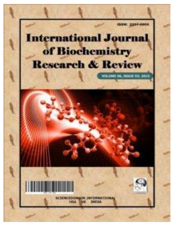

International Journal of Biochemistry Research & Review

21(1): 1-13, 2018; Article no.IJBCRR.39539
ISSN: 2231-086X, NLM ID: 101654445

Biochemical, Nutritional and End Use Perspectives of Wheat Grass as Potential Dietary Supplement

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2018/39539
Editor(s):
(1) Halit Demir, Professor, Department of Chemistry, Faculty of Art and ScienceYuzuncu, Yil University, Turkey.
Reviewers:
(1) Łukasz Woźniak, Institute of Agricultural and Food Biotechnology, Poland.
(2) Nilgün Ertaş, Necmettin Erbakan University, Turkey.
(3) Patrícia Matos Scheuer, Federal Institute of Santa Catarina, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history/23374

Original Research Article

Received 1st November 2017
Accepted 22nd February 2018
Published 28th February 2018

ABSTRACT

Wheat grass being substantial cereal grass crop in the world; copious source of nutrients with noteworthy nutritional and therapeutic value. The research, wheat grass was grown in indoor trays and then used as powder and in drink. The objective were to use the wheat grass to formulate a suitable processing procedure for wheat grass powder (WGP) enriched food products. Both raw WGP and cookies were analyzed for total dietary fiber (TDF), soluble dietary fiber (SDF), insoluble dietary fiber (IDF), total phenolic content (TPC) and antioxidant activity. Drink was analyzed for pH, viscosity and total soluble solids (TSS). WGP addition showed a significant effect on mixographic (peak height and peak time) and farinographic studies; water absorption, arrival time, dough development time (DDT) and mixing tolerance index (MTI). The cookies prepared using different levels were generally accepted by sensory panelists of the department but 3% substitution level of WGP have high acceptability. Moreover, on the basis of physicochemical and sensory attributes, 10% supplementation level of wheat grass in drink was best making it a nutrient enriched food source.

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Keywords: Wheat grass; biochemical evaluation; dietary fibers; rheology; wheat grass cookies; wheat grass drink.

ABBREVIATIONS

WGP : Wheat grass powder
DDT : Dough development time
MTI : Mixing tolerance index
TDF : Total dietary fiber
SDF : Soluble dietary fiber
IDF : Insoluble dietary fiber
TPC : Total phenolic content
TSS : Total soluble solids

1. INTRODUCTION

Health as a fundamental human right is also a worldwide social goal. It includes all humans, disregard of age. Poor food habits and sedentary self-indulgent lifestyle are the causes of perpetuation of diseases [1]. Now in recent times, trend towards functional and nutraceutical foods have been increasing. A functional food may be defined as, "any food that has a positive impact on an individual's health, state of mind or physical performance in addition to its nutritive value" [2]. Nature can be regarded as an important storehouse of medicines. There are a large number of plants that are known for having therapeutic potential. The integral source of phytochemicals and phyto-pharmaceuticals are plants. In various parts of the world plants are used as folk remedies [3].

Cereals and its ingredients are known for having functional and nutraceutical potential. As they provide energy, proteins, dietary fiber, minerals, vitamins and antioxidants that are needed for human health. Wheat grass is one of the cereal grasses that have numerous benefits. Grasses can be regarded as the introductory food for most of the land based life. After a long research conducted by various scientists in the 1930s, wheat grass was said to be the finest grass food of all [4]. Grasses have many health protecting and regenerating properties and wheat grass is one of the cereal grasses that have many nutritional benefits [5]. It is one of the foods that is included in the category of green foods that are regarded as super natural nutrient source by health-conscious people [4].

Nutritional profile of wheat grass comprised on a vast list like vitamin A, B complex, C, D, E, F and K; choline and folic acid. Minerals like iron (Fe), calcium (Ca), potassium (K), sodium (Na), manganese (Mn), sulphur (S), phosphorus (P), cobalt (Co), magnesium (Mg), zinc (Zn) and amino acids like alanine, arginine, glycine, isoleucine, leucine, glycine, cystein, tryptophan, threonine, glutamic acid, lysine, histidine, phenylalanine, methionine, aspartic acid, valine, proline and tyrosine are present in it. Superoxide dismutase(SOD), DNAse, catalase, nitrogen oxyreductase, polyphenoloxidase, lipase, phospholipase, cytochrome oxidase, malic dehydrogenase, fatty acids transhydrogenase, phosphatase, RNAse, peroxidase, protease, hexokinase and nitrate reductase are the enzymes that make it worthy [6].

Wheat grass is the power house of many nutrients like minerals and vitamins that are responsible for maintaining the human health. It can also be considered as a complete and whole protein which contains almost thirty enzymes and about seventy percent chlorophyll in crude form. One ounce (280 ml) of wheat grass juice equals in nutrition to about 2.5 pounds (1.1 kg) of green leafy vegetables as it contains same quantity of amino acids, vitamins and minerals similar to that are present in 2.5 pounds of vegetables. Wheat grass juice, besides containing chlorophyll, has many therapeutic purposes [7].

