crude fibre content was found in WYCYT (E-14) (10.21%). Among the different released and advanced line of wheat cultivars WYCYT (E-14) gave significantly highest amount of carbohydrate (72.84%) whereas BARI gom-24 contains significantly lowest amount of carbohydrate (67.62%).

In case of calcium content of different released and advanced line of wheat varieties was ranged from 0.51% to 0.60%. Sonora-64 contained the highest amount of Ca (0.60%) on the other hand WYCYT (E-14) contained the lowest amount of Ca (0.51%). Magnesium content of different varieties is ranged from 0.26% to 0.31%. The highest amount of magnesium content was found in Sonora-64 (0.31%) and the cultivar WYCYT (E-14) contained significantly lower amount of magnesium (0.26%). Six wheat varieties contained a wide range of K which was 0.13% to 0.23%. The highest amount of potassium found in BARI gom-22 (0.23%) whereas the lowest amount of potassium was found in BARI gom-24 (0.12%).

The analysis of different released and advanced line of wheat cultivars showed a varied ranged of Cu from 11.22ppm to 14.26ppm. Sonora-64 contained significantly higher amount of Cu (14.26ppm) on the other hand significantly lowest amount of copper found in BARI gom-24 (11.22ppm). among the different released and advanced line of wheat varieties Significantly highest amount of iron was found in Sonora-64 (279.24ppm) and the variety BARI gom-24 contained significantly lowest amount of Fe (239.10ppm). The analysis of different released and advanced line of wheat cultivars showed a varied ranged of B from 12.00ppm to 16.87ppm. Significantly highest amount of B (16.87ppm) was found in WYCYT (E-13) on the other hand the lowest amount of B was found in BARI gom-24 (12.00ppm). Among the different released and advanced line of wheat cultivars significantly highest amount of Zn content found in Sonora-64 (42.78ppm) and the lowest amount of Zn content (33.26ppm) was found in WYCYT (E-14).

From the above discussion it was observed that none of the cultivars/variety of wheat performed the best by all nutrient parameters. But BARI gom-24 (Prodip) performed the better considering the nutrient contents. WYCYT (E-14) could be considered better for carbohydrate. BARI gom-22 (sufi), BARI gom-23 (Bijoy) also performed well results in carbohydrate, protein and fibre contents. In case of minerals most of the varieties contained the higher amount of minerals than the reference rate due to change of fertilizer application rate and as well as soil properties of the different wheat growing area. Different hybrid varieties viz. Sonora-64, BARI gom-24 and BARI gom-22 showed the best performance for the most of the minerals. Farmers are cultivating wheat in their field for the consumption as feed, fodder as well as public consumption. Based on the information mentioned above, it may concluded that BARI gom-24, BARI gom-23, BARI gom-22 and WYCYT (E-14) can be grown in large scale as they contained the highest amount of different nutrient contents.

RECOMMENDATION

- Further analysis of different wheat varieties should be done to know their nutritional content.
- Nutritional analysis is also important for breeders to evolve more nutrient rich wheat variety.
- Chemical composition and nutritional traits suggests the future strategy for the nutritionist, health advisor and dieticians as to know how to make best use of the wheat.

CHAPTER VI

REFERENCES

Ahmad I, Ahmad N, Kausar T and Ashraf M (2005), Effect ofbmaltogenic amylase on the shelf life of bread, *Pak. J. Food Sci.* 15: 15-19.

Anand, K., Sharma, P. and Chaturvedi, N. 2013. A comparative study of varietal variations on nutritional quality of wheat malt and sensory attributes of prepared non-conventional malted beverages. *Bev. Food World* 40 (2):34-36.

Anderson , J.W. and S.R. Bridge, 1988. Dietary fibre contents of selected foods. Am. J. Clin Nutr., 47: 440-447

Aivaz, M. & Mosharraf, L. (2013). Influence of different treatments and particle size of wheat bran on its mineral and physicochemical characteristics. International Journal of Agricultural Sciences, 3, 608–619.

BARI (Bangladesh Agricultural Research Institute). (1990). Means of profitable wheat cultivation, Wheat Research Center. *Bangladesh Agril. Res. Inst.* Nashipur, Dinajpur. 1-11.

BARI (Bangladesh Agricultural Research Institute), Annual Report, 2015-2016. Bangladesh Agricultural Research Institute, Gazipur, Bangladesh (2016).

BBS (Bangladesh Bureau of Statistics), 2014. Statistical Year Book of Bangladesh. Statistical Division, Ministry of Planning, Govt. People's Republic of Bangladesh, p. 2.

BBS (Bangladesh Bureau of Statistics). (2013). Annual Survey Report. Bangladesh Bureau of Statistics. Statistics Division. Government of the Peoples Republic of Bangladesh. Dhaka. 37.

Belderok B, Mesdag H, Donner DA (2000) Bread-Making Quality of Wheat. Springer, New York.

