

CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study has successfully formulated a functional lifestyle beverage by blending different phenotypic variants of *Clitoria ternatea* (bunga telang) extracts. The laboratory analysis showed similar total nutrient yield but the free-radical scavenging capacity of pure Mauve strain was significantly higher (39.73%) than Wild Type (30.79%). Equal blending of the variants resulted in a temporary reduction in antioxidant scores due to pigment interactions, however, a ratio of 25:75 Wild Type to Mauve (Variant WM3) was successful in optimising this bioactive synergy.

The WM3 blend was the preferred formulation, with the highest score of colour preference, in a standardised sensory panel of 80 consumer judges using a 9-point Hedonic scale. Meanwhile, the addition of Ital Lemon juice, Ronin mint syrup and sugarfree Tropicana Slim lychee syrup managed to cover the earthy odour (*langu*) of the raw flower with very consistent positive consumer acceptance for all samples. Finally, the analysis of the ready beverage resulted in an antioxidant score of 14.08 %. The natural acidity of the lemon juice effectively stabilised the bright pink colour matrix, and the incorporation of Nutrijell grape jelly offered a structural shield that protected the sensitive bioactive compounds from environmental degradation, successfully balancing functional health benefits with high consumer appeal.

5.2 Recommendations

Based on the practical limitations identified in this study, future research should focus on three concrete technological approaches in order to successfully prepare the WM3 beverage formulation for mass commercialisation. First, long term stability testing must be conducted to evaluate the behaviour of the 14.08% antioxidant activity and the sensitive anthocyanin colour pigments in a long storage period. These trials should be done to compare quality retention at ambient room temperature and refrigerated storage to determine the exact commercial shelf life of the product for retail markets. Secondly, future formulation trials should investigate the use of natural, zero-calorie sweeteners, such as stevia or monk fruit extracts. This will enable researchers to fully replace any existing commercial syrups, further reducing the current ~3.45g/100mL sugar profile to cater to health-conscious consumers looking for zero-sugar functional beverages. Finally, future studies should investigate other bases for texturising, replacing the current grape jelly with hydrocolloids from seaweeds such as agar-agar or carrageenan. These alternative bases will be tested to determine whether different cross-linked gel structures can provide better physical encapsulation, thus protecting the sensitive *Clitoria ternatea* bioactive compounds from environmental degradation during preparation and storage.

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APPENDICES

APPENDIX 1 Loss Weight Result From Dehydration Process

Cultivar Type	Total Initial Weight (g)	Total Final Weight (g)	Cumulative Weight Loss (g)	Average Weight Loss Per Tray (g)	Moisture Loss (%)
Wild Type(Blue)	48.1699	45.9774	2.1925	0.1827±0.0470	4.55
Mauve Type(Pinkish)	48.2190	46.6231	1.5959	0.1330±0.0423	3.31

APPENDIX 2 Moisture Content Analysis Calculation

Cultivar Type	Production Group	Mean Sample Initial Weight (g)	Mean Loss Weight (g)	Average Wet Basis Moisture (Mwb %)	Cultivar Overall Average (Mwb %)
Wild Type	Batch 1	2.0125 ± 0.0021	0.1503 ± 0.0193	7.47 ± 0.97	7.87 ± 0.74
	Batch 2	2.0207 ± 0.0028	0.1674 ± 0.0104	8.27 ± 0.49	
Mauve Type	Batch 1	2.0155 ± 0.0064	0.1562 ± 0.0185	7.54 ± 1.01	7.75 ± 0.73

	Batch 2	2.0117 ± 0.0059	0.1607 ± 0.0078	7.97 ±- 0.35	
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APPENDIX 3 Sample Weight and Volume Calculation for Extraction

Run (Triplicate)	Ratio (Wild : Mauve)	Weight of Wild (g)	Weight of Mauve (g)	Total Powder (g)	Water (mL)
1-3	100 : 0	1.09	0	1.09	43.6
4-6	75 : 25	0.82	0.27	1.09	43.6
7-9	50 : 50	0.55	0.55	1.1	44
10-12	25 : 75	0.27	0.82	1.09	43.6
13-15	0 : 100	0	1.09	1.09	43.6

Method: Warm Water Maceration.
Temperature: 60°C.
Time: 30 Minutes.
Ratio: 1:40 (w/v).
Condition: Darkness (Cover with foil).

