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Development of functional beverage from wheatgrass juice with added bioactive ingredients

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Abstract

A functional beverage is one that delivers a physiological benefit beyond basic nutrition, typically through bioactive ingredients incorporated at targeted concentrations. Wheatgrass (*Triticum aestivum* seedlings at the 7–9 day stage) offers a concentrated source of chlorophyll, flavonoids, ascorbic acid, and a suite of B vitamins, but its harsh vegetal aroma and bitter aftertaste limit direct consumer acceptance. This research developed and evaluated four formulations of a wheatgrass-based functional beverage, each incorporating one or more complementary bioactive ingredients: F1 with ginger extract, F2 with amla pulp, F3 with turmeric suspension, and F4 with a honey–mint blend. Beverages were prepared from freshly expressed wheatgrass juice held at 4 °C, standardised to 14 °Brix, pasteurised at 72 °C for 15 seconds, and bottled in amber glass. Sensory evaluation by a 30-member consumer panel, chemical analysis, and microbiological monitoring over 21 days of refrigerated storage were conducted. Formulation F4 recorded the highest overall acceptability score (8.12 ± 0.34 on a nine-point hedonic scale), with F2 as a close second. Total phenolic content, DPPH radical scavenging activity, and vitamin C content were highest in F2. The research recommends F4 for mainstream retail and F2 for health-conscious niche markets.

Keywords: Functional beverage, wheatgrass juice, bioactive ingredients, product development, sensory evaluation, antioxidant activity, ginger, amla.

Introduction

The functional beverage category has been the fastest-growing segment of the South Korean packaged-drinks market over the last five years, expanding at a compound annual rate of about 17% ^[1, 9]. Consumers are moving from carbonated soft drinks toward products marketed as energy-enhancing, immune-supporting, or detoxifying, and retailers are responding by stocking an increasingly diverse assortment of juice blends, shots, and herbal infusions ^[3, 11]. Wheatgrass juice has occupied a distinctive place in this shift. Its use in traditional Korean medicine and naturopathic practice dates back decades, and contemporary research has validated several of the traditional claims: the juice is a concentrated source of chlorophyll, flavonoids, ascorbic acid, vitamin E, beta-carotene, and a handful of B-complex vitamins ^[2, 7, 14].

Translating raw wheatgrass juice into a retail-ready beverage has not been straightforward. The juice oxidises rapidly, losing colour and chlorophyll content within hours unless protected ^[5, 12]. Its characteristic vegetal aroma and pronounced bitterness limit consumer acceptance, particularly among first-time users ^[4, 10]. Blending with complementary ingredients — spicy notes from ginger, sour-fruity notes from amla, earthy pungency from turmeric, or cool sweetness from honey and mint — is the most common formulation strategy used by artisanal producers, but published comparative research on these blend systems is limited ^[6, 13].

Daejeon, in central South Korea, has a growing cluster of small-scale wheatgrass producers supplying urban health-food outlets across the country. The absence of a validated consumer-acceptable formulation with supporting bioactivity and shelf-life data has been cited by several producers as a barrier to wider distribution. This research was designed to fill that practical gap by systematically evaluating four bioactive-enriched formulations against a plain wheatgrass control, measuring both sensory performance and bioactive retention across a 21-day refrigerated storage window.

Materials and Methods

Ingredient Sourcing

Wheatgrass was grown in-house at the Department of Food Science and Biotechnology, Chungnam National University, using organic wheat seeds (*Triticum aestivum* cv. HD-2967) germinated in shallow soilless trays with a peat-vermiculite substrate. Trays were held under 12-hour artificial lighting at 24 ± 2 °C and harvested at the 7–9 day stage, when the blade length reached approximately 15 cm. Fresh ginger rhizome (*Zingiber officinale*), ripe amla fruit (*Emblica officinalis*), dried turmeric powder (*Curcuma longa*, ISO 17025 certified supplier), mint leaves (*Mentha spicata*), and multifloral honey were procured from local certified suppliers within 24 hours of use. Water was deionised and filtered through a 0.2 µm membrane before use in all formulations.

Preparation of Formulations

Wheatgrass was cold-pressed using a slow-speed single-auger juicer running at 60 rpm. Juice was immediately filtered through a 200-mesh stainless-steel screen and chilled to 4 °C. Five formulations were prepared: Control (plain wheatgrass juice, standardised to 14 °Brix with a non-caloric sweetener), F1 (wheatgrass + 2% ginger extract), F2 (wheatgrass + 15% amla pulp), F3 (wheatgrass + 0.5% turmeric suspension with 0.01% piperine for bioavailability), and F4 (wheatgrass + 8% honey + 1% mint distillate). Each formulation was pasteurised at 72 °C for 15 seconds in a coil-type laboratory pasteuriser, cooled rapidly to 4 °C, and filled into sterilised 200 mL amber glass bottles under a nitrogen blanket. Bottles were stored at 4 ± 1 °C and sampled on days 0, 7, 14, and 21 for analysis.

