In vitro antioxidant potential of Sweet Potato (*Ipomoea batatas)* and Green Gram (*Vigna radiata*) hummus

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Abstract- **Antioxidants are crucial in neutralising free radicals by acting as chelators of transition metals, inhibiting enzymatic systems responsible for generating reactive oxygen species (ROS), and reducing hydrogen peroxides and organic hydroperoxides. This study aims to evaluate the *in vitro* antioxidant potential of sweet potato (*Ipomoea batatas*) and green gram (*Vigna radiata*) hummus by assessing its total phenolic content, flavonoid content, and key antioxidant properties. The findings seek to determine its functional food potential and contribution to dietary antioxidants. Two hummus variations were prepared and were analysed for their *in vitro* antioxidant potential. Gas Chromatography-Mass Spectrometry (GC-MS) was used to identify bioactive components, while standard procedures were employed to assess nutrient and phytochemical content. Antioxidant activity was evaluated using DPPH and FRAP assays. A sensory evaluation was conducted with 50 semi-trained panellists using a 9-point hedonic scale. Statistical analysis was performed to determine variations in antioxidant potential. The results indicated that Variation 2, with a higher green gram content, exhibited stronger radical scavenging activity and lower IC_{50} values, suggesting greater antioxidant capacity. On the other hand, Variation 1, richer in sweet potato, demonstrated higher total phenolic content, ferulic acid, and total antioxidant capacity, reflecting a stronger bioactive profile. Sensory evaluation results favoured Variation 1, which scored higher in appearance, flavour, colour, texture, and overall acceptability. In conclusion, while both variations display notable antioxidant potential and health benefits, Variation 1 is more suitable for consumers prioritising taste and sensory qualities. Variation 2, however, is better suited for individuals seeking enhanced functional and antioxidant properties.**

Key words: **Antioxidants, *in vitro,* sweet potato, green gram, hummus, bioactive compounds, free radicals, oxidative stress.**

I. INTRODUCTION

Functional foods provide health benefits beyond basic nutrition, helping to reduce disease risk and promote overall well-being. Also known as nutraceuticals or designer foods, they have gained global popularity. The concept originated in Japan in the 1980s under the Ministry of Health and Welfare, later expanding to North America and other regions [1]. An inevitable byproduct of living in an oxygen-rich environment is the production of free radicals (FRs). FRs have beneficial effects at moderate concentrations and play physiological functions in cellular responses to trauma, which include protection against pathogens, the development of a mitogenic response, and the operation of several cellular signalling pathways. Oxidative stress (OS) is a detrimental process that plays a key role in damaging cell structures and tissues, occurring when free radicals (FRs) exceed the body's antioxidant defences [2].

An antioxidant is defined as "any substance that significantly delays or prevents oxidation of that substrate when present at low concentration compared with that of an oxidisable substrate". There are several ways to characterise antioxidants, but one of the most straightforward is that they are molecules that may shield different parts of biological systems from oxidative damage [3], [4]. Antioxidants play a crucial role in neutralising free radicals, reducing oxidative stress, and promoting overall health. Incorporating antioxidant-rich foods into the diet can help enhance protective benefits against various diseases. In this context, sweet potato and green gram hummus emerge as a functional food, combining the nutrient density of sweet potato with the protein and bioactive compounds of green gram.

Hummus, a dish made from chickpeas (*Cicer arietinum*), originated in the Middle Eastern and Mediterranean regions [5] and is widely consumed among Arabs and Jews [6]. Its rich flavour comes from tahini, a sesame seed paste blended with olive oil, and a high proportion of pulses and edible seeds from leguminous plants such as peas, beans, lentils, and chickpeas. In this study, green gram and sweet

potato are explored as alternative ingredients, offering a unique variation with enhanced nutritional and functional properties.