Wheat grass may be converted into fresh juice, prepared drink or dried to make powder for the use of humans and animals; both the forms offer almost all the nutrients present in it i.e. minerals, enzymes, chlorophyll, vitamins and amino acids. Wheat grass juice can be defined as an extract squeezed from the mature sprouts of wheat seeds [8]. It has many potential benefits for people as it restores body balance, builds the blood, cleanses the lymph system, removes toxins of the body cells, provide nourishment to the kidney and liver and restores energy. It can be used as an effective and safe treatment for ailments such as obesity, high blood pressure, diabetes, asthma, ulcers, some cancers, gastritis, anemia and eczema [9].

Wheat grass juice has recently become the interest of many people as a vitality drink [10]. It can be taken orally having no side effects and regarded as a complete food. Wheat grass in the powder form is more palatable than fresh wheat grass juice due to many reasons by all age groups and its therapeutic efficacy is equal to that of fresh wheat grass. One teaspoon of wheat grass powder that is about 3g is equal in nutritional value to about 40g of fresh wheat grass [4].

Among foodstuff, biscuits are much liked and consumed by a wide range of population due to its longer shelf life, variety of taste and low cost. Many attempts are being made by adding nutritive ingredients to improve nutritional and functional value of biscuits, to be competitive in the market and to fulfill demand for healthy and functional products [11]. With this background present work was undertaken to study nutritional, functional and end product quality of wheat grass both in juice and powder form.

2. MATERIALS AND METHODS

2.1 Wheat Grass

Wheat grass was grown by planting wheat seeds according to the method of [10] with slight modifications. Wheat seeds were first soaked in water overnight. After one night soaking, steeped seeds were kept under moistened cloth for 24 hours to promote germination onset (cloth was sprayed with water to keep it moistened with 8 hour interval). Earthen pots were filled with 2.5 inches of soil. Soaked seeds were then spread evenly over the soil and seeds were again covered with a 0.5 inch layer of soil. For proper growth of wheat grass water in small quantity was evenly sprinkled over soil with 3-4 hours of indirect sunlight. On tenth day after germination of seeds, grass was about of 6 inches tall, it was cut from 0.5 inches above soil surface.

2.2 Preparation of Wheat Grass Juice (WGJ) and Powder (WGP)

The juice of wheat grass leaves was prepared as described by Shah, Sheth [9]. For preparation of wheatgrass juice, 100 g. fresh wheat grass was crushed by adding 40 mL water and finally filtering it through four layers of muslin cloth and final filtrate volume was adjusted to 100 mL by adding more water.

The wheat grass leaves were washed with water and dried in dehydrator as described by Sharma, Velu [12] with slight modification as described here. The leaves were dried in dehydrator at 30-35ºC for 24 hours. The dried leaves were coarsely powdered in a blender and powder was stored in polythene bags.

2.3 Analysis of Wheat Grass Powder

2.3.1 Chemical characteristics

Wheat grass powder (WGP) was evaluated for chemical composition i.e. moisture, ash, crude fat, crude fiber and crude protein and dietary fiber [13].

2.3.2 Phytochemical analysis of WGP

Wheat grass powder was analyzed for the presence of reducing sugars, tannins and saponins as described by Tandon, Arora [14].

2.4 Dough Characteristics

Wheat flour blends with WGP were prepared by substituting it at 3, 5 and 7% level. Farinograph (E-380 Model, Brabender OHG, Duisburg, Germany) was used to determine the influence of WGP on dough rheology according to the AACC [13] standard methods. Characteristics of dough measured by farinograph were water absorption, arrival time, departure time, dough development time, and mixing tolerance index and dough stability. Mixograph (National Mfg. Co, Lincoln, Nebraska, USA) was also used to study the extent of effect caused by WGP on dough rheology, according to AACC [13] standard methods.

2.5 Preparation of Cookies

The formula used for preparation of cookies was as follows: 500g composite flour, 250g sugar, 300g shortening, 3.0g cardamom powder, 7.0g leavening agent and 2 eggs.

First of all creaming was done in 10 minutes by adding shortening and sugar. Then eggs were added and mixing was done for few minutes. Then composite flour and leavening agent was added. Cardamom powder was added after thoroughly mixing of this mixture for 5-6 minutes. Then molding was done and weight, height and diameter were measured. At the end baking was done at 180ºC for 10-12 minutes.

2.6 Analysis of Cookies

2.6.1 Chemical characteristics of cookies

Cookies were evaluated for chemical composition i.e. moisture (method No. 44-15A), ash (method No. 08-01), crude fat (method No. 30-10), crude fiber (method No. 32-10), crude protein (method No. 46-10), soluble dietary fiber (Method No.32-07), insoluble dietary fiber (Method No.32-20) and total dietary fiber (method No.32-05) [13].

2.6.2 Preparation of extract

10 % (w/v) extract of wheat grass powder and cookies was prepared with 70% ethanol. The homogenate was centrifuged at 13500g for 30 minutes at temperature of 4°C and the resulting supernatants were analyzed for future experiment.

