Extraction Of Holy Basil Essential Oil and Its Application as A Flavouring Agent in Minimal-Ingredient Clean Label Smoothie

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***Abstract*—Holy basil (*Ocimum sanctum Linn.*, Tulsi) and Clean – label food together demonstrates natural, minimally processed, free from synthetic additives, essential for sustainable and health-conscious beverages. Essential oils, particularly Tulsi (*Ocimum sanctum*) obtained through hydro-distillation, offer bioactive potential despite modest yields. Similarly, Smoothies provide nutrient enriched clean-label beverage. This study extracted Tulsi essential oil and incorporated it into a minimal-ingredient smoothie with blueberries, bananas, and stevia. Nutritional analysis confirmed stable macronutrient values, while sensory evaluation with 40 panelists validated enhanced aroma, flavour complexity, and overall acceptability, despite mild herbal notes. The findings demonstrate that Tulsi essential oil can serve as an effective natural flavouring agent, offering a sustainable pathway for clean-label functional beverages that balance extraction efficiency, nutritional integrity, and consumer wellness demands.**

I. INTRODUCTION

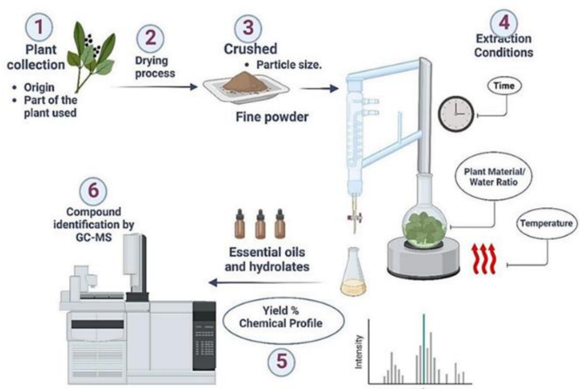
Holy basil (*Ocimum sanctum* Linn., Tulsi) and smoothies exemplify the convergence of traditional herbal medicine and modern functional food innovation. Tulsi, characterized by its distinct aroma and rich phytochemical profile, is particularly abundant in eugenol and complementary phenolics such as apigenin and rosmarinic acid, which collectively impart antibacterial, antioxidant, anticancer, and antidiabetic activities. [1,6,8]. Despite its therapeutic promise, challenges in standardization and stability persist due to variability in cultivation, harvesting, and storage conditions. Essential oils (EOs) are volatile organic compounds obtained mainly through distillation from medicinal and aromatic plants, with yields and quality depending on plant part, species, and extraction technique.[2]. Hydrodistillation, often using the Clevenger apparatus, remains the most common method due to its simplicity and cost-effectiveness, though it has drawbacks such as long extraction times, low yields, and degradation of heat-sensitive compounds. Optimization of parameters like plant material-to-water ratio (commonly 1:10), temperature (100–175 °C), and extraction time (3–4 hours) can improve yield and preserve chemical integrity. [3,7]. Despite advances in supercritical CO_2, ultrasound-assisted extraction, and microwave methods, HD remains practical, safe, and widely used, avoiding solvents and extreme conditions. [9].

In parallel, Smoothies are nutrient-rich blended beverages made from fruits and vegetables, often enhanced with dairy or plant-based ingredients, providing fiber, antioxidants, vitamins, and minerals that support weight management and chronic disease prevention.[4]. Increasing demand for clean-label foods has driven interest in natural additives like essential oils and plant extracts with antimicrobial and antioxidant properties.[5]. Functional ingredients such as basil, blueberries, bananas, and stevia contribute bioactive compounds including eugenol, anthocyanins, carotenoids, and steviol glycosides, offering health benefits ranging from cardioprotection to anti-inflammatory effects. [10,11]. Together, these components highlight the role of smoothies as convenient functional foods that integrate traditional plant wisdom with modern dietary trends, promoting sustainability, personalized nutrition, and consumer wellness.[12]

Fig 1: Ocimum Sanctum

II. MATERIALS AND METHODS

Holy Basil leaves were pre-processed (washing, drying, grinding) and subjected to hydro-distillation using a Clevenger-type apparatus. A mixture of dried plant material and distilled water was heated for 120 minutes, yielding 0.21% essential oil. The samples extracted were stored at refrigeration under 4-degree Celsius Smoothie formulations were developed using minimal ingredients including blueberries, Yelakki banana, curd, and stevia for sweetness. To assess the extract Nutritional Analysis, Sensory Evaluation, and Gas Liquid Chromatography were conducted for quality assurance and product acceptability.



III. RESULTS AND DISCUSSION

3.1. Extraction Yield:

Hydro-distillation of *Ocimum sanctum* yielded 5.5 ml of essential oil from dried plant material, confirming the generally low yield (0.1–3% of plant weight) typical of Tulsi oils, influenced by drying time, plant weight, and distillation parameters.

Table 1: Extraction yield

	1st Extraction Yield of Essential oil	2nd Extraction Yield of Essential oil
Period of Drying	2-3 days	2 days
Before drying	750 g	2000 g
After drying	500 g	1750 g
Yield	1.5 ml	4.0 ml

3.2. Smoothie Formulation:

Table 2: Ingredients with amount required to make the recipe with or without essential oil

Ingredients	Amount (g/ml)	
	Smoothie without Essential oil	Smoothie with Essential oil
Blueberry	16.54 g	16.54 g
Yelakki Banana	16.54 g	16.54 g
Curd	85 ml	85 ml
Stevia	1g	1 g
Holy Basil Essential oil	-	0.1 ml / 100 µ

Fig 2: Blueberry Smoothie

3.3. Gas liquid chromatography:

Out of 37 parameters; 3 were identified: palmitic acid (55.05/100 g), cis-10-heptadecenoic acid (27.85/100 g), and alpha-linolenic acid (17.09/100 g) as the main constituents, while the other 34 remained as Not Detected.

