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Research article

Impact of solvent and supercritical fluid extracts of green tea on physicochemical and sensorial aspects of chicken soup

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Abstract: Designer foods carrying nutraceuticals or polyphenols are in fame to address varied free radical mediated disorders. In this context, green tea extract incorporation in designer products is considered as an effective approach to improve antioxidant capacity owing to epigallocatechin gallate (EGCG). In the current project, EGCG was extracted using solvent (acetone) and supercritical fluid (CO_2) extraction methods. Then, EGCG was quantified in the resultant extracts via high performance liquid chromatography (HPLC) system that showed an upper hand of EGCG in supercritical fluid extract (77.23 mg/g) as compared to acetonic extract (65.88 mg/g) at constant extraction temperature and time. In product development phase, different chicken soup prototypes were prepared such as S_0 (Control soup without green tea extract), S_1 (soup carrying 3% acetonic green tea extract) and S_2 (soup carrying 2.5% supercritical CO_2 green tea extract). The resultant products were then analyzed for physiochemical and sensory aspects during storage intervals; 0, 24, 48, 72 and 96 hr. Storage impacted significantly on some color values like a*, b* and chroma. The statistical analysis demonstrated obvious impact of treatments and storage on total soluble solids (TSS). Further, storage affected significantly on pH and acidity of the resultant samples. Green tea extract carrying products significantly improved TPC; S_1 (46.66 ± 2.39 mg GAE/100mL) and S_2 (49.19 ± 2.36 mg GAE/100mL) in contrast to control treatment (18.19 ± 0.89 mg GAE/100 mL). During storage, significant decline in TPC was noted from 39.43 ± 1.98 to 36.02 ± 1.82 mg GAE/100 mL. Moreover, considerable response of treatments was viewed on taste scores whilst, storage impacted remarkably on flavor, taste, texture and overall-acceptability, excluding organoleptic response regarding color. Conclusively, supercritical fluid green tea extract based designer chicken soup (S_2) has proven its relatively better antioxidants retention, storage stability and sensory profile in comparison to conventional solvent green tea extract based soup (S_1).

Keywords: designer food; chicken soup; epigallocatechin gallate; high pressure liquid chromatography; total polyphenol content; storage study

1. Introduction

Dietary intervention is a novel approach to replenish conventional edibles with numerous nutraceuticals or polyphenols, extracted from plant materials like tea, fruits, vegetables, spices and herbs in order to develop designer foods. Nutraceuticals or polyphenols are capable to arrest uncontrollable free radical mediated oxidation reactions hence addresses the incidences of dyslipidemia, hyperglycemia and related oxidative stress [1–3]. According to an estimate, the nutraceutical market is growing by 2.7%, annually [4]. Further, nutraceuticals have attained the GRAS (generally recognized as safe) status by FDA authorization [1].

Green tea (*Camellia sinensis* L.) belongs to Theaceae family and origin back to China. It comprises of both volatile and non-volatile constituents [5]. Dried green tea leaves contain 30% of polyphenols however, 70% of this phenolic composition is comprised of epigallocatechin gallate, epicatechin gallate, epigallocatechin, epicatechin and gallocatechin [6]. Due to the presence of numerous health boosting components in green tea, it has comparable antioxidant ability as that of vitamin C and E [7,8].

Varied extraction techniques are currently employed to extract polyphenols. Conventionally, solvent extraction procedure was adopted but nowadays innovative techniques like supercritical fluid extraction system is gaining fame especially for optimized extraction [9]. In solvent extraction, different types of solvents are often employed such as acetone, ethanol, ethyl acetate, water, butanol and methanol [10]. Further, the optimal volume of organic solvent and water is regarded as 50:50 however, pure solvent based extractions have previously reported lower yields [11]. On the other hand, supercritical fluid extraction (SFE) is one of the green extraction technologies that ensures ecofriendly extraction procedure and solvent free, non-toxic extract [12,13].

Nowadays, dietary habits are often overlooked due to the lack of consumer awareness. In order to overcome this shortcoming, scientific fraternity has brought numerous polyphenols in the limelight to reduce varied ailments. The objectives of current project were (1) to extract green tea catechins especially EGCG using optimized conventional and supercritical fluid extraction procedures, then (2) the resultant extracts were quantified for epigallocatechin gallate (EGCG) using HPLC system. (3) Based on EGCG content in each of the extract, specified proportions of each extract was incorporated in the chicken soup to develop designer chicken soup. (4) The respective prototypes were then stored under refrigeration conditions and tested for varied physicochemical and sensory characteristics over set storage intervals to analyze the impact of storage on each of the extract based designer product. Briefly, it is hypothesized that different extraction modes for green tea impact on physicochemical and sensory aspects of chicken soup over storage.