Berbert P A ; Stenning B C Analysis of densityindependent equations for determination of moisture content of wheat in the radiofrequency range . Journal of Agricultural Engineering Research 1996 , 65 (4) : 275 – 286

Branland, G., Dardevet, M., Saccomano, R., Lagoutte, F. and Gourdon, J. 2001. Genetic diversity of wheat storage proteins and bread wheat quality. *Euphytica.* 119: 56-67.

Brady Carter, PhD (2016) Complete Moisture Analysis for Wheat.

Buschmuller C, Wiedey W, Doscher C, Dressler J, Breitkreutz J. 2008. In- line monitoring of granule moisture in fluidized-bed dryers using microwave resonance technology. European Journal of Pharmaceutics and Biopharmaceutics 69: 380–387.

Chowdhury K, Khan S, Karim R, Obaid M and Hasan GMMA (2012), Quality and Shelf-Life Evaluation of Packaged Biscuits Marketed in Bangladesh, *Bangladesh J. Sci. Ind. Res.* 47: 29-42.

CIMMYT (International Maize and Wheat Improvement center). (2013). WHEAT: CGIAR Research Program (CRP) led by CIMMYT. [http://wheat.org/who-we-are/about-us].

Cornell H (2003) In: Cauvain SP (ed) Bread Making: Improving Quality. Woodhead Publishing, Cambridge

Delcour J.A. & Hoseney R.C., 2010. Structure of cereals, Starch, Minor Constituents, Dry Milling. Principles of cereal science and technology. 3rd ed., St Paul Minnesota, AACC International, Inc., 1-2; 34-40; 71-72; 129-130.

Dhingra, S. and Jood, S. 2004. Effect of flour blending on functional, baking and organoleptic characteristics of bread. *Int. J. Food Sci. Tech*. 39: 213-222.

Duska C, Damir K, Dubravka T, Biserka P and Jelena D (2001), Gluten as a Standard of Wheat Flour Quality, *Food Tech. Biotechnol.* 39: 353–361.

Food and Agricultural Organization (FAO), Food Outlook Global Market analysis November (2012), ISSN 0251-1959.

Gamal, A., Salah M. A., Mutlaq M. and Otaibi 2012. Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.) *Food and Nutrition Sciences* (3): 322-328

Gear J.S., Brodribb A.J., Ware A., Mann J.I. (1981) Fibre and bowel transit times. *British Journal of Nutrition,* Vol. 45, p. 77–82.

Gulzar, A., Saeed, M.K., Ali, M.A., Ahmad I., Ashraf, M. and Huq, I. 2010. Evaluation of physiochemical properties of different wheat (*Triticum aestivum* L.) varieties. *Pak J. Food Sci*. 20 (1-4): 42-46

Gupta, R. B., Batey, I. L., and MacRitchie, F. (1992). Relationships between Protein Composition and Functional Properties of Wheat Flours. Cereal Chem. 69: 125-131

Hoseney, R.C. 1994. Principles of Cereal Science and Technology. 2nd ed. Am. Assoc. of Cereal Chem. Inc., St. Paul, Minnesota, USA.

Hruskova M and Famera O (2003), Prediction of wheat and flour Zeleny sedimentation value using NIR technique, *Czech J. Food Sci*. 21: 91-96.

Ikhtiar K, Alam Z. 2007.Nutritional composition of Pakistani wheat verities . Journal of Zhejiang University Science B 8:555-559.

Imtiaz, H., Burhan, U. M. and Gulzar, M. A. 2011. Evaluation of weaning foods formulated from germinated wheat and mungbean from Bangladesh. *African Journal Food Science* 5(17): 897-903.

Kumar P, Yadava RK, Gollen B, Kumar S, Verma RK and Yadav S (2011), Nutritional Contents and Medicinal Properties of Wheat, *L. Sci. M. Res*. 22: 1-7.

Kaur, A., Singh, G., and Kaur, H. 2000. Studies on use of emulsifiers and hydrocollids as fat replacer in baked product. *J. Food Sci.Technol*. 37: 250-255.

Khan, I. and Zeb, A. 2007. Nutritional composition of Pakistani wheat varieties. *Journal of Zhejiang university science.* 8(8):555-559

Madan, S., Mukherjee, J. and Yunus, M. 2003. Carbohydrates and protein content of developing grains of wheat cultivars. *J. Food Sci. Tech.* 40 (2): 219-221.

Manu, Punia, D. and Khetarpaul, N. 2008.Nutritional evaluation of wheat chapatti supplemented with underutilized grains and leaves. Proceedings of National Seminar on Food. Safety and Quality pp: 246-250.

Nabila, Y.M., Rabab, H. S. and Amal A. M. 2012. Nutritional and biological assessment of wheat biscuits supplemented by fenugreek plant to improve diet of anemic rats. *Academic Journal of Nutrition* 1 (1): 01-09

Nasir ,M., Masud, S.,Faquir, M. and Sharif, K.(2003) Effect of moisture on the shelf life of wheat flour. *Int. J. Agri. Biol., Vol. 5, No. 4, 2003*

Naik, H., Sekhon, KS. Baljit, S., Kaur, A. and Rather, AH. 2007. Influence of triticals and wheat classes on pretzel quality. *J. Food Sci. Tech*. 44(5): 495-499

Ndife, J. Abdulraheem, L. O. and Zakari U. M. 2011. Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. *African J. of Food Science* 5(8): 466 – 472.

