Journal of Current Pharma Research (JCPR)

Volume 21, Issue 9, September 2025 **jcpr.humanjournals.com** ISSN: 2230-7842, 2230-7834

Formulation and Evaluation of Fast Disintegrating Tablets of Wheatgrass Powder for Antibacterial Oral Therapy

Swarupeshwari R. Pauskar[1], Archana S. Patil[*], Shourya J. Jadhav, Abhishek A. Revankar

[1]Department of Pharmaceutics, KLE College of Pharmacy, KLE Academy of Higher Education and Research, Belagavi, Karnataka, India.

Received: 2025-08-20 Revised: 2025-08-31 Accepted: 2025-09-16

ABSTRACT

The present study focuses on the formulation and evaluation of fast-disintegrating tablets (FDTs) of wheatgrass (*Triticum aestivum*) powder as a novel alternative to conventional mouthwashes for improving oral hygiene. Wheatgrass is a well-known medicinal plant with established antibacterial, anti-inflammatory, and wound-healing properties. The goal was to overcome the limitations of liquid mouthwashes, such as instability, high alcohol content, and portability issues, by developing a solid dosage form that can be easily dispersed in water before use. FDTs were formulated by direct compression using superdisintegrants like crospovidone, croscarmellose sodium, and sodium starch glycolate. Pre-compression parameters including flow properties and post-compression evaluations such as weight variation, hardness, friability, disintegration time, and wetting time were conducted. Phytochemical screening revealed the presence of flavonoids, amino acids, tannins, and glycosides, supporting the therapeutic potential of wheatgrass. The antimicrobial activity was assessed against *Streptococcus mutans* and *Streptococcus oralis* using minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), and disc diffusion assays. Wheatgrass powder demonstrated antibacterial activity at higher concentrations, while ciprofloxacin exhibited superior efficacy at all levels.Among all formulations, F2 (containing crospovidone 10%) showed the shortest disintegration and wetting time with acceptable mechanical properties. The study concludes that wheatgrass-based FDTs could be a promising herbal mouthwash alternative, though higher concentrations may be required to achieve bactericidal efficacy.

Keywords: Wheatgrass powder, fast-disintegrating tablets, Herbal mouthwash, antibacterial activity, *Streptococcus mutans*, *Streptococcus oralis*

INTRODUCTION

Microorganisms are tiny living organisms, often too small to be seen with naked eye, that include bacteria, viruses, fungi, and protozoa. These organisms can exist in a variety of environments and can be both beneficial and harmful to other living beings. A broad microbiome made up of bacteria, viruses, fungus, archaea and protozoa is found in the human mouth. Dental caries or tooth decay and periodontal disease are two major oral disorders in humans caused by these bacteria. [1] Dental cavities are one of the many infectious disorders of the mouth that are brought on by oral microbes. [2] Diseases of the mouth and teeth, such as periodontal disease and dental caries are among the most prevalent worldwide, affecting individuals of almost all ages and regions. [3]

The available formulations to manage dental diseases like mouthwash, toothpaste, topical gels and ointments, chewing gum, antibiotics and probiotics. Thus, aim of study is to formulate novel solid mouthwash containing a herbal ingredient.

In India, wheatgrass plant is the most commonly found herb. Wheatgrass is known as the young grass of the Poaceae family. The leaves of wheatgrass are flat, narrow 20–38 cm long, 1.3 cm broad, and the culms are simple, hollow or pithy, glabrous. Numerous nutritional benefits are associated with this plant. It has been demonstrated that this plant possesses many nutritional values like antibacterial, anticarcinogenic, anti-inflammatory, laxative and diuretic. [4] In addition to being a popular health food, wheatgrass juice is also known to be beneficial as a dietary supplement. Powdered wheatgrass offers an abundance of health-promoting elements, such as minerals, amino acids, vitamins A, B, C, E, and K, enzymes, and chlorophyll. In addition to helping to neutralise infections and get rid of parasites, chlorophyll is essential for preventing tooth decay. [5,6] Wheatgrass has been used to treat gingivitis and other periodontal disorders due to its therapeutic properties. Additionally, it functions as a bactericidal natural antibiotic against bacteria that cause periodontal disease, halitosis, and dental cavities. [7]