2. Materials and methods

2.1. Procurement of raw material and chemicals

The research was conducted in the Functional and Nutraceutical Food Research Section, National Institute of Food Science and Technology, University of Agriculture, Faisalabad. In this study, green tea leaves of Qi-Men variety were obtained from National Tea Research Institute (NTRI), Shinkiari, Mansehra. The reagents and standards were acquired from Merck (Merck KGaA, Darmstadt, Germany) and Sigma-Aldrich (Sigma-Aldrich Tokyo, Japan).

2.2. Preparation of green tea extracts

2.2.1. Conventional solvent extraction (CSE)

The extracts were prepared by treating dried green tea leaves with binary solvent; aqueous acetone (50% v/v) for 50 min at 50 °C [14]. Afterwards, solvent extract was filtered and concentrated using Rotary Evaporator (Eyela, Japan).

2.2.2. Supercritical fluid extraction (SFE)

Supercritical fluid extract of green tea was prepared via supercritical fluid technology (SFT)-150 system using 99.8% pure CO_2 at 50 °C. After the placement of sample in 100 mL extraction vessel, supercritical CO_2 approached to fluid state at increasing pressure to 3000 psi. At this pressure CO_2 gas get converted to fluid state i.e., carrying gas like diffusion property to get diffused into the plant matrix and liquid like solubilizing capacity to solubilize the desired antioxidant i.e., epigallocatechin gallate (EGCG) into it. As EGCG is polar in nature hence it was extracted using supercritical CO_2 in combination with ethanol (as co-solvent). After 50 min, the extract was collected in the vials manually by reducing the set pressure as per the guidelines of [15].

2.3. HPLC quantification of EGCG

Epigallocatechin gallate was quantified through HPLC system, being considered as the major antioxidant moiety in the resultant extracts. For sample preparation, 100 mg of supercritical fluid extract was added in eppendorf vial carrying 900 uL of mobile phase, whereas 500 uL of conventional solvent extract was added in eppendorf vial along with 500 uL of mobile phase. All the replicate samples were subjected to vortex mixing using gyromixer followed by filtration prior to analysis. HPLC system specifications in accordance with method elucidated by [16] consisted of C_{18} column (250 mm × 4.6 mm, 5.0 µm particle size), auto sampler with 10 µL of sample injection, 40 °C column temperature. Mobile phase was consisted of solvent A (acetonitrile/acetic acid/water 6:1:193) and solvent B (acetonitrile/acetic acid/water 60:1:139) however, flow rate was 1 mL/min. For EGCG quantification, UV detector was employed at 280 nm, by comparing retention time of peaks in samples to that of standard.

2.4. Formulation of designer chicken soup prototypes

Conventional and supercritical fluid extracts of green tea were incorporated in the formulation of chicken soup to prepare designer prototypes with higher antioxidant potential that not only improves the oxidative stability of the food while storage but also scavenge free radical hence prevent oxidative stress within the physiological system of the body. The ingredients involved in the making of designer chicken soup were chicken, chicken stock, egg white, carrot, green cabbage, green capsicum, garlic, corn-flour, vinegar, sauces, seasonings and conventional solvent green tea extract or supercritical fluid green tea extract. For ten servings, one teaspoon spoon of garlic paste and 250 grams of chicken julienne strips were sauté in one table spoon of butter until color changes followed by the addition of 1 L of chicken stock and 500 mL of water. Then, bring it to boil along with the addition of vinegar (one table spoon), sauces and seasonings to taste followed by simmering for 10 min. Afterwards, corn-flour water slurry was gradually added to thicken the mixture trailed by the addition of diced and sliced carrot, green cabbage and green capsicum. After cooking for 3 min, three egg whites were incorporated in the mixture along with constant stirring. Lastly, the respective extracts were included in their set doses; S_1 (soup carrying 3% conventional solvent green tea extract) and S_2 (soup carrying 2.5% supercritical fluid green tea extract). For comparison, the proportions of green tea extract were selected on the basis of HPLC analysis of EGCG. However, control soup treatment (S_0) was free from green tea extract.

2.5. Storage study of designer chicken soup prototypes

Chicken soups was evaluated for different physiochemical and sensorial aspect at specific storage intervals; 0, 24, 48, 72 and 96 hr under-refrigeration.