APPENDIX 4 Primary Peak Wavelength (λ_{max}) Summary

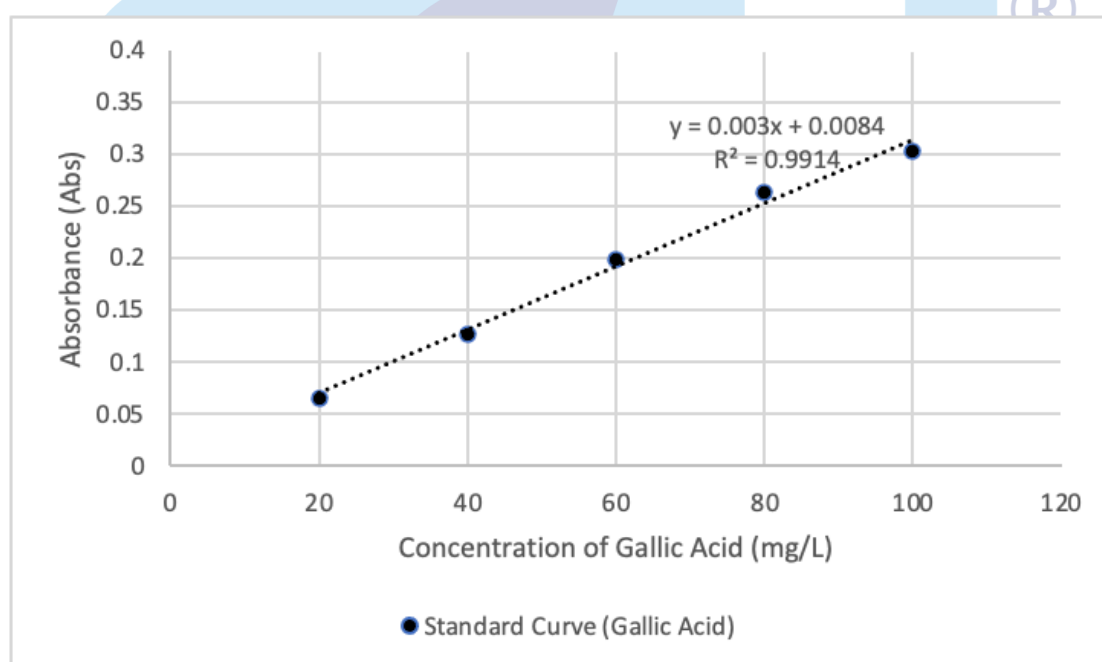
Note: Values represent the mean primary peak wavelength and its corresponding maximum absorbance (n=3) for each flower extract formulation.

Extract Blend Ratio	Primary Peak (λ_{max})	Absorbance Value
W1	620 nm	0.592

WM1	620 nm	0.544
WM2	620 nm	0.371
WM3	619 nm	0.235
M1	532 nm	0.131

Note: W1= 100% Wild, WM1= 75%Wild&25%Mauve, WM2= 50%Wild&50%Mauve, WM3= 25%Wild&75%Mauve, M1= 100%Mauve

APPENDIX 5 Gallic Acid Standard Curves



APPENDIX 6 One-Way ANOVA: Total Anthocyanin Content (TAC)

SUMMARY

Groups	Count	Sum	Average	Variance
W1	3	366.43	122.14	17.30463
WM1	3	272.56	90.85	2.21763

WM2	3	265.61	88.54	0.87923
WM3	3	206.58	68.86	0.39510
M1	3	182.48	60.83	0.43893

Significance level 0.05

ANOVA

Source of Variation	SS	df	MS	F	P-value	F-critical
Between Groups	6790.5261	4	1697.63	399.71483	5.5374E-11	3.47804
Within Groups	42.4711	10	4.25			
Total	6832.9972	14				

Post-Hoc Test

Comparison	Difference	Tukey HSD	Significant ?
W1 vs WM1	31.2900	5.1960	Yes
W1 vs WM2	33.6067	5.1960	Yes
W1 vs WM3	53.2833	5.1960	Yes
W1 vs M1	61.3167	5.1960	Yes
WM1 vs WM2	2.3167	5.1960	No
WM1 vs WM3	21.9933	5.1960	Yes
WM1 vs M1	30.0267	5.1960	Yes
WM2 vs WM3	19.6767	5.1960	Yes
WM2 vs M1	27.7100	5.1960	Yes
WM3 vs M1	8.0333	5.1960	Yes

APPENDIX 7 One-Way ANOVA: Total Phenolic Content (TPC)