2.6.3 Measurement of total phenolic content

Total phenolic content was quantified by Folin-Ciocalteu reagent method as described by Kulkarni, Tilak [15] with slight modifications. In 50 µl of sample/standard, 3.5 ml of water was added followed by FC (Folin-Ciocalteu) reagent of 250 µl. Solution was mixed and incubated at room temperature for 8 minutes. 750 µl of 20% sodium carbonate was dissolved in mixture and incubated at room temperature. After incubation, UV-Vis spectrophotometer (IRMECO Germany) was used to take absorbance at 765 nm. Gallic acid's solution was prepared by dissolving its 25 mg in distilled water of 25 ml and its reading was taken as a standard at same 765 nm absorbance. Gallic acid concentration ranged from 0 to 450 µg/ mL. Standard curve of acid was used in total phenolic content's calculation of samples. Same procedure was followed for all other samples and preceded three replications.

TPC was calculated by the following formula

$$C = c \times V / m$$

Where:

C= total contents of phenolic compounds in mg GAE/g
c= concentration of Gallic acid mg/ml
V= the volume of extract
m= weight of extract in g

The total phenolic content (TPC) was expressed as mg Gallic Acid Equivalents/gram of dry extract.

2.6.4 Radical scavenging activity by using DPPH method

The antioxidant activity of plant methanol extract was determined based on the radical scavenging ability in reacting with a stable DPPH free radical by following the method of Brand-[14]. 1g of sample were extracted with 10 ml of 80% methanol (for 2 hours). Briefly, DPPH of 4 mg was dissolved in 100 ml methanol to prepare a solution, 50 µl methanol extract was added in 2 ml of this solution. Mixture was vigorously shaken and allowed to rest in the dark at room temperature. After a while reading was taken at 515 nm absorbance. The experiment was carried out in triplicate. Radical scavenging activity was calculated as.

$$\text{Reduction of absorbance (\%)} = [(AB - AA) / AB] \times 100$$

Where:

AB = absorbance of blank sample (t = 0 min)
AA = absorbance of tested extract solution (t = 15 min)

2.7 Evaluation of Cookies

2.7.1 Physical characteristics

Cookies width was measured by horizontally placing six cookies (edge to edge) and then rotating at 90º angles for replication.

Cookies thickness was measured by placing six cookies vertically on one another and replicate readings were taken.

Spread factor was calculated according to method no. "10-53" described in [13]. The spread factor was calculated according to the following formula

$$SF = \frac{W}{T} \times CF \times 10$$

Where CF = Correction factor at constant atmospheric pressure (1.0 in this case).

Texture analysis was done according to [16] by using texture analyzer (Mod. TA-XT2, stable micro system, Surrey, UK) interfaced with a computer, which controls the instrument and records the data. For the data treatment, the Texture Expert program version 1.21 was used. For every formulation, three repeated measurements were taken and mean values were reported

2.7.2 Sensory evaluation of cookies

Acceptability of product was determined by evaluating sensory characteristics of cookies incorporated with WGP. Cookies were evaluated for color, crispiness, taste, flavor, texture and overall acceptability on a 9-point hedonic scale [17].

2.8 Raw Wheat Grass Juice Analysis

pH of the juice will be determined by digital pH meter as described by Houška, Strohalm [18]. Brix (%) was generally used as indicator for soluble solid content %. The total soluble solids of the juice samples were determined by using digital refractometer as described by Waghray, Gulla [19]. Juice viscosity was determined by using Brookfield DV-I viscometer (LVDVE) as described by Kareem and Adebowale [20]. Apparent viscosity was measured at 25ºC temperature; sample was stirred for 40s before viscosity measurement. Spindle number 2 was used for this measurement rotated at 30 rpm. Viscometer reading was noted in centipoises (cp) units.

2.9 Preparation of Wheat Grass Drink (WGD)

The formula used for the preparation of drink was as follows: 500 mL apple extract, 500 mL water, 100g sugar, 1.5g malic acid, 1.0g CMC, 2-3 drops caramel color, 1mL apple flavor and 0.5g sodium benzoate. Wheat grass juice was replaced with water in the percentage of 5, 10 and 15.

Apples at commercial maturity were purchased from a local market and stored at 4ºC until processed. Apples were water washed, each apple was cut in four pieces and seeds were removed carefully. Moulinex, Commercial Juice extractor was used to extract the juice.

Apple extract, water and wheat grass juice were mixed and heated to about 65ºC. CMC was mixed with sugar and added in juice while continuously stirring the drink to avoid the clump formation and malic acid was also added in it. After that drink was cooled to room temperature and color, flavor and sodium benzoate added in drink. Drink was filled in bottles and stored at 4ºC.

2.10 Analytical Characterization of Drink

Drink was checked for pH, total soluble solids and viscosity as described in section 2.8.

2.11 Sensory Evaluation of Drink

Drink was evaluated for appearance, taste, aroma, mouth feel and overall acceptability on a 9-point hedonic scale [17].

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Wheat Grass Powder

Chemical composition of wheat grass powder was illustrated in Table 1 & Fig. 1. Wheat grass powder contains 4.06% moisture, 5.4% ash, 17.7% crude fiber, 0.29% crude fat, 21.6% protein and 50.95% nitrogen free extract. The results related to the proximate composition of wheat grass powder are similar to the previous findings [6,21].