2.5.1. Physicochemical analysis

2.5.1.1. Color

The chicken soup samples were evaluated for color following the protocol of [17]. Purposely, the sample was placed in the plastic cup and light captures the values of L (lightness), a* (−a greenness; +a redness) and b* (−b blueness; +b yellowness) using bench-top colorimeter (CIELAB SPACE, Color Tech-PCM, USA). Further, the color tonality aspects were used to compute chroma and hue angle. After the application of formula for hue angle, the actual range was found; +a & +b = 0–90 (red–yellow), −a & + b = 90–180 (yellow–green), −a & −b = 180–270 (green–blue) and + a & − b = 270–360 (blue–purple).

$$\text{Chroma} = [a^{*2} + b^{*2}]^{1/2}$$

$$\text{Hue angle} = \tan^{-1} (b^*/a^*)$$

2.5.1.2. pH

The resultant prototypes were taken in 50 mL beaker and pH was recorded by pH meter; Ino Lab 720, Germany [18].

2.5.1.3. Total acidity

Total acidity was estimated by titrating the samples against 0.1 N sodium hydroxide till pink color attained [18].

2.5.1.4. Total soluble solids

Total soluble solids of designer chicken soups were determined by employing digital hand refractometer (TAMCO, Model No. 90021, Japan) at set storage intervals and the obtained results were expressed as °Brix [18].

2.5.1.5. Total polyphenols (Folin-Ciocalteu method)

The total polyphenols in prototypes was obtained as per the method of [19]. In this regard, Folin-Ciocalteu reagent was employed to determine the TPCs of the soup samples. Purposely, 50 µL of the sample was mixed with 1.0 mL of Na_2CO_3 (20%) followed by the addition of 50 µL of Folin-Ciocalteu reagent. The mixture was incubated for 40 min at 25 °C. Absorbance was measured at 765 nm using microplate reader (Model No. ELx-800 BioTek, USA). Different concentrations of gallic acid (standard) were used to attain calibration curve. Total phenolic contents were calculated in terms of milligram gallic acid equivalent (GAE)/100mL.

2.5.2. Sensory response

Designer chicken soup samples, carrying green tea extracts, were evaluated using 9-point hedonic scale system; 9 = like extremely; 1 = dislike extremely [20]. The evaluation was carried out in the Sensory Evaluation Laboratory of the NIFSAT, University of Agriculture, Faisalabad, involving students and staff members (n = 15), aging 25–45 years. Various sensory attributes including taste, color, flavor, odor, consistency and overall acceptability of the prepared products were scored. All the three treatments were served hot under soft white light. To remove any biasness, the treatments were presented to the judges in transparent plates coded with random numbers. The judges were requested to express their opinion by assigning scores to each treatment. For effective response, panelists were provided with mineral water and unsalted crackers to neutralize their mouth receptors. The sensorial evaluation was performed at set storage intervals.

2.6. Statistical analysis

The findings of the research plan were subjected to statistical modeling to probe the efficacy of each parameter using statistical software Statistix 8.1. Moreover, Microsoft Excel (version 2013) was employed for handling and summarization of data. Triplicate readings were taken for each test except for sensory response (n = 15). Two-way ANOVA under CRD was performed for two factors; treatment and storage study to determine the level of significance followed by comparison of means as described by [21].

3. Results and discussions

3.1. HPLC quantification of EGCG

HPLC analysis showed better yield of supercritical fluid extract 77.23 mg/g at 3000 psi due to its gas like diffusing properties and liquid like solubilizing power. On the other hand, conventional solvent extraction using acetone showed lower quantification of EGCG (65.88 mg/g) due to the absence of supercritical phase.

Table 1. HPLC quantification for EGCG (mg/g dry matter) in green tea extracts.

Green tea extracts	Concentration of EGCG (mg/g of dry matter)
Acetonic extract	65.88 ± 2.95
Supercritical CO_2 extract	77.23 ± 3.01

These results are in agreement with [22], they analyzed supercritical fluid extract of green tea by HPLC and found EGCG in the range of 82.30 ± 2.82 to 89.66 ± 0.17 mg/g. Further, Park et al. determined EGCG as 63–90 mg/g through supercritical fluid extraction in the presence of ethanol (cosolvent) [23]. Later, Cheng-Chi et al. measured the EGCG as 73.8 mg/g of dry green tea extracted through supercritical carbon dioxide at 2500 psi at 40 ℃ [24]. One of their peers, Ghoreishi and Heidari explored EGCG as 73.31 mg/g, extracted through SFE at 44 ℃ and 2900 psi [25]. In context to conventional solvent extraction, acetonic extract was found more potent to extract green tea catechins than other alcoholic solvents [10, 26–28].