Mouthwash also known as an oral rinse, is a liquid solution formulated to rinse the mouth, teeth and gums. It is designed to reduce oral bacteria, freshen breath and provide additional protection against dental issues such as tooth decay and gum disease. Mouthwash often contains antiseptic, antibacterial agents and sometimes fluoride, making it an effective adjunct to brushing and flossing in maintaining oral hygiene. In mouthwash active ingredients are often antibacterial agents that temporarily reduce the overall number of germs in the oral cavity. Typically, these products are used as a preventive strategy or in conjunction with other forms of treatment. [8]

Thus, mouthwashes have been developed to be diluted with water and used for gargling once or twice daily. However, these liquid preparations have drawbacks such as stability issues, bulkiness and high alcohol content, which can cause a burning sensation in the mouth if not properly diluted. To overcome these limitations, it is necessary to develop a dosage form that retains the benefits of mouthwash while minimizing its disadvantages. One such formulation is the development of dispersible tablets containing antimicrobial agents for oral hygiene. These tablets can be reconstituted with water before use. This proposed work aims to explore the use of dispersible tablets as a local mouthwash by formulating wheatgrass powder into oral dispersible tablets, thereby effectively addressing the limitations of traditional mouthwashes and toothbrushes.

Materials and Method

Wheatgrass powder was procured from All Herbscare India, Crosspovidone, croscarmellose sodium, sodium starch glycolate, MCC, mannitol, aspartame and talc were used from KLE college of Pharmacy.

Methodology:

Formulation of Fast disintegrating tablets containing Wheatgrass powder:

Direct compression was used to make the fast-disintegrating tablets containing wheatgrass powder. Each ingredient was run individually through a 36-mesh sieve. A tiny amount of the wheatgrass powder and diluents were combined each time, blended and set aside to create a homogenous combination. Next, using a single punch machine, the materials were weighed, combined in a geometrical order and compressed into tablets with an 8 mm flat round punch. [9]

Pre formulation Studies:

For each formulation, the combined drug and excipient blends were evaluated for pre formulation studies like flowability, bulk density, tapped density, percentage compressibility, and angle of repose.

Bulk density: Accurately weigh a known quantity of the powder sample to find the powder's tapped bulk density. Carefully transfer the powder into the graduated cylinder, being careful not to tap or compress it as you fill it. Note down the initial volume of powder occupied. After that, either by hand or with the help of a mechanical tapped density tester, tap the cylinder repeatedly until the powder volume stabilises and reaches a minimum. Once the volume is tapped, record it. Calculate the tapped bulk density using the formula:

$$\text{Tapped Bulk Density} = \frac{\text{Weight of Powder}}{\text{Tapped Volume of the Powder}}$$

Compressibility index: The powder's compressibility index was calculated using Carr's compressibility index.

$$\text{Carr's index} = \frac{Tapped\ Density - Bulk\ Density}{Tapped\ Density} \times 100$$

Hausner's Ratio: The following formula can be used to calculate Hausner's ratio, which determines how easy it is for powder to flow. [10]

$$\text{Hausner's Ratio} = \frac{\text{Tapped Density}}{\text{Bulk Density}}$$

Angle of Repose: By measuring the angle of repose, which is associated with the interparticulate frictions, the powder blend's flow properties have been determined. The fixed funnel method was used to determine the angle of repose. This method forms the powder blend into a cone by pouring it through a funnel. The inverse slope of this ratio is known as the angle of repose. The height of the resulting cone (h) is divided by half the width of the cone's base (r). Calculated using formula. [11]

$$Tan\,\theta = \frac{h}{r}$$

Evaluation of Tablet

Weight variation:

Twenty tablets were randomly chosen from each formulation, and their average weight was calculated. Each tablet was then weighed individually and compared to the average weight.