Nitika, Punia, D. and Khetarpaul, N. 2008. Physico-chemical characteristics, nutrient composition and consumer acceptability of wheat varieties grown under organic and inorganic farming conditions. *International J. Food Sci.Nutr*.59(3):224-245.

Ozturk L, Yazici MA, Yucel C, Torun A, Cekic C, Bagci A, Ozkan H, Braun H-J, Sayers Z, Cakmak I (2006) Physiol. Plant. 128: 144–152.

Qazi, I.M., Wahab, S., Shad, A.A., Zeb,A.and Ayub,M. 2003.Effect of different fermentation time and baking on phytic acid content of whole wheat flour bread. *Asian J. Plan*t *Sci*. 2B (8):597- 601.

Rahman, S. and Kader, A. 2011. Comparison of nutritional and physiochemical properties of Banaladeshi wheat varieties. *World Applied Science Journal* 12 (2): 178-181.

Rehman, Z., and Shah, W.H. 2005. Thermal heat processing effects on antinutrients, protein and starch digestibility of food legumes. *Food Chem.* 327-331.

Sangwan, V. and Dahiya, S. 2013. Physico-chemical and nutritional properties of wheat-sorghumsoybean composite flours and their biscuits. *Asian J. Dairy & Food Res.*, 32 (1) 65-70.

Sharma, K. 2000. Rheological and baking characteristics of some wheat varieties grown in Haryana. Msc. Thesis, CCSHAU, Hisar, India

Shewry, P. R., Halford, N. G., Tatham, A. S., Popineau, Y., Lafiandra, D. and Belton, P. S. (2003). The high molecular weight subunits of wheat glutenin and their role in determining wheat processing properties. In *Advances in Food and Nutrition Research*, vol. Volume 45, pp. 219-302: Academic Press.

Shewry PR, Napier JN, Tatham AS. 1995. Seed storage proteins: structure and biosynthesis the plant cell 7:945-56

Singh, M. Sharma, N. Khatkar, BS. 2006. End use quality of Indian wheats: Milling properties and composition. *J. Food Sci. Technol*. 43(3) 322-324.

Sood, S. Minhas, S., Kalia, M. and Katoch, S. 2010. Effect of processing on the nutritional quality of wheat. *Processed Food Industry* 31: 26-31.

Syeda A, Batool N, Rauf, Tahir SS and Razia K (2012), Microbial and Physico-chemical contamination in the wheat flour of the twin cities of Pakistan, *Int. J. Food Safety* 14: 75-82.

Suhasini, A.W., Malleshi, N.G. and Hanchinal , RR. 2004. Malting characteristics and protein profile of a few bread and durum Indian wheat varieties. *J. Food Sci.Technol*.41 (6) 622-626.

Welch RM, Graham RD (2002) Plant Soil 245: 205–214 Cakmak I (2004) IFS Proceedings No. 552, pp 1–28, International Fertiliser Society, York

Wrigley, C. W. and Bietz, J. A. (1988). Proteins and amino acids.: St. Paul American Association of Cereal Chemistry.

Wrigley C (2004), Cereals - Overview, Encyclopedia of Grain Science, pp-187-201;

Yadav, S. Kumar, P. Yadava, R.K. Gollen, B, Kumar, S. and Verma R.K. 2011. Nutritional Contents and Medicinal Properties of Wheat. *Life Sciences and Medicine Research*. 22:1-10.

APPENDIX I

Zone wise gross cropped areas and production of wheat in Bangladesh in the year 2014

Zone	Cultivated Area (ha)	Cultivated Area (%)	Production (MT)	Yield (t/ha)
Rajshahi Zone	166,782	36.78	539,967	3.24
Rangpur Zone	124,921	27.55	365,873	2.93
Jessore Zone	63,417	13.99	186,389	2.94
Barisal Zone	71,136	15.69	205,838	2.89
Other zone	27,165	5.99	77,203	2.84
Total	453,421	100	1,375,270	3.03

Source: DAE, 2014.

APPENDIX II

Adoption area of Wheat varieties and share of area identified by the expert in Bangladesh in the year 2014

List top Modern Variety (MV) as identified in EE	Total country/ domain cropped/ net sown area (ha)	% Area adopted under the variety (ha) by EE
BARI Gom 24 (Prodip)	186,026	41.03
BARI Gom 23 (Bijoy)	50,170	11.06
BARI Gom 22 (Sufi)	1,519	0.34
BARI Gom 21 (Shatabdi)	113,221	24.97
BARI Gom 26	51,814	11.43
BARI Gom 25	20,165	4.45
BARI Gom 19 (Sourav)	8,175	1.8
BARI Gom 18 (Protiva)	5,160	1.14
BARI Gom 27	4,938	1.09
Kanchan	3,627	0.8
BARI Gom 28	3,249	0.72
BARI Gom 20 (Gourav)	2,802	0.62
Others	2,135	0.47
Inkilab	419	0.09

Source: Expert elicitation workshop, 2014