SUMMARY

Groups	Count	Sum	Average	Variance
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W1	3	6008.7	2002.90	501.51000
WM1	3	6364.8	2121.60	8465.67000
WM2	3	5736.3	1912.10	8735.61000
WM3	3	6173.7	2057.90	4339.47000
M1	3	5948.85	1982.95	992.61750

Significance level 0.05

ANOVA

Source of Variation	SS	df	MS	F	P-value	F-critical
Between Groups	74894.3760	4	18723.59	4.06418	0.0328	3.47804
Within Groups	46069.7550	10	4606.98		1916	969
Total	120964.1310	14				

Post-Hoc Test

Comparison	Difference	Tukey HSD	Significant ?
W1 vs WM1	118.7000	171.1317	No
W1 vs WM2	90.8000	171.1317	No
W1 vs WM3	55.0000	171.1317	No
W1 vs M1	19.9500	171.1317	No
WM1 vs WM2	209.5000	171.1317	Yes
WM1 vs WM3	63.7000	171.1317	No
WM1 vs M1	138.6500	171.1317	No

WM2 vs WM3	145.8000	171.1317	No
WM2 vs M1	70.8500	171.1317	No
WM3 vs M1	74.9500	171.1317	No

APPENDIX 7 One-Way ANOVA: Total Antioxidant Activity (TAA)

SUMMARY

Groups	Count	Sum	Average	Variance
W1	3	92.3815208	30.79	6.25765
WM1	3	64.8033003	21.60	15.13464
WM2	3	69.4891222	23.16	16.40117
WM3	3	83.5514151	27.85	12.52627
M1	3	119.198342	39.73	7.36750

Significance level 0.05

ANOVA

Source of Variation	SS	df	MS	F	P-value	F-critical
Between Groups	623.5640	4	155.89	13.51174	0.00048431	3.47804
Within Groups	115.3745	10	11.54			
Total	738.9385	14				

Post-Hoc Test

Comparison	Difference	Tukey HSD	Significant
			?
W1 vs WM1	9.1927	8.5640	Yes
W1 vs WM2	7.6308	8.5640	No
W1 vs WM3	2.9434	8.5640	No
W1 vs M1	8.9389	8.5640	Yes
WM1 vs WM2	1.5619	8.5640	No
WM1 vs WM3	6.2494	8.5640	No
WM1 vs M1	18.1317	8.5640	Yes
WM2 vs WM3	4.6874	8.5640	No
WM2 vs M1	16.5697	8.5640	Yes
WM3 vs M1	11.8823	8.5640	Yes

APPENDIX 8 Non-Parametric Sensory Test Sheets

8.1 Friedman Test Result for Color Preference (Formulated Drink)

Number of Data, n 80

Number of Sample, k 5

Degree of Freedom: 4

Significance Level, α : 0.05

Variables	Mean Ranks	SSt	Sse	Q	p-Value
112(W1)	2.8	17.73	2.169	8.1758	0.085347
397(WM1)	3.2				
478(WM2)	2.9				
617(WM3)	3.3				

772(M1) 2.8

Conclusion

NO SIGNIFICANT DIFFERENT

8.2 Friedman Test Result for Overall Acceptance (Formulated Drink)

Number of Data, n 80

Number of Sample, k 5

Degree of Freedom: 4

Significance Level, α : 0.05

Variables	Mean Ranks	SSt	Sse	Q	p-Value
112(W1)	2.9	4.98	2.169	2.2968	0.681346
397(WM1)	3.2				
478(WM2)	3.0				
617(WM3)	3.0				
772(M1)	3.0				

Conclusion

NO SIGNIFICANT DIFFERENT

8.3 Wilcoxon Signed-Rank Post-Hoc Analysis

Sensory Attribute	Pair No.	Sample Comparison Pair	Z-Score	p-value (Asymp. Sig. 2-tailed)	Statistical Decision ($\alpha=0.05$)
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Color Preference	1	112 vs. 397	-2.4555	0.0141	SIGNIFICANT DIFFERENT
	2	112 vs. 478	-1.3450	0.1786	NO SIGNIFICANT DIFFERENT
	3	112 vs. 617	-2.7196	0.0065	SIGNIFICANT DIFFERENT
	4	112 vs. 772	0.1323	0.8947	NO SIGNIFICANT DIFFERENT
	5	397 vs. 478	1.6774	0.0935	SIGNIFICANT DIFFERENT
	6	397 vs. 617	-1.5934	0.1111	NO SIGNIFICANT DIFFERENT
	7	397 vs. 772	1.3675	0.1715	NO SIGNIFICANT DIFFERENT
	8	478 vs. 617	-1.5934	0.1111	NO SIGNIFICANT DIFFERENT
	9	478 vs. 772	1.3675	0.1715	NO SIGNIFICANT DIFFERENT
	10	617 vs. 772	2.0729	0.0382	SIGNIFICANT DIFFERENT
Overall Acceptance	1	112 vs. 397	-1.2664	0.2054	NO SIGNIFICANT DIFFERENT
	2	112 vs. 478	-0.3294	0.7418	NO SIGNIFICANT DIFFERENT
	3	112 vs. 617	-0.6853	0.4931	NO SIGNIFICANT DIFFERENT
	4	112 vs. 772	-0.7638	0.4450	NO SIGNIFICANT DIFFERENT
	5	397 vs. 478	0.9045	0.3657	NO SIGNIFICANT DIFFERENT