Hardness:

The hardness test was conducted to assess the resistance of the tablets during shipping, storage, handling, and transportation. Ten tablets in total were chosen randomly and their hardness was tested with a Monsanto hardness tester. Each tablet was placed in the tester, and force was applied until it fractured. The results were recorded in kg/cm².

Friability:

Using a friabilator, the variation of the tablets was calculated and expressed as a percentage. Ten randomly selected tablets in total were weighed, placed inside the device, and run for four minutes at 25 rpm. The tablets were reweighed after a predetermined amount of time. The formula below was then used to determine the friability. [9]

$$\text{Friability} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

Thickness:

Twenty tablets were selected randomly from the formulations, and each tablet's thickness was measured using a vernier calliper. The millimetre was used to express it, and an average was calculated. [12]

Disintegration Test:

The USP Disintegration Test Apparatus II (Electrolab ED-2, India) was utilised to measure the disintegration time of FDTs. Six disintegration tubes were used to store the prepared tablets, which were held in place by discs placed into each tube to keep the tablets from drifting. As a disintegration medium, distilled water was maintained at 37 °C±0.5 °C. Each FDT's consumption of time to fully disintegrate and leave no residue behind was noted.

Wetting time:

Each prepared tablet was gently held in place with tissue paper and then put in a petri plate with six millilitres of water. Wetting time was defined as the amount of time it took for the tablet to completely wet. For every three batches. A standard deviation was calculated through trial and error. [9]

Minimum Inhibitory Concentration (MIC) Test:

9 dilutions of each drug have to be done with BHI for MIC.

1) In the initial tube 20microliter of drug was added into the 380microliter of BHI broth.

2) For dilutions 200microliter of BHI broth was added into the next 9 tubes separately.

3) Then from the initial tube 200microliter was transferred to the first tube containing 200microliter of BHI broth. This was considered as 10-1 dilution.

4) From 10-1 diluted tube 200microliter was transferred to second tube to make 10-2 dilution.

5) The serial dilution was repeated up to 10-9 dilution for each drug.

6) From the maintained stock cultures of required organisms, 5microliter was taken and added into 2ml of BHI (brain heart infusion) broth.

7) In each serially diluted tube 200microliter of above culture suspension was added.

8) The tubes were incubated for 24 hours and observed for turbidity.

Minimum Bactericidal Concentration (MBC) Test:

1) From the MIC dilutions tubes, were plated (which was sensitive in MIC) and incubated for 24 - 48 hrs then next day the colony count was taken.

2) MBC is done to see whether there was bactericostatic or bactericidal effect of the extract (Drug) against the organism.

3) If there is no growth then - its bactericidal effect.

4) If there is growth then - its bacteriostatic effect.

Disc Diffusion Test:

01)Media used: - Brain Heart Infusion agar

02)Temperature: -Bring agar plates to room temperature before use.

03) Inoculum preparation: -

a. Using a loop or swab, transfer the colonies to the plates.

b. Visually adjust turbidity with broth to equal that of a 0.5 McFarland turbidity standard that has been vortexed. Alternatively, standardize the suspension with a photometric device.

04) Inoculation of Agar plate: -

a. Within 15 min of adjusting the inoculum to a McFarland 0.5 turbidity standard, dip a sterile cotton swab into the inoculum and rotate it against the wall of the tube above the liquid to remove excess inoculum.

b. Swab entire surface of agar plate three times, rotating plates approximately 60º between streaking to ensure even distribution. Avoid hitting sides of petriplate and creating aerosols. c. Allow inoculated plate to stand for atleast 3 minutes but no longer than 15 min before making wells.