Sweet potato (*Ipomoea batatas*) is believed to have originated in the lowlands of Central or South America, supported by high genetic diversity in the region. It later spread globally and is now widely cultivated in Asia, Africa, the Americas, and Oceania, with China as the largest producer. European immigrants likely introduced it to North America in the 17th–18th centuries [7]. Sweet potato (*Ipomoea batatas (L.) Lam*) is rich in nutrients and offers various health benefits, including anti-inflammatory, hepatoprotective, anticoagulant, and antidiabetic properties. Its bioactive compounds, such as phenolic acids, carotenoids, and peptides, have anticancer potential and contribute to its therapeutic value [8], [9], [10].

Green gram (*Vigna radiata L.*) is a major edible legume grown on over 6 million hectares worldwide. It is valued for its drought tolerance, low input needs, and short growth cycle of about 70 days. Widely cultivated in Asia, especially in China, India, Bangladesh, Pakistan, and Southeast Asia, it is also grown in dry regions of southern Europe and warmer parts of North America [11]. Other than providing basic nutritional needs, recent research has found numerous additional potential health benefits of mung beans, including their hypoglycemic and hypolipidemic effects, as well as their antihypertensive, anticancer, anti-melanogenesis, hepatoprotective, and immunomodulatory qualities [12], [13], [14], [15], [16], [17]. The present study focused on formulating sweet potato and green gram hummus and evaluating its *in vitro* antioxidant potential, aiming to explore a functional food-based approach to combat oxidative stress.

II. MATERIALS AND METHODS

An *in vitro* experimental research design was employed to assess the antioxidant potential of the hummus. The analysis was carried out at Affyclone Laboratories Pvt. Ltd., an ISO-certified facility in Chromepet, Chennai. The sensory evaluation took place in the Food Science Lab of the Department of Home Science, Women's Christian College, Chennai. The study was approved by the Institutional Ethics Committee of the Department of Home Science, Women's Christian College, Chennai.

1. Procurement and Hummus Preparation

Sweet potato (*Ipomoea batatas)* and green gram (*Vigna radiata)* were purchased from an organic shop. Sweet potato (with skin) and germinated green gram hummus were prepared in two variations (30 g:50 g and 50 g:30 g). The ingredients were washed and cooked before preparation. Sweet potato, with its skin, was boiled until soft for easy mashing, giving the hummus a slightly coarse texture. Green gram was soaked for 8–12 hours, then sprouted over 1–2 days with periodic rinsing. Once sprouts reached 1–2 cm, they were blanched for 25 minutes to soften and reduce the raw taste. Finally, the sprouts were blended with boiled sweet potato, tahini, olive oil, lemon, and seasonings to create a smooth and flavourful hummus.

2. Preparation of extracts

The aqueous and ethanolic extracts of Variations 1 and 2 were prepared to analyse the nutrient content, phytochemicals, and *in vitro* antioxidant potential of the hummus. For the aqueous extract, sweet potato and green gram in specified proportions were boiled in distilled water, cooled, filtered, and condensed at 50°C to obtain a gummy extract [18]. The ethanolic extract was prepared by soaking the ingredients in ethanol for 72 hours, followed by filtration and condensation at 50°C [19]. These extracts were then used for further analysis, including GC-MS for bioactive component identification.

3. Phytochemical and nutritional analysis of the hummus

Gas Chromatography-Mass Spectrometry (GC-MS) was used to identify the bioactive compounds in the hummus by comparing mass spectra with those in the NIST database. Additionally, the quantification of nutrients, including carbohydrates, protein, fat, dietary fibre, vitamin A, vitamin C, and iron, as well as phytochemicals like total phenolic content, total flavonoids, total ferulic acid content, and total antioxidant content, was carried out using the standard AOAC protocols.

4. Assessment of the *in vitro* antioxidant potential of the hummus

In vitro antioxidant potential of both Variations of the hummus was evaluated using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay and Ferric Reducing Antioxidant Power (FRAP) assay using standard protocols. Antioxidant activity was measured at

concentrations ranging from 20 µl to 100 µl, and the IC_{50} values were calculated for both assays.