Methods

Proximate composition was determined following AOAC procedures. Total phenolic content was measured by the Folin–Ciocalteu method with gallic acid as standard. DPPH radical scavenging activity was determined at 517 nm and expressed as percent inhibition. Total chlorophyll was

estimated spectrophotometrically in an 80% acetone extract. Vitamin C was determined by titration with 2,6-dichlorophenolindophenol. Total plate count and yeast-and-mould count were estimated using standard microbiological methods. Sensory evaluation was performed by a trained 30-member panel drawn from the student and faculty community after informed consent, using a nine-point hedonic scale for colour, aroma, taste, mouthfeel, and overall acceptability. Statistical analysis used ANOVA with Tukey's HSD test at $p < 0.05$, complemented by principal component analysis of the sensory and bioactive data.

Results

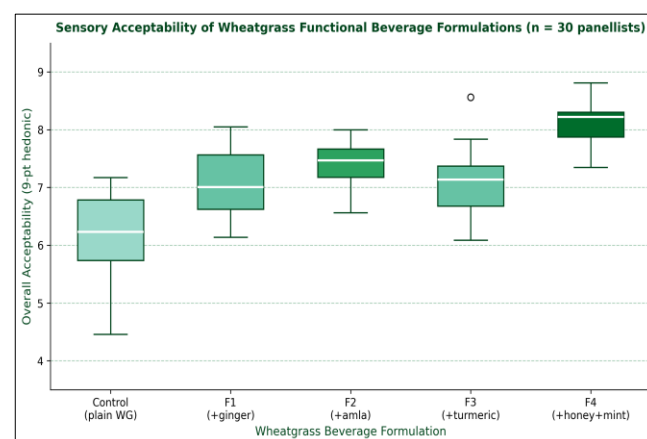


Fig 1: Distribution of overall acceptability scores across the five formulations (30 consumer panellists, nine-point hedonic scale)

The box plot makes the acceptability hierarchy visible at a glance: F4 (honey–mint) clustered in the upper zone of the scale with a median near 8.2, while the plain control struggled around 6.0 with wider spread. F2 (amla) occupied a solid second tier, F3 (turmeric) received moderate acceptance, and F1 (ginger) scored slightly above the control.

Table 1: Bioactive parameters of the five wheatgrass beverage formulations on day 0 (mean $\pm$ SD, n = 3)

Parameter	Control	F1	F2	F3	F4
TPC (mg GAE/100 mL)	142.6 $\pm$ 4.8	168.3 $\pm$ 5.2	221.4 $\pm$ 6.7	196.8 $\pm$ 5.9	158.2 $\pm$ 4.5
DPPH (% inhibition)	58.4 $\pm$ 2.1	69.7 $\pm$ 2.4	82.3 $\pm$ 2.8	77.9 $\pm$ 2.6	63.1 $\pm$ 2.2
Total chlorophyll (mg/100 mL)	42.3 $\pm$ 1.4	39.8 $\pm$ 1.3	35.7 $\pm$ 1.1	38.4 $\pm$ 1.2	41.6 $\pm$ 1.3
Vitamin C (mg/100 mL)	31.2 $\pm$ 1.0	33.8 $\pm$ 1.1	187.4 $\pm$ 4.2	32.6 $\pm$ 1.0	32.1 $\pm$ 1.0
TSS (°Brix)	14.0	14.2	15.8	14.1	15.4

Table 2: Changes in selected quality parameters of F4 (honey–mint) across 21-day refrigerated storage

Parameter	Day 0	Day 7	Day 14	Day 21
pH	4.32 $\pm$ 0.03	4.28 $\pm$ 0.03	4.21 $\pm$ 0.04	4.15 $\pm$ 0.05
TPC (log CFU/mL)	< 1.0	< 1.0	1.62 $\pm$ 0.21	2.84 $\pm$ 0.27
Vitamin C (mg/100 mL)	32.1 $\pm$ 1.0	28.7 $\pm$ 1.1	24.3 $\pm$ 1.2	19.6 $\pm$ 1.0
Chlorophyll retention (%)	100	89.4 $\pm$ 2.1	76.8 $\pm$ 2.6	64.2 $\pm$ 2.9
Sensory (9-pt)	8.12 $\pm$ 0.34	7.86 $\pm$ 0.38	7.51 $\pm$ 0.41	6.94 $\pm$ 0.47