The wheat grass found to contain 4.12% soluble dietary fiber, 23.07% insoluble dietary fiber and 27.19% total dietary fiber shown in Fig. 2. The results related to dietary fiber in wheat grass are related to the studies conducted by Chaturvedi, Sharma [21] and Svihus, Newman [22]. Total phenolic content in wheat grass powder was found to be 6.13 mg GAE/g. The results are in accordance with the previous findings of Tandon, Arora [14] who observed TPC in various extracts of wheat grass ranging from 2.44 to 6.48. The antioxidant activity (% Inhibition) of wheat grass powder was observed 51% as shown in Fig. 3. Present results are supported by previous findings [23].

3.2 Phytochemical Analysis of Wheat Grass Powder

The results for phytochemical analysis are presented in Table 2. Phytochemical screening gave positive results for reducing sugars (fehling A solution turned to brick red precipitate), tannins (bluish green colour appeared) and saponins (thick persistent appeared). Their positivity was confirmed by the analyses of Tandon, Arora [14] and Kothari, Jain [24].

3.3 Influence of Wheat Grass Powder on Dough Characteristics

Incorporation of WGP at 3, 5 and 7% levels showed significant difference in dough properties as shown in Table 3 and 4. Addition of WGP at different levels increased the water absorption from 62.5 (0%) to 67% (7%), arrival time from 1.4 to 2.1 min, DDT from 3.5 to 4.5 min and MTI from 35 to 84 BU while decreased departure time from 13.0 to 8.5 min and dough stability from 11.5 to 6.4 min. Increase in water absorption may be attributed to hydroxyl groups present in the fiber structure which interact with water through hydrogen bonds [25]. Dachana, Rajiv [26] also reported the same results that water absorption increases by increasing the amount of dried wheat grass powder in wheat flour.

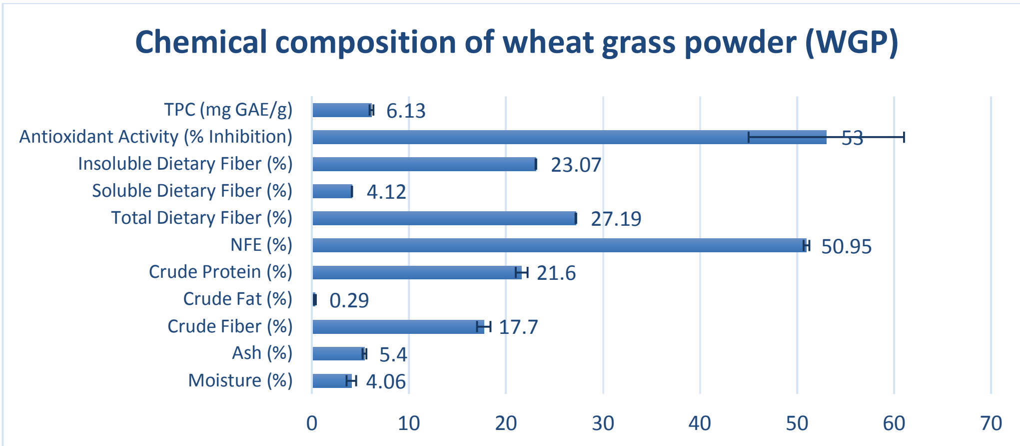

Fig. 1. Chemical composition of wheat grass powder (WGP)

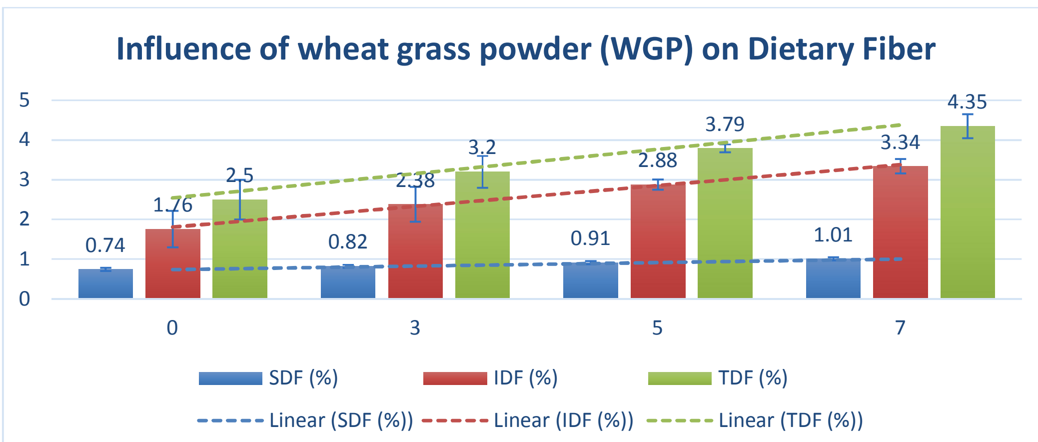

Fig. 2. Influence of wheat grass powder (WGP) on Dietary Fiber

Table 1. Chemical composition of wheat grass powder (WGP)