5. Sensory evaluation of the hummus

Both Variations of the sweet potato and green gram hummus underwent a sensory evaluation to assess key attributes, including appearance, flavour, colour, texture, and overall acceptability. A 9-point hedonic rating scale was used to measure sensory responses. The evaluation was conducted with 50 semi-trained panellists from the Department of Home Science, Women's Christian College, Chennai, who provided feedback on the sensory characteristics of the hummus.

6. Data analysis

The data collected from the study were analysed for mean, standard deviation, and correlation using Microsoft Word.

III. RESULTS AND DISCUSSION

1. Quantitative estimation of nutrients in the hummus

Variation 2 was found to have higher levels of carbohydrates, protein, fat, dietary fibre, and iron compared to Variation 1. However, the mean Vitamin A and C content was slightly greater in Variation 1 than in Variation 2. This difference was attributed to the higher proportion of sweet potato in Variation 1, as sweet potato is recognised as a rich source of Vitamin A [20]. The results of the nutrient analysis of Variation 1 and Variation 2 of the hummus are represented in Table 1.

Sweet potato's edible roots, stems, and leaves are rich in nutrients like proteins, fibre, carbohydrates, vitamins, and minerals, along with bioactive compounds such as lutein, carotenoids, and polyphenols. Studies have highlighted its diverse health benefits, including antioxidant, cardioprotective, anti-obesity, anti-diabetic, anti-inflammatory, and anti-cancer properties [21]. Green gram is a good source of carbohydrates, important fatty acids, vitamins, minerals, and fibre, Green gram is high in high-quality proteins that are highly digestible [22]. Several studies have shown that, in comparison to ungerminated seeds, legume sprouts contain lower amounts of non-nutritive components and higher levels of nutrients, including digestible protein, amino acids, accessible carbs, and other substances [23], [24].

Table 1: Micronutrient and macronutrient content of the hummus

Nutrients	Unit	Variation 1	Variation 2
Carbohydrate	g/80g	0.31	0.56
Protein	g/80g	1.84	2.8
Fat	g/80g	7.1	9.09
Dietary fibre	mg/80g	148.8	361.04
Vitamin A	µg/80g	6082.16	5471.04
Vitamin C	mg/80g	6.16	5.93
Iron	g/80g	2.52	3.91

2. Identification of bioactive compounds present in the hummus using GC-MS (Gas Chromatography Mass Spectrometry).

The bioactives identified from the GC-MS analysis in both Variations 1 and 2 possessed either antioxidant, anti-cancer, anti-inflammatory, neuroprotective, cardioprotective, anticholinergic, anti-tumour, anti-psychotic and anti-bacterial properties owing to the presence of these bioactive compounds. The identified compounds belonged to classes such as fatty acid methyl esters, alkanes, lactones, bile acid derivatives, glycosides, triterpenes, and alkaloids. Variations 1 and 2 shared several bioactive compounds, 11-octadecenoic acid, methyl ester, 9,12-octadecadienoic acid (Z,Z)-, methyl ester, and n-hexadecanoic acid were consistently present across both variations, known for their antioxidant, anti-inflammatory, antimicrobial, and cholesterol-lowering properties. Squalene, a natural triterpene with potent antioxidant and skin-protective roles, was also identified. The second variation uniquely featured (+)-Sesamin, a well-known lignan with antioxidant, anti-inflammatory, and lipid-lowering effects, and thymol, recognized for its antimicrobial and antioxidant actions. Additional bioactive constituents like dihydrosarsasapogenin, proscillaridin, and oxybutynin suggest potential therapeutic relevance, including anti-inflammatory and cardiovascular benefits. Compounds such as ethyl oleate, stearic acid, and various methyl or esterified derivatives contribute to the functional lipid matrix and support membrane integrity and

metabolic regulation. Several other trace compounds were detected in both variations, which may further enhance the antioxidant or antimicrobial potential of the samples. The chromatograms for both variations are shown in Figs. 1 and 2.