	6	397 vs. 617	0.6055	0.5449	NO SIGNIFICANT DIFFERENT
	7	397 vs. 712	0.6187	0.5361	NO SIGNIFICANT DIFFERENT
	8	478 vs. 617	0.6055	0.5449	NO SIGNIFICANT DIFFERENT
	9	478 vs. 772	-0.3851	0.7002	NO SIGNIFICANT DIFFERENT
	10	617 vs. 772	-0.3851	0.7002	NO SIGNIFICANT DIFFERENT



GLOSSARY

% Inhibition	Percentage of DPPH free radical molecules neutralized by antioxidants
%RSD	Relative Standard Deviation percentage monitoring laboratory assay precision
°C	Degrees Celsius (unit of temperature control used in maceration and drying)
112	Randomized 3-digit blinding sensory key code distributed for sample W1
2AP	2-Acetyl-1-pyrroline (Volatile aroma compound from pandan leaves responsible for sweet scent)
397	Randomized 3-digit blinding sensory key code distributed for sample WM1
478	Randomized 3-digit blinding sensory key code distributed for sample WM2
617	Randomized 3-digit blinding sensory key code distributed for sample WM3
772	Randomized 3-digit blinding sensory key code distributed for sample M1

A	Optical absorbance value recorded at the targeted analytical wavelength indicator
$A_{\lambda_{max}}$	Peak absorbance value recorded at the maximum absorption wavelength
BD	Beverage Drink prototype formulation (Final consumer-optimized blend)
BPOM	<i>Badan Pengawas Obat dan Makanan</i> (National Agency of Drug and Food Control of Republic of Indonesia)
C	Concentration value derived from the standard reference linear regression path
CH_3OH	Methanol solvent molecule used in extraction matrices
$C_{18}H_{12}Cl_8N_5O$	2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical powder chemical formula
C_6H_6O	Phenol ring reactive core chemical compound formula
$C_7H_6O_5$	Gallic acid monohydrate calibrant standard chemical formula
DF	Volumetric dilution factor adjustment applied during laboratory spectrophotometric scanning
DPPH	2,2-Diphenyl-1-picrylhydrazyl stable free radical molecule used to track antioxidant capacity

$d\ H_2O$	Distilled Water purified carrier solvent agent
df	Degrees of Freedom parameter applied during statistical testing (e.g., df = 4 in Friedman test)
ϵ	Molar absorptivity extinction coefficient constant assigned for pigment content formulas
FGD	Focus Group Discussion sensory alignment and product optimization testing panel
GAE/L	Gallic Acid Equivalents per Liter metric unit used to quantify phenolic concentrations
HAT	Hydrogen Atom Transfer protective free radical scavenging pathway
HCl	Hydrochloric acid modifier utilized to adjust extraction pH conditions
KCl	Potassium chloride buffer salt used in pH differential assays
l	Path length dimension of the quartz testing spectrophotometer cuvette cell
λ_{max}	Wavelength coordinates tracking maximum light absorption expressed in nanometers
M1 / M2	100% pure Mauve mutant <i>Clitoria ternatea</i> flower cultivar extract control samples

M_{wb}	Moisture content percentage baseline monitored via gravimetric wet basis calculations
mg/L	Milligrams per Liter (standard unit of expression for Total Anthocyanin Content)
n	Total sample population size targeted during consumer testing panel evaluations ($n=80$)
Na_2CO_3	Sodium carbonate alkaline buffering salt used in total phenolic assay coloring
nm	Nanometers (metric unit of light wavelength used in UV-Vis spectrum analysis)
p -value	Calculated asymptotic significance probability value used to determine hypothesis rejection boundaries
pH	<i>Potentia Hydrogenii</i> structural scale measuring liquid acidity or basicity levels
Q	Calculated test statistic score output generated from the Friedman non-parametric analysis
SET	Single Electron Transfer radical reduction and neutralization pathway
TAA	Total Antioxidant Activity aggregate percentage value of a matrix
TAC	Total Anthocyanin Content quantitative spectrophotometric metric