Parameter	Wheat grass Powder
Moisture (%)	4.06±0.5
Ash (%)	5.4±0.2s
Crude Fiber (%)	17.7±0.7
Crude Fat (%)	0.29±0.1
Crude Protein (%)	21.6±0.6
NFE (%)	50.95±0.3
Total Dietary Fiber (%)	27.19±0.03
Soluble Dietary Fiber (%)	4.12±0.01
Insoluble Dietary Fiber (%)	23.07±0.02
Antioxidant Activity (% Inhibition)	51±8
TPC (mg GAE/g)	6.13±0.2

**All characteristics except moisture are expressed on dry matter basis.*
Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05.
Values are means of three replicate ± standard deviation

Table 2. Phytochemical screening of wheat grass powder

Compound	Observation	Results
Reducing sugars	Fehling A solution turned to brick red precipitate	+ve
Tannins	Appearance of Bluish green colour	+ve
Saponins	Appearance of thick persistent	+ve

Table 3. Effect of wheat grass powder (WGP) on farinographic characteristics

WGP (%)	WA (%)	AT (min)	DT (min)	DS (min)	DDT (min)	MTI (BU)
0 (Control)	62.5^{b}±1.5	1.4^{c}±0.1	13.0^{a}±0.6	11.5^{a}±0.1	3.5^{b}±0.3	35.0^{d}±1
3	64.0^{b}±1.6	1.7^{b}±0.1	10.9^{b}±0.4	9.2^{b}±0.1	3.90^{b}±0.3	52.0^{c}±1
5	64.9^{ab}±1.7	1.9^{ab}±0.2	9.0^{c}±0.6	7.1^{c}±0.2	3.97^{ab}±0.4	67.0^{b}±1
7	67.0^{a}±2.16	2.1^{a}±0.2	8.5^{c}±0.4	6.4^{d}±0.1	4.5^{a}±0.2	84.0^{a}±2

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation.
WA, water absorption; AT, arrival time; DT, departure time; DDT, dough development time; DS, dough stability; MTI, mixing tolerance index

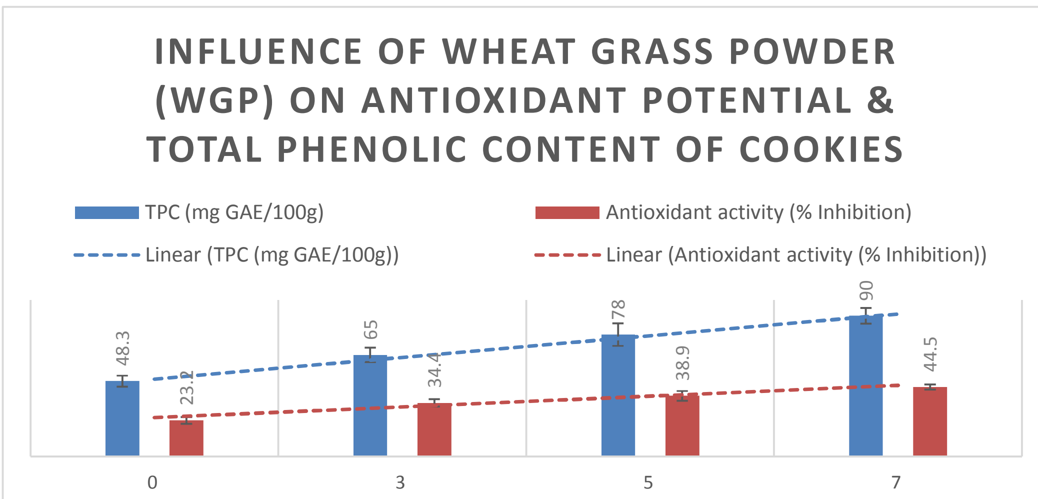

Fig. 3. Influence of wheat grass powder (WGP) on Total Phenolic content and Antioxidant potential of cookies

The results are also in accordance with the earlier findings [27,28]. Sharma, Velu [12] observed the decrease in dough stability by the addition of dried *Tinospora cordifolia* leaves powder in wheat flour and reported that this decrease in dough strength is due to interaction between fiber and gluten. The findings of Ajila, Leelavathi [29] are also in accordance with the present results. Decrease in stability indicates the decrease in dough resistance, may have been caused by the fact that fiber diluted the gluten proteins of the flour [30]. Increasing of DDT may be due to the interaction of fiber with the gluten which is responsible for the prevention of protein hydration [25]. There is an inverse relationship between dough strength and MTI. As MTI was increased as the level of addition of dried wheat grass was increased that is the indication of decrease in dough strength [26]. Ashoush and Gadallah [31] also reported the increase in MTI due to dilution of gluten. Addition of WGP at different levels decreased the peak time and peak height as presented in Table 4. The present results are supported by earlier findings [32].