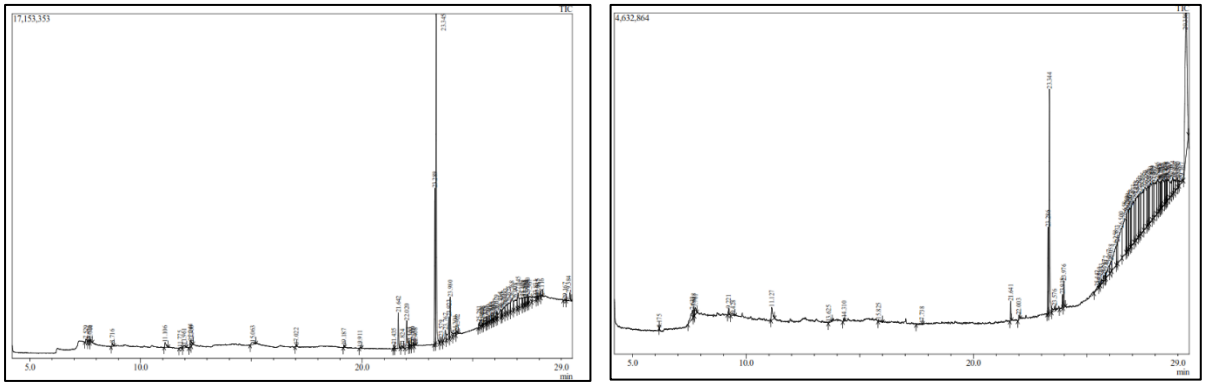

Fig. 1 & 2: GC-MS chromatogram depicting the retention times and intensity in Variations 1 and 2.

From the above GC-MS findings, it is clear that both Variation 1 and Variation 2 contained diverse bioactive compounds with therapeutic potential. Variation 1 was richer in phenolic acids and flavonoids, enhancing its antioxidant and anti-inflammatory properties, while Variation 2 exhibited bioactive compounds linked to antimicrobial and metabolic health benefits. Both variations demonstrated significant functional food potential, with their benefits depending on specific health needs.

3. Quantitative estimation of phytochemicals in the hummus

For the quantification of phytochemicals, Variation 1 exhibited a higher concentration of total phenolic content, ferulic acid, and total antioxidants, indicating its stronger potential for combating oxidative stress and contributing to overall antioxidant activity. These compounds are known for their roles in reducing free radical damage and supporting cellular health. On the other hand, Variation 2 contained a higher level of flavonoids, which are associated with anti-inflammatory, antimicrobial, and metabolic health benefits. The variation in phytochemical composition between the two formulations suggests that each offers distinct functional properties, with Variation 1 being more effective in antioxidant defence and Variation 2 potentially providing broader bioactive benefits. Table 4 presents the quantified phytochemical composition of Variation 1 and Variation 2 of the hummus.

Table 4: Quantification of phytochemicals in the hummus

Phytochemicals	Variation 1 (mg/100ml) (in 10g of the sample)	Variation 2 (mg/100ml) (in 10g of the sample)
Total phenolic content (mg GAE/g)	71.51 ± 0.67	30.27 ± 3.08
Flavonoids (mg QE/g)	4.95± 1.28	8.62 ± 0.57
Ferulic acid content (mg FAE/g)	475.96 ± 11.09	406.12 ± 13.40
Total antioxidants (mg AAE/g)	75.44 ± 0.78	62.36 ± 0.52

4. Antioxidant activity of the hummus using DPPH and FRAP assays

Hummus was tested for antioxidant activity using two separate assays: the DPPH (2,2-diphenyl-1-picrylhydrazyl) Assay and the FRAP (Ferric Reducing Antioxidant Power) Assay. The DPPH Assay measures the hummus's radical scavenging activity, while the Frap Assay measures its ferric reduction capacity. It was observed that both variations showed a dose-dependent increase in radical scavenging activity; that is, as the concentration increased, the radical scavenging activity also increased. Variation 1 recorded a maximum of 36.87 per cent inhibition at 100µl and

Variation 2 recorded 47.64. This observation indicates that, though both variations exhibited radical scavenging ability at this concentration, it was not significant enough to produce even 50 per cent inhibition. The IC50 of Variation 1 is 291.68 and for Variation 2 is 118.66, indicating that higher concentrations of the sample are needed to exhibit 50 per cent radical scavenging activity. Figure 3 illustrates the results of the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay.