05) Stock solution preparation: - Prepare the stock solution weighing 10mg of compound and dissolve it in 1ml of DMSO

06) Addition of compound into plate: -

a. Take hollow tube of 5mm diameter, heat it. Press it on above inoculated Agar plate and remove it immediately by making a well in the plate. Likewise, make five well on each plate. b. With the help of micropipette add 75µl, 50µl, 25µl, 10µl and 5µl in each well. This will be done for one compound when they want to know the quantity grading. If they want to compare between different compounds then in one plate different compounds will be put with fixed quantity ie., 50 µl.

07) Incubation: - a. Incubate plates within 15 min of compound application. b. Invert plates, and stack them no more than five high. c. Incubate for 18-24 hrs at 37 ºC in incubator.

08) Reading plates: - a. Read plates only if the lawn of growth is confluent or nearly confluent. b. Measure diameter of inhibition zone to nearest whole millimeter by holding the measuring device.

Note:

1. In anti-fungal disc diffusion method, Sabouraud agar medium is used instead of Brain heart infusion agar.

2. For Facultative anaerobes, incubate plates in the Co2 Jar and keep the jar in the incubator at 37 ºC.

3. For Anaerobic organisms, incubate plates in the Anaerobic jar and keep the jar in the incubator at 37 ºC. [13]

Results and Discussion

Table 01: Description Macroscopic

Physical Characterization	Wheatgrass Powder
Nature	Powder
Colour	Greenish
Odour	Aromatic
Taste	Bitter

Table 02: Physico-Chemical Standards

Tests	Results
Moisture content	2.189%
Ash value	17.455%
Acid insoluble Ash	5.522%
Water soluble Ash	6.569%
Water soluble extractive	28.622%
Alcohol soluble extractive	14.033%

Wheatgrass was subjected to phytochemical screening utilising different solvents for extraction, including water and ethanol. Phytochemical qualitative analysis of wheatgrass is shown in Table. The purpose of screening was to analyse a variety of secondary metabolites found in Wheatgrass. Using different extract, the screening examination of wheatgrass showed that the aqueous and alcholic extracts included carbohydrates, reducing sugar, monosaccharides, amino acids, flavonoids and tannins are present in both aqueous and alcholic extract. Whereas proteins, cardiac glycosides are present in alcholic extract.

Table 03: Preliminary Phytochemical Screening

Tests	Aqueous Extract	Alcholic Extract
Carbohydrates	Positive	Positive
Reducing sugar	Positive	Positive
Monosaccharides	Positive	Positive
Pentose sugar	Negative	Positive
Non reducing sugar	Negative	Negative
Hexose sugar	Negative	Negative
Proteins	Negative	Positive
Amino acids	Positive	Positive
Steroids	Negative	Negative
Flavonoids	Positive	Positive
Alkaloids	Negative	Negative
Tannins	Positive	Positive
Cardiac glycosides	Negative	Positive
Anthraquinone glycosides	Negative	Negative
Saponin glycosides	Positive	Negative

Table 04 shows the contents of several formulations. The findings of the preformulation studies and assessment parameters, which included the weight variation, friability, hardness, thickness, disintegration time and wetting time, were determined to be satisfactory as shown in tables 05 and 06.

Table 04: Formulation of fast disintegrating tablet containing wheatgrass powder

Ingredients	F1	F2	F3	F4	F5	F6
Wheatgrass Powder	50	50	50	50	50	50
Crospovidone (PPXL)	5	10	-	-	-	-
Croscarmellose Sodium (AC-DI-SOL)	-	-	5	10	-	-
Sodium Starch Glycolate	-	-	-	-	5	10
Mannitol	116	111	116	111	116	111
Microcrystaline cellulose	15	15	15	15	15	15
Magnesium stearate	4	4	4	4	4	4
Talc	5	5	5	5	5	5
Aspartame	5	5	5	5	5	5
Total	200mg	200mg	200mg	200mg	200mg	200mg

Table 05: Preformulation studies of mixture

Parameters	F1	F2	F3	F4	F5	F6
Bulk density (g/ml)	1.61	1.59	1.62	1.60	1.66	1.60
Tapped density (g/ml)	1.94	1.94	1.95	1.93	1.96	1.93
Compressibility index (%)	17.01	18.04	17.01	17.09	15.3	17.09

The formulation with sodium starch glycolate and crospovidone exhibits a suitably short disintegration time. The disintegration time of the formulations containing only croscarmellose sodium as shown in Table 1. Observed that the formulation design of the fast-disintegrating tablet containing wheatgrass took longer than one minute.