3.4 Influence of Wheat Grass Powder on Nutritional Characteristics of Cookies

The moisture and ash contents in cookies ranged from 3.85 to 5.28% and 0.77 to 1.2% respectively (Table 5). The protein content in control treatment was 7.98% and increased to 8.64%, 9.15% and 9.44% with 3, 5 and 7% addition of WGP respectively. The total dietary fiber content improved from 2.50 to 4.35% with rise in WGP from 0 to 7%. WGP incorporation significantly enhanced the total phenolic content of cookies. The total phenolic content increased from 48.3 to 90.0 mg GAE/100g and % inhibition increased from 23.2 to 41.5% (Table 6). The present results are in accordance with the findings of [33,34,35,29,26,31,36,37].

3.5 Influence of Wheat Grass Powder on Physical Characteristics of Cookies

WGP showed positive effect on thickness and hardness while negative impact on diameter, spread factor and fracture ability of cookies. With the increase in WGP from 0 to 7%, the diameter of cookies was decreased from 50.1 to 47.5mm and thickness was increased from 10.1 to 11.3mm while spread factor was decreased from 49.8 to 41.9. The hardness of cookies was increased and fracture ability was decreased with the addition of WGP. Results are supported by [26,12].

3.6 Influence of Wheat Grass Powder on Sensory Characteristics of Cookies

The sensory characteristics of WGP cookies are presented in Table 8 and Fig. 4. The sensory scores for color, flavor, taste, texture, crispiness and overall acceptability decreased with increasing WGP from 0-7%. The color of cookies steadily changed to green from golden brown. From these results it was concluded that cookies with 5% WGP can be consumed without any adverse effect.

3.7 Analytical Characterization of WGJ

Wheat grass juice was analyzed for pH, total soluble solids and viscosity. The results have been presented in Table 9 and depicted in Fig. 5 that showed that wheat grass juice has a pH of 7.1 and the present results are similar to the previous findings [8]. Brix of wheat grass juice was found to be 3.63 which are in accordance with the previous results [19]. Viscosity of wheat grass juice was recorded 3 centipoises. The results regarding viscosity of wheat grass juice are close to earlier findings [38].

3.8 Influence of Wheat Grass Juice (WGJ) on Characteristics of Apple Juice

As obvious from Table 10 and Fig. 6 the pH of apple juice was significantly affected by WGJ addition while WGJ has no significant effect on brix and viscosity of apple juice. The findings of the present study are in line with the earlier results [38,39,8,40].

3.9 Influence of Wheat Grass Juice (WGJ) on Sensory Characteristics of Apple Juice

The sensory characteristics of drink are presented in Table 11 and Fig. 7. The sensory scores for appearance, aroma, taste, mouth feel and overall acceptability decreased with increase in WGJ from 0 to 15%.

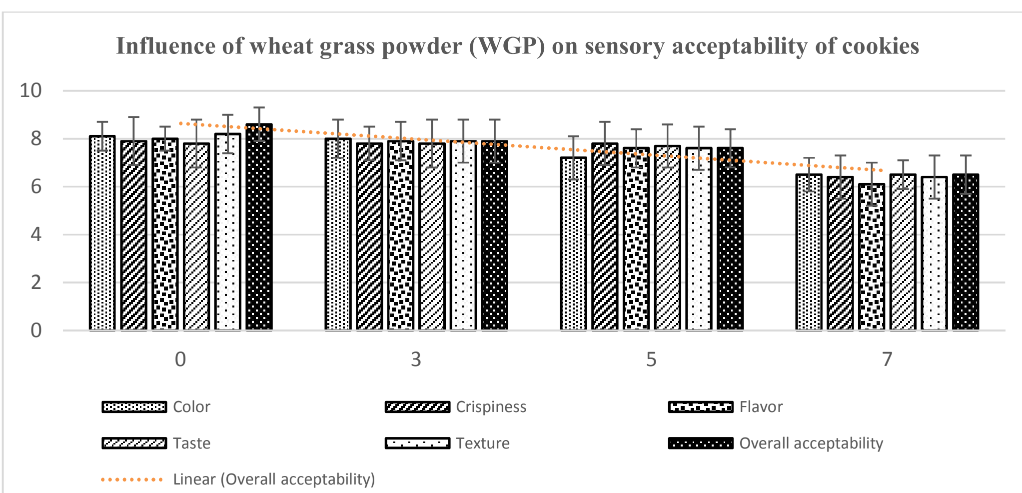

Fig. 4. Influence of wheat grass powder (WGP) on sensory acceptability of cookies