3.2. Physiochemical analysis

3.2.1. Color

Statistical analysis regarding storage impacted significantly on a*, b* and chroma however, non-momentous effect was viewed on hue angle and L* value. Further, the impact of treatments was non-significant on all aspects of color tonality except hue angle. Means regarding L* values indicated S_0 (41.88 ± 2.08) at par with S_2 (41.55 ± 2.13), this is because the supercritical fluid extract of green tea was yellowish in color as the control soup sample already had. However, S_1 (38.86 ± 1.93) was carrying extract with greenish tonality in addition to higher level than supercritical fluid extract hence imparted darker shade. However, slight darkness was observed throughout storage duration from 41.73 ± 2.06 to 39.75 ± 1.97. Considering a* value i.e., an indication of redness to greenish hue from positive to negative signs, it demonstrated non-significant impact as extract was minor as compared to soup quantity. However, higher positive tendency of a* value for S_2 expressed more redness as supercritical fluid extract was dark yellowish to red hue thus showed slight difference than control sample. During storage, red color become lighter either due to degradation of bioactive ingredients in extract on storage or due to interaction between ingredients. The means regarding b* value presented slightly higher values of control and supercritical fluid extract based chicken soup, this was due to yellowish color of supercritical fluid extract almost closer to the color of control prototype. Whilst, b* value in acetonic extract based soup was slightly less due to greenish color of extract. However, storage impacted negatively by obviously suppressing yellowness due to degradation effect of bioactives. Means for chroma values showed non-substantial variation among the treatments from 10.92 ± 0.55 to 11.79 ± 0.56. Whilst, storage study indicated significant decrement in chroma value from 12.11 ± 0.61 to 10.53 ± 0.51. The statistical findings related to hue angle impacted significantly on prototypes; S_0 as 65.50 ± 3.28, S_1 64.01 ± 3.06 and S_2 64.78 ± 3.24, whereas storage effected non-substantially on hue angle from 63.84 ± 3.42 to 64.92 ± 3.28 at initiation and termination of storage period, respectively.

Table 2. Effect of treatments on color tonality of chicken soup prototypes.

Treatments	Color tonality				
	L value	a* value	b* value	Chroma	Hue angle
S_0	41.88 ± 2.08	4.71 ± 0.27	10.33 ± 0.53	11.36 ± 0.53	65.50 ± 3.28^{a}
S_1	38.86 ± 1.93	4.79 ± 0.22	9.82 ± 0.49	10.92 ± 0.55	64.01 ± 3.06^{b}
S_2	41.55 ± 2.13	5.03 ± 0.22	10.66 ± 0.53	11.79 ± 0.59	64.78 ± 3.24^{ab}

Note: Data values represent mean ± SD (*n* = 3); Values containing different alphabets are significant ($p < 0.05$); S_0 (control soup without green tea extract); S_1 (soup carrying 3% acetonic green tea extract); S_2 (soup carrying 2.5% supercritical CO_2 green tea extract).

Table 3. Impact of storage on color tonality of chicken soup prototypes.

Parameters	Storage intervals (Hours)				
	0	24	48	72	96
L value	41.73 ± 2.06	41.24 ± 2.04	40.76 ± 2.01	40.34 ± 2.02	39.75 ± 1.97
a* value	5.34 ± 0.26^{a}	4.98 ± 0.24^{ab}	4.84 ± 0.23^{bc}	4.60 ± 0.21^{bc}	4.46 ± 0.18^{b}
b* value	10.87 ± 0.53^{a}	10.60 ± 0.51^{a}	10.33 ± 0.48^{ab}	10.00 ± 0.46^{ab}	9.54 ± 0.45^{b}
Chroma	12.11 ± 0.61^{a}	11.71 ± 0.57^{ab}	11.41 ± 0.56^{abc}	11.00 ± 0.54^{bc}	10.53 ± 0.51^{c}
Hue angle	63.84 ± 3.42	64.85 ± 3.39	64.90 ± 3.41	65.31 ± 3.35	64.92 ± 3.28

Note: Data values represent mean ± SD (*n* = 3); Values containing different alphabets are significant ($p < 0.05$).

The current study is in accordance with previous analysis of green tea extract enriched food products. Previously, a color analysis of chicken treated with green tea extract was studied. Storage study (up to 12 days) regarding green tea treated cooked meat showed L*, a* & b* values ranging from 52.5 to 56.2, 1.1 to 5.2 and 1.5 to 5.4 with hue angle from 68 to 72, respectively [29]. Moreover, Bañón et al. measured the effect of L*, chroma and hue angle on green tea extract treated beef patties that resulted in increased L* value from 43.3 to 45.4, 45.3 & 47.4 where, chroma values changed from 20.1 to 21.2, 17.6 & 14.9 and hue angle from 18, 22, 24.3 & 30.6 after a storage duration of 0 (control), 3, 6 & 9 days. The results hypothesized an increase