Table 06: Evaluation of FDT containing Wheatgrass powder

Evaluation Parameters	F1	F2	F3	F4	F5	F6
Weight Variation (%)	2.4	1.7	1.3	1.9	1.9	0.5
Thickness (mm)	2.64	2.53	2.54	2.59	2.61	2.59
Friability (%)	0.21	0.58	0.47	0.3	0.48	0.37
Disintegration Time (Sec)	54	49	75	62	53	51
Hardness	6.75	5.91	5.37	5.32	6.22	5.89
Wetting Time (Sec)	56	41	36	49	43	55

S.mutants (Wheatgrass Powder)

Wheatgrass powder showed sensitivity (S) at higher concentrations (100 µl/ml and 50 µl/ml), effectively inhibiting S. mutans growth. At lower concentrations (25 µl/ml and below), S. mutans exhibited resistance (R), indicating that wheatgrass powder's inhibitory effect diminishes with decreasing concentrations. Control samples treated with wheatgrass powder and ciprofloxacin combinations (B+C and B+O) also showed sensitivity.

S.mutants (Ciprofloxacin)

Ciprofloxacin was sensitive (S) at all tested concentrations, demonstrating robust antibacterial activity against S. mutans.

S. oralis (Wheatgrass Powder)

S. oralis was sensitive (S) to wheatgrass powder at concentrations of 100 µl/ml, 50 µl/ml, 25 µl/ml, and 12.5 µl/ml. At concentrations of 6.25 µl/ml and below, S. oralis showed resistance (R), similar to the pattern observed with S. mutans. Control samples treated with wheatgrass powder and ciprofloxacin combinations (B+C and B+O) showed sensitivity.

S. oralis (Ciprofloxacin)

Ciprofloxacin was sensitive (S) at all concentrations tested, indicating strong antibacterial properties against *S. oralis*.

Table 07: MIC

Sl. No.	Samples	100 µl/ml	50 µl/ml	25 µl/ml	12.5 µl/ml	6.25 µl/ml	3.12 µl/ml	1.6 µl/ml	0.8 µl/ml	0.4 µl/ml	0.2 µl/ml	B + C	B+ O
S.mutans													
1	Wheat grass powder	S	R	R	R	R	R	R	R	R	R	S	R
2	Ciprofloxacin	S	S	S	S	S	S	S	S	S	R	S	R
S.oralis													
1	Wheat grass powder	S	S	S	S	R	R	R	R	R	R	S	R
2	Ciprofloxacin	S	S	S	S	S	S	S	S	S	R	S	R

S. mutans (Wheatgrass Powder)

The MBC results indicated that wheatgrass powder's effectiveness decreased with lower concentrations. MIC values increased as the concentration decreased, implying that higher doses of wheatgrass are necessary to achieve bactericidal effects. Ciprofloxacin showed "No Growth" (NG) at all concentrations, indicating a potent bactericidal effect against *S. mutans*.

S. oralis (Wheatgrass Powder)

The MBC for *S. oralis* mirrored the results seen in S. mutans, with increasing MIC values at lower wheatgrass concentrations, suggesting higher doses are required for bactericidal action. Ciprofloxacin also demonstrated "No Growth" (NG) at all concentrations tested against *S. oralis*.