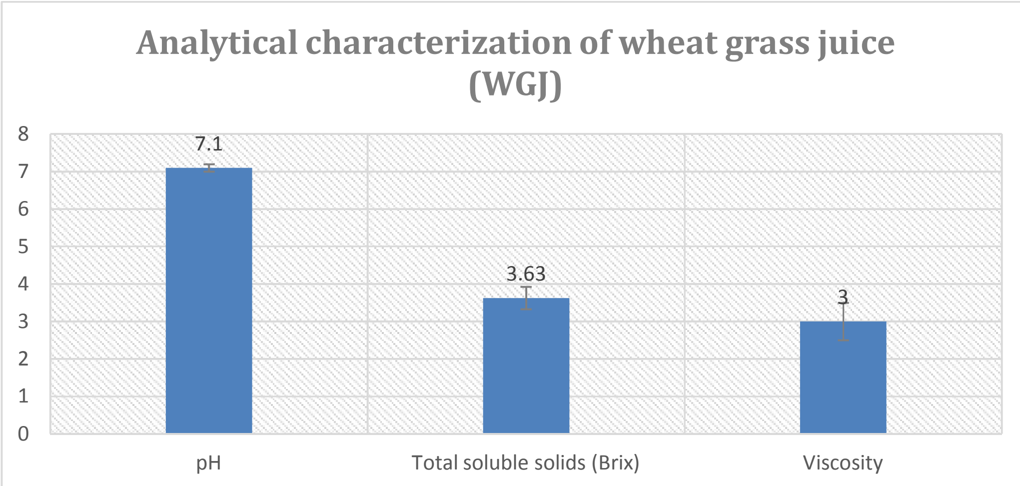

Fig. 5. Analytical characterization of wheat grass juice (WGJ)

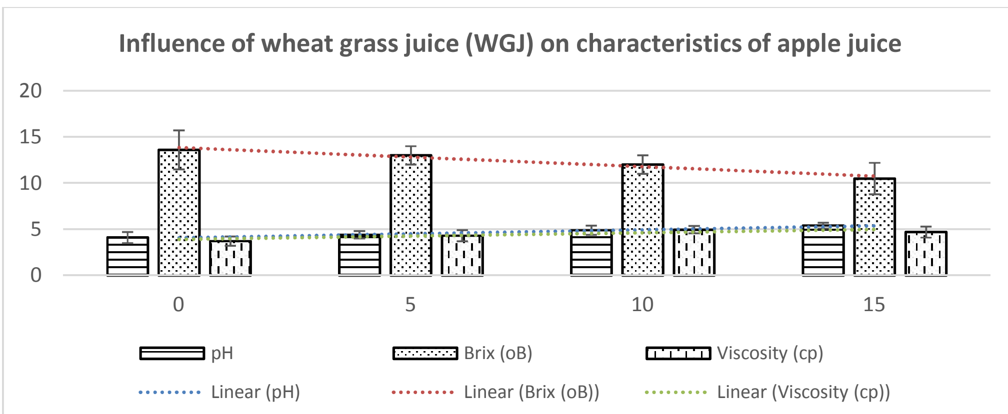

Fig. 6. Influence of wheat grass juice (WGJ) on characteristics of apple juice

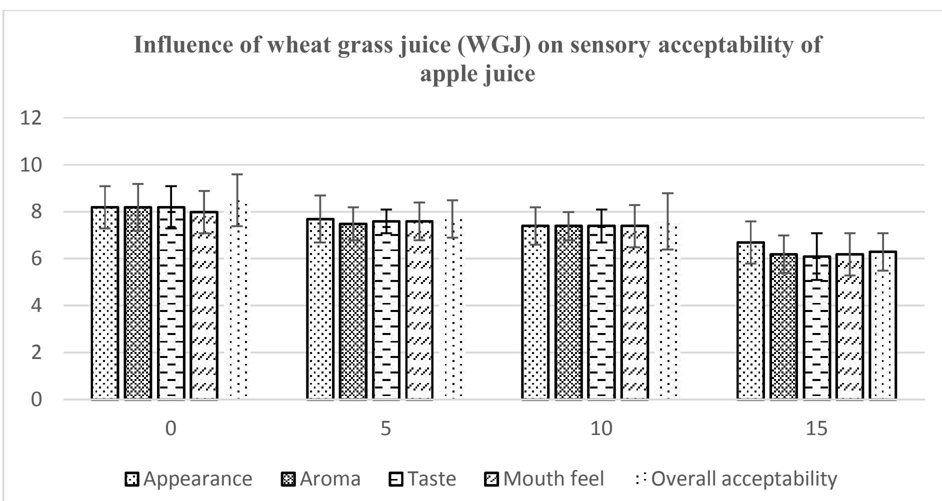

Fig. 7. Influence of wheat grass juice (WGJ) on sensory acceptability of apple juice

Table 4. Effect of wheat grass powder (WGP) on mixographic characteristics

WGP (%)	Peak Time (min)	Peak Height (%)
0 (Control)	4.7^{a}±0.3	62^{a}±2
3	4.1^{b}±0.3	59^{ab}±3
5	4^{b}±0.4	55^{bc}±4
7	3.8^{b}±0.2	51^{c}±4

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation

Table 5. Influence of wheat grass powder (WGP) on the proximate composition* of cookies

WGP (%)	Moisture (%)	Ash (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)	NFE (%)
0 (Control)	3.85^{c}±0.14	0.77^{c}±0.05	22.5^{a}±1.1	1.20^{c}±0.06	7.98^{c}±0.4	63.7^{a}±1.5
3	4.14^{c}±0.14	0.94^{b}±0.01	21.9^{ab}±0.9	1.63^{bc}±0.06	8.64^{b}±0.2	58.7^{b}±1
5	4.54^{b}±0.22	1.04^{b}±0.02	20.1^{bc}±1	2.01^{ab}±0.02	9.15^{ab}±0.4	55.2^{c}±1.4
7	5.28^{a}±0.14	1.2^{a}±0.1	19.2^{c}±1	2.39^{a}±0.03	9.44^{a}±0.2	50.5^{d}±0.8