3.4. Nutritional Analysis:

Nutritional analysis of the clean-label blueberry smoothie showed stable macronutrient values between control and sample: energy ~60 kcal/100 g, carbohydrates ~10.5 g, protein 2.9 g, and fat 0.7 g. Ash content remained identical (0.3 g%), while moisture dropped from 87.9 g% to 83.4 g%, giving the sample a thicker consistency. The sample also showed a sharper taste profile due to lower pH (2.27 vs. 3.98), with titratable acidity slightly reduced. Tannin content increased marginally (11.18 & 11.32 mg), remaining within safe limits.

Table 2: Nutritional Analysis

Test Parameters	Test Results for Control (S1)	Test Results for Sample (S2)	Maximum Limits (per 100 g)
Energy	59.9 kcal	60.3 kcal	No regulatory limit
Carbohydrate	10.5 g	10.6 g	No regulatory limit
Protein	2.9 g	2.9 g	No regulatory limit
Fat	0.7 g	0.7 g	No regulatory limit
Moisture content	87.9 g%	83.4 g%	No regulatory limit
Ash content	0.3 g %	0.3 g%	0.3 – 0.5 g%
Titratable Acidity	0.144 g%	0.117 g%	Max 1.2 %
Tannin Content	11.18 mg	11.32 mg	15 – 20 mg
Total soluble solids	11.0 Brix	11.0 Brix	Mini 10.0 Brix
pH	3.98	2.27	Max 4.0

3.5. Sensory Evaluation:

Sensory evaluation with 40 panelists confirmed that Tulsi essential oil enhanced aroma, flavour complexity, and overall acceptability, though some noted mild herbal bitterness. Overall, Tulsi EO enriched the smoothie's functional properties while maintaining nutritional integrity, supporting its role as a natural flavouring agent in clean-label functional beverages.

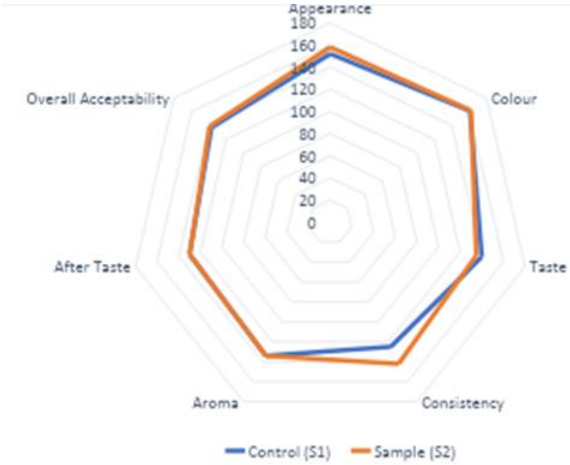


Figure 3: Radar Chart of Sensory evaluation

IV. CONCLUSION

The project demonstrated how traditional herbal therapeutics can be integrated into modern functional beverage development. Hydro-distillation using the Clevenger apparatus provided Tulsi essential oil with a defined compounds present, while a clean-label smoothie was formulated with blueberries, bananas, and stevia, avoiding synthetic additives. Sensory evaluation confirmed that the addition of Tulsi oil enhanced aroma, colour, viscosity, and overall appeal, with panelists noting a distinct herbal flavour that maintained consumer acceptability. In conclusion, the study shows that *Ocimum sanctum* essential oil can serve as a natural flavouring agent, offering a sustainable and wellness-oriented pathway for clean-label functional foods.

V. LIMITATIONS

The study revealed certain limitations that must be acknowledged. The active compounds in Holy Basil essential oil, particularly eugenol, are highly unstable and degrade rapidly when exposed to light, oxygen, or heat, resulting in diminished flavor intensity and reduced therapeutic efficacy over time. Moreover, the absence of synthetic preservatives, while consistent with clean-label principles, makes the smoothie vulnerable to microbial contamination and enzymatic browning, thereby restricting its storage stability. In addition, the taste profile of Holy Basil EO is highly sensitive to dosage; even minor variations can easily dominate the delicate blueberry notes, ultimately lowering consumer acceptance.

VI. RECOMMENDATIONS

Future research should prioritize the application of nanoemulsion technology, where oil-in-water nanoemulsions can be developed to stabilize Holy Basil essential oil, mask its strong odor, and improve bioavailability. To enhance product longevity without compromising sensitive nutrients, non-thermal preservation methods such as High-Pressure Processing (HPP) and Pulsed Electric Fields (PEF) should be explored. Additionally, creating natural antimicrobial blends by combining Holy Basil EO with plant extracts or organic acids may provide synergistic microbial control while maintaining clean-label integrity. Comprehensive packaging studies are also necessary to evaluate microbial behavior and ensure commercial stability. Employing advanced extraction methods like Microwave Assisted Hydro-distillation (MAHD) and Supercritical Fluid Extraction (SFE) could further improve yield, purity, and dosage accuracy of essential oils. Finally, large-scale consumer acceptance trials are essential to validate the market readiness of EO-incorporated clean-label foods.

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