TPC	Total Phenolic Content colorimetric concentration value
UV-Vis	Ultraviolet-Visible range screening spectrophotometer instrument setup
$t_{1/2}$	Calculated chemical reaction kinetic metric indicating a color pigment's storage half-life
W1	100% pure Wild Type deep blue <i>Clitoria ternatea</i> extract control sample
WM1	75% Wild Type : 25% Mauve Type balanced botanical extract blend sample
WM2	50% Wild Type : 50% Mauve Type intermediary botanical extract blend sample
WM3	25% Wild Type : 75% Mauve Type optimized synergistic botanical extract blend sample
W_1	Initial sample mass weight parameter determined prior to moisture oven convective drying

W_2 Final constant dry mass weight parameter determined after oven moisture evaporation

w/v Weight-to-volume ratio parameter specifying analytical preparation concentrations (e.g., 1:40 w/v)

v/v Volume-to-volume ratio metric indicating liquid dilution levels during analysis

α Statistical significance error probability boundary limit (assigned threshold value of 0.05)

$\pm$ SD Plus-or-minus the standard deviation (denoting experimental variance bounds in data tables)

CURRICULUM VITAE

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EDUCATIONAL HISTORY

Hochschule Albstadt Sigmaringen

University | September 2024 - February 2025

- Major: Food Nutrition & Hygiene

Swiss German University

University | 2022 - 2026

- Major: Food Technology

IPEKA PLUS BSD

Senior high School | 2019 - 2022

WORK EXPERIENCE

Internship at pacocon Sustainability Concepts GmbH

Sustainable Packaging Development (Consultant & Agency) Division | March 2025 - August 2025

- Key responsibilities: Researching eco-friendly packaging materials, analyzing European packaging regulations, and evaluating the sustainability impact of various packaging concepts. Conduct market and regulatory analyses, assess recyclability and compliance with food safety standards, and explore innovative strategies for circular packaging systems.

Internship at PT FRISIAN FLAG INDONESIA

R&D Packaging Specialist Division | Nov 2023 - Feb 2024

- Key responsibilities: Packaging Design and development, material testing and analysis, product and packaging optimization, Regulatory compliance, innovation project, data collection and Reporting, Quality control

ORGANIZATION EXPERIENCE

Student Board of Executive Swiss German University

President of Student Board of Executive (SBOE) | 2024

- Lead all the members of student board of executive

Member of Kaderisasi Fund Raising Division | 2023

- Helped provide funding and produce income for Kaderisasi

Member of Orientation Event Division | 2023

- Coordinate the events and schedule for Orientation

Secretary of Sport Division (BEM) | 2022 - 2023

- Provide MOM (Minutes Of Meeting)

DIFCom (Digital Innovation Food Competition) under SAFT

Master of Ceremony | 2023

SAFT (Student Association of Food Technology)

Member | 2022 - Present

- Provide funding with all committee and coordinate events under SAFT

Senior High Student Council

Head of Sport Division | 2020 - 2021

- Managed all member of Sports Division
- Provide and coordinate online event of Sports: Esports Competition

Member of IPEKA CUP Event Division | 2019 - 2020

- Coordinate the events and schedule

PERSONAL PROFILE

Date of birth: 22.11.2003 in Jakarta

Marital Status: Unmarried

Nationality: Indonesia

SKILLS SUMMARY

- Leadership skills
- Event Coordinator & management
- Docs, Sheets, Slides, Drive, Canva, iMovie, GarageBand.
- Food Safety: HACCP, GMP
- Sustainability Packaging: Design for Recycling, LCA, bio-based materials, and Design for Recycling.
- Product Development: R&D Formulation, Scale-up, and Sensory Science.
- Lab Analysis: Microbiology, Titration, pH, Brix, and aw Testing.
- Instrumentation: HPLC, GC-MS, spectrophotometry.
- Regulatory: FDA/EFSA compliance, nutritional labeling, and green claims.
- Technical Software: Minitab, Design experts

CERTIFICATION

- Certificate of FOOD HANDLER
- Certificate of Good Manufacturing Practice (GMP)

LANGUAGE

- Bahasa Indonesia - Mother tongue
- English - Advance Level

24 December 2025

DATE



SIGNATURE