**All characteristics except moisture are expressed on dry matter basis. Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation*

Table 6. Influence of wheat grass powder (WGP) on dietary fiber, antioxidant activity and total phenolic content of cookies

WGP (%)	SDF (%)	IDF (%)	TDF (%)	TPC (mg GAE/100g)	Antioxidant activity (% Inhibition)
0 (Control)	0.74^{d}±0.04	1.76^{c}±0.46	2.50^{c}±0.5	48.3^{d}±3.5	23.2^{d}±2.2
3	0.82^{c}±0.04	2.38^{b}±0.44	3.20^{b}±0.4	65.0^{c}±4.6	34.4^{b}±2.3
5	0.91^{b}±0.04	2.88^{ab}±0.13	3.79^{ab}±0.1	78.0^{b}±7.2	38.9^{b}±3.1
7	1.01^{a}±0.04	3.34^{a}±0.18	4.35^{a}±0.3	90.0^{a}±5	44.5^{a}±1.6

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation

Table 7. Influence of wheat grass powder (WGP) on physical characteristics of cookies

WGP (%)	Diameter (mm)	Thickness (mm)	Spread factor	Hardness (g)	Fracturability (mm)
0 (Control)	50.1^{a}±1	10.1^{c}±0.5	49.8^{a}±2.9	1742.3^{d}±50	80.5^{a}±1.1
3	49.1^{ab}±0.2	10.4^{bc}±0.2	47.4^{ab}±1	1891.3^{c}±27.5	80.3^{a}±0.7
5	48.3^{bc}±0.9	10.8^{ab}±0.3	44.6^{bc}±2	1994.9^{b}±23	78.4^{ab}±2.3
7	47.5^{c}±0.7	11.3^{a}±0.4	41.9^{c}±0.9	2325.6^{a}±65.6	76.1^{b}±1.3

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation

Table 8. Influence of wheat grass powder (WGP) on sensory acceptability of cookies

WGP (%)	Color	Crispiness	Flavor	Taste	Texture	Overall acceptability
0 (Control)	8.1^{a}±0.6	7.9^{a}±1	8.0^{a}±0.5	7.8^{a}±1	8.2^{a}±0.8	8.6^{a}±0.7
3	8.0^{a}±0.8	7.8^{a}±0.7	7.9^{a}±0.8	7.8^{a}±1	7.9^{b}±0.9	7.9^{b}±0.9
5	7.2^{b}±0.9	7.8^{a}±0.9	7.6^{a}±0.8	7.7^{a}±0.9	7.6^{c}±0.9	7.6^{b}±0.8
7	6.5^{c}±0.7	6.4^{b}±0.9	6.1^{b}±0.9	6.5^{b}±0.6	6.4^{d}±0.9	6.5^{c}±0.8

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05

Table 9. Analytical characterization of wheat grass juice (WGJ)

Parameter	WGJ
pH	7.1±0.1
Total soluble solids (Brix)	3.63±0.3
Viscosity	3±1

Table 10. Influence of wheat grass juice (WGJ) on characteristics of apple juice

WGJ (%)	pH	Brix (^{o}B)	Viscosity (cp)
0 (Control)	4.1^b±0.6	13.6^a±2.1	3.73^b±0.5
5	4.4^b±0.4	13^a±1	4.30^{ab}±0.6
10	4.9^{ab}±0.5	12^a±1	4.97^a±0.4
15	5.4^a±0.3	10.5^a±1.7	4.70^{ab}±0.6

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation

Table 11. Influence of wheat grass juice (WGJ) on sensory acceptability of apple juice

WGJ (%)	Appearance	Aroma	Taste	Mouth feel	Overall acceptability
0 (Control)	8.2^a±0.9	8.2^a±1	8.2^a±0.9	8.0^a±0.9	8.5^a±1.1
5	7.7^{ab}±1	7.5^b±0.7	7.6^{ab}±0.5	7.6^a±0.8	7.7^b±0.8
10	7.4^b±0.8	7.4^b±0.6	7.4^b±0.7	7.4^a±0.9	7.6^b±1.2
15	6.7^c±0.9	6.2^c±0.8	6.1^c±1	6.2^b±0.9	6.3^c±0.8

Values in the row with the same letter in superscript are not significantly different from each other at P≤0.05. Values are means of three replicate ± standard deviation

4. CONCLUSION

Wheat grass proved itself as a bundle of nutrients. Physical analysis of cookies in present research revealed that there was a significant difference among treatments for diameter, hardness and spread factor of cookies. Addition of WGP increased the thickness of cookies in addition to uplifting its overall nutritional profile. Sensory evaluation results concluded that drink with 10% WGJ can be consumed without any adverse effect. Addition of WGJ in drink was more appealing and surely be full of nutraceutical benefits.

PRACTICAL APPLICATION

Wheat grass being the neglected and undermined, have great health potential and can be utilized in enriched food items. Wheat grass supplemented food products including confectionery and beverages having powder or extract can be introduced in market in order to divert the masses towards natural products.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23374