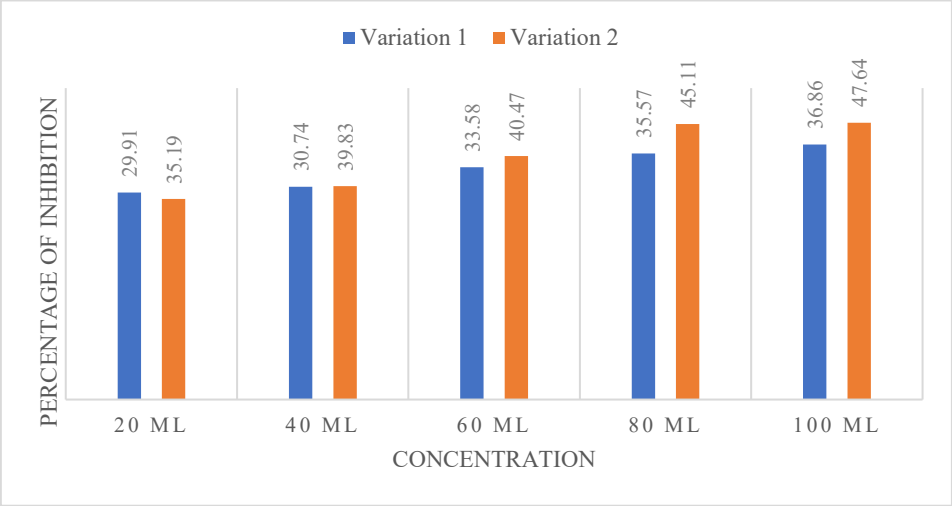

Fig. 3: Radical scavenging activity of the hummus (Variations 1 and 2) – DPPH Assay

For the FRAP assay, both Variations 1 and 2 possess good ferric ion-reducing ability. However, Variation 2 exhibited a higher ability than Variation 1 at all concentrations (20µl to 100µl). Additionally, the IC_{50} value is lower in Variation 2 (10.69 mg) compared to Variation 1 (13.94mg), indicating that a lower concentration of Variation 2 is required to achieve 50 per cent inhibition, thereby demonstrating its greater ferric-reducing ability. This increased antioxidant activity in Variation 2 may be attributed to its higher green gram content, which is known for its rich flavonoid and phenolic acid content. While sweet potato also contributes to antioxidant capacity, the higher proportion of green gram in Variation 2 appears to enhance FRAP activity significantly, making it more effective in scavenging free radicals. Figure 4 illustrates the results of the FRAP assay.