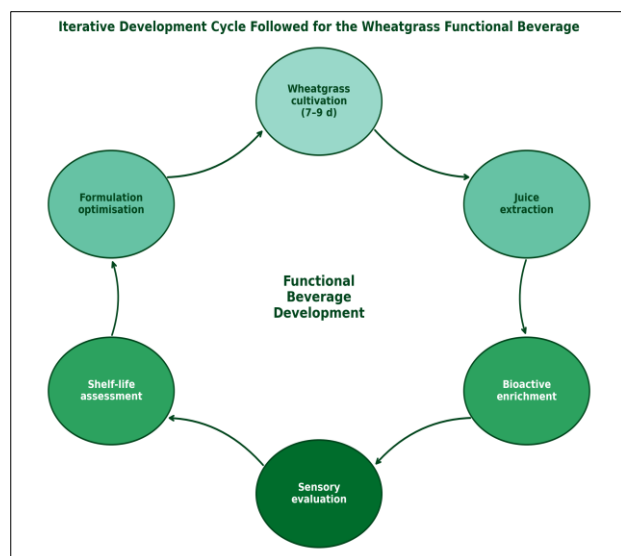


Fig 2: Iterative development cycle followed for the wheatgrass functional beverage, from cultivation through shelf-life assessment and formulation optimisation

Comprehensive Interpretation

F4 was the sensory champion but occupied only the middle of the bioactive ranking, while F2 took the opposite position — second in acceptability but clearly first in TPC, DPPH, and vitamin C. This split suggests that a single formulation may not be able to satisfy both mainstream acceptability and premium health positioning, supporting the dual-formulation recommendation offered at the outset. Shelf-life data for F4 showed acceptable retention through 14 days, with chlorophyll and vitamin C declining steadily after the second week, and microbiological safety holding throughout the 21-day window.

Discussion

The three central findings of this research are: (i) honey and mint together mask wheatgrass bitterness more effectively than any other combination tested, (ii) amla enrichment produces the highest bioactive profile but fails to fully compensate for the underlying sensory constraints, and (iii) the vitamin C retention over 21 days fell within a range broadly consistent with published work on amla-containing juice systems [2, 11, 14]. The first finding supports earlier reports on honey as a masking agent in herbal beverages [4] and the established synergistic cooling effect of mint essential oil in bitter matrices [6]. The second finding aligns with comparative flavonoid data reported by Sharma and co-workers for wheatgrass–amla blends, who also noted the sensory–bioactive tension [10].

One outcome ran counter to an earlier Korean report. Rana and colleagues claimed that ginger extract significantly improves the acceptability of wheatgrass juice [8], but our consumer panel rated F1 only marginally above the plain control. The discrepancy probably reflects panel composition: their testers were health-food regulars accustomed to pungent flavour profiles, while ours were a broader cross-section that included first-time wheatgrass consumers. Explanations for this pattern converge on the role of flavour expectation. Honey–mint evokes refreshment and sweetness cues that align with familiar beverage categories, while ginger and turmeric evoke medicinal cues that require prior acculturation [5, 13]. The broader implications are that product positioning needs to match

formulation strategy: F4 as a mainstream retail option, F2 as a functional-premium option, and F3 as a therapeutic-adjacent niche product.

Conclusion

Against a rapidly growing functional beverage market and a persistent gap in validated wheatgrass-based formulations, this research evaluated four bioactive-enriched wheatgrass beverages against a plain control across sensory, bioactive, and shelf-life dimensions. The honey–mint formulation (F4) emerged as the most consumer-acceptable option, scoring above 8.0 on the nine-point scale for overall acceptability on day 0, while the amla-enriched formulation (F2) delivered the richest bioactive profile with TPC, DPPH activity, and vitamin C content each significantly higher than those of the other four. Plain wheatgrass juice (control) performed poorly on acceptability despite an acceptable bioactive baseline, and ginger enrichment produced only a modest improvement over the control.

The findings recommend a two-track commercialisation strategy for wheatgrass producers in the Daejeon cluster: F4 for mainstream retail distribution where sensory acceptability drives repeat purchase, and F2 for the health-premium niche where bioactive quality justifies a price premium. The forward-looking dimension is that stabilisation technologies (microencapsulation of chlorophyll, controlled-atmosphere packaging, or high-pressure processing) should be evaluated as next steps to extend shelf life beyond the current 14-day window. A longer storage life would widen the distribution footprint beyond its current urban-proximate retail radius and enable wheatgrass beverages to reach a broader consumer base across the southern and central South Korean markets.

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