Table 08: MBC

Sl. No.	Samples	100 µl/ml	50 µl/ml	25 µl/ml	12.5 µl/ml	6.25 µl/ml	3.12 µl/ml	1.6 µl/ml	0.8 µl/ml	0.4 µl/ml	0.2 µl/ml	B+C	B+O
S.mutans													
1	Wheat grass powder	04	28	32	74	96	102	112	124	168	210	NG	318
2	Ciprofloxacin	NG	NG	NG	NG	NG	NG	NG	NG	NG	128	NG	268
S.oralis													
1	Wheat grass powder	NG	NG	NG	24	48	64	98	102	112	126	NG	290
2	Ciprofloxacin	NG	NG	NG	NG	NG	NG	NG	NG	NG	109	NG	386

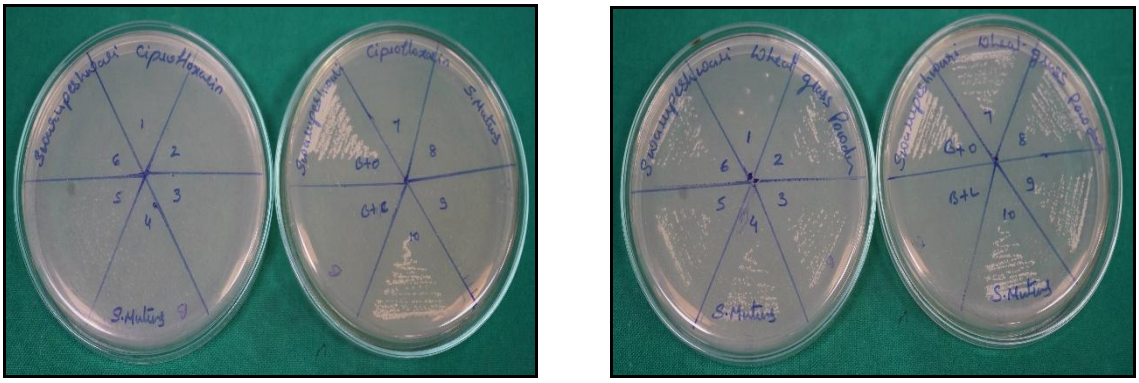
S. mutans (Wheatgrass Powder)

Despite showing sensitivity at higher concentrations in MIC tests, wheatgrass powder was resistant (R) across all concentrations in the disc diffusion test, indicating no significant zone of inhibition around the discs. Ciprofloxacin exhibited a 48 mm zone of inhibition, clearly demonstrating its sensitivity and strong antibacterial effect against *S. mutans*.

S. oralis (Wheatgrass Powder)

Wheatgrass powder showed resistance (R) in the disc diffusion test across all concentrations, as no significant inhibition zones were observed. Ciprofloxacin displayed a 50 mm zone of inhibition, indicating sensitivity and effectiveness against *S. oralis.*

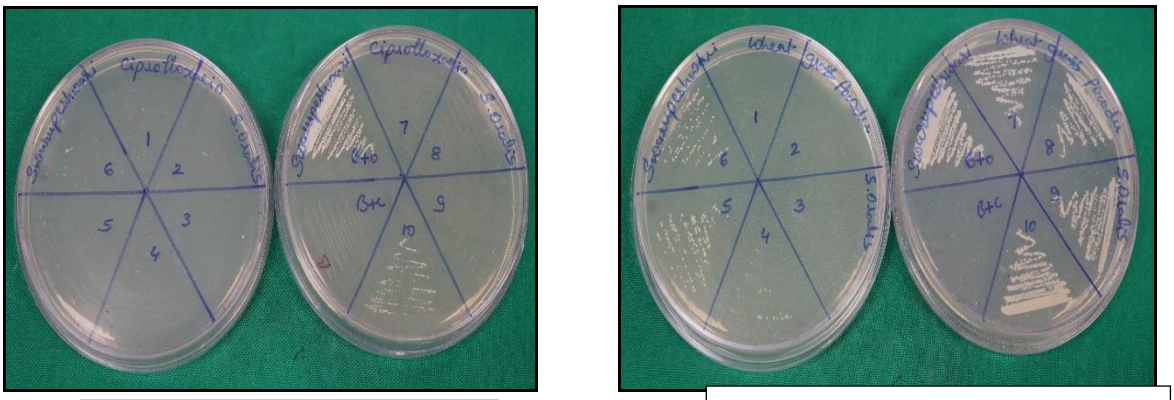
Journal of Current Pharma Research (JCPR)
Volume 21, Issue 9, September 2025 jcpr.humanjournals.com ISSN: 2230-7842, 2230-7834