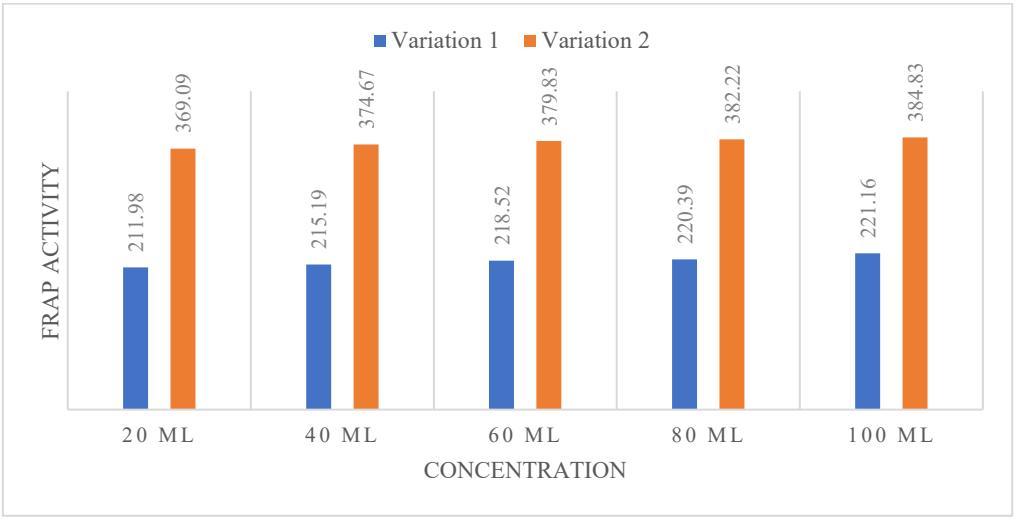

Fig.4: Ferric-reducing activity of the hummus (Variations 1 and 2) - (FRAP) assay

5. Sensory evaluation of the hummus

Five sensory attributes were used to assess the sensory quality of the two variations of hummus. They were appearance, flavour, colour, texture and overall acceptability. A scorecard with a 9-point hedonic rating scale that was used for the evaluation is given in Appendix C. Fifty semi-trained panel members participated in the sensory evaluation. Table 5 represents the results of the sensory evaluation.

Table 5: Sensory evaluation of the hummus (*p < 0.01)

Sensory Parameters	Variation 1 Mean ± Sd	Variation 2 Mean ± Sd	"t" Value	"p" Value
Appearance	8.58 ± 0.49	8.2 ± 0.40	4.1870	0.00006
Flavour	8.32 ± 0.47	7.4 ± 0.49	9.5201	1.33239
Colour	8.38 ± 0.39	8.18 ± 0.0.49	2.2718	0.025
Texture	8.48 ± 0.50	8.2 ± 0.40	3.0625	0.0028
Overall acceptability	8.42 ± 0.49	7.9 ± 0.30	6.3021	0.00008

Sensory analysis revealed that Variation 1 was preferred over Variation 2. The higher sweet potato content in Variation 1 is likely to have contributed to a more appealing texture and flavour, making it the more favoured formulation. Despite Variation 2's higher antioxidant and nutrient content, its sensory attributes were rated lower, indicating that functional benefits do not always correlate with sensory appeal. These results suggest that optimising hummus formulations requires balancing nutritional benefits with sensory appeal to ensure consumer acceptance.

IV. CONCLUSION

The study compared two variations of sweet potato and green gram hummus based on nutritional composition, bioactive compounds, antioxidant activity, and sensory evaluation. Variation 2 had higher protein, dietary fibre, and carbohydrate content, making it nutritionally richer, whereas Variation 1 had greater vitamin A, vitamin C, and total antioxidant content due to its higher sweet potato proportion. GC-MS analysis identified several common bioactive compounds in both variations. However, Variation 1 contained distinct antimicrobial and anti-HIV compounds, while Variation 2 had exclusive anticancer, neuroprotective, and cardioprotective compounds. Additionally, Variation 1 exhibited higher total phenolic and ferulic acid content. In contrast, Variation 2 had a greater concentration of flavonoids enhancing its stronger radical scavenging activity (DPPH assay) as well as ferric-reducing power (FRAP activity). Sensory evaluation favoured Variation 1, indicating that a higher sweet potato content enhanced flavour and texture. Overall, Variation 1 exhibited higher antioxidant potential, greater phenolic and ferulic acid content, and was preferred based on sensory evaluation, while Variation 2 was nutritionally superior, rich in flavonoids and demonstrated stronger radical scavenging and ferric-reducing activity. Sensory analysis showed a preference for Variation 1, likely due to its higher sweet potato content, which enhanced texture and flavour. Although Variation 2 had greater antioxidant and nutrient content, it scored lower in sensory attributes. This highlights the need to balance nutritional benefits with sensory appeal for better consumer acceptance.

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