Standard (*S. mutans)*

Wheatgrass powder (*S. mutans)*

Figure 1: MBC results of *S. mutans*



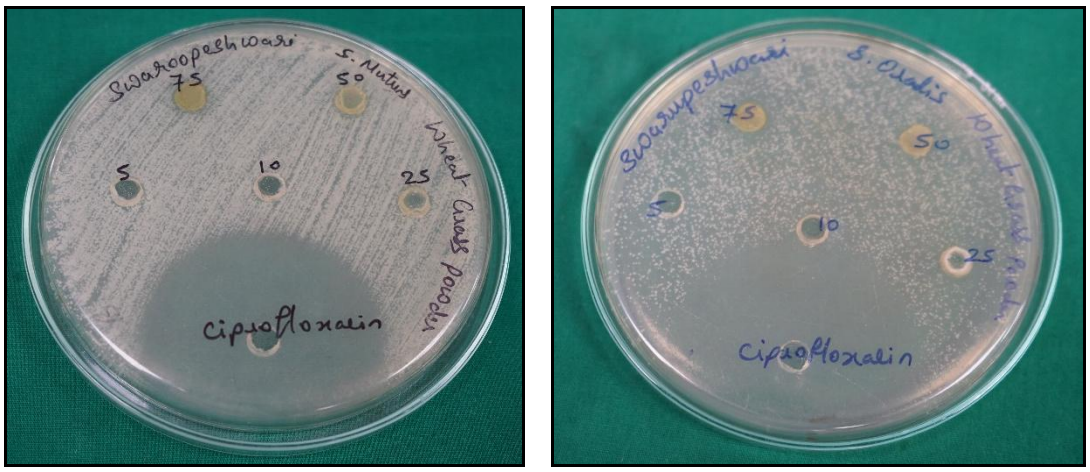
Standard (*S. Oralis)*

Wheatgrass powder *(S. Oralis)*

Figure 2: MBC results of *S. Oralis*

Table 09: Disc diffusion

Sl. No.	Organism	75µl/ml	50µl/ml	25µl/ml	10µl/ml	05µl/ml	Ciprofloxacin
S.mutans							
1	Wheat grass powder	R	R	R	R	R	48mm
S.oralis							
1	Wheat grass powder	13mm	R	R	R	R	50mm



(S. mutans) ***(S. Oralis)***

Figure 3: Result of disc diffusion

Conclusion:

The phytochemical screening confirmed the presence of key metabolites in wheatgrass with proteins and cardiac glycosides found only in the alcoholic extract. Preformulation studies indicated that formulations with sodium starch glycolate and crospovidone had shorter disintegration times, while those with only croscarmellose sodium took longer, highlighting the importance of disintegrant choice in developing efficient, fast-disintegrating wheatgrass tablets. Wheatgrass powder displays antibacterial activity against *S. mutans* and *S. oralis*, being effective only at higher concentrations. These results suggest that while wheatgrass powder may have potential as an antibacterial agent, further optimization and research are needed to enhance its efficacy.

Acknowledgement:

The author would like to thank KLE college of Pharmacy Belagavi, Karnataka for providing facilities to conduct this research work. The author are thankful to Shri B.M.K. Ayurveda Mahavidyalaya Central Research Laboratory, Belagavi to provide Phytochemical and Physicochemical analysis and Maratha Mandal's NGH Institute of Dental Sciences and Research Center, Bauxite Road, Balagavi to provide Anti-microbial facility.

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How to cite this article:
Archana S. Patil et al. Jcpr.Human, 2025; Vol. 21 (9): 13-22

Conflict of Interest Statement:
The authors have no conflicts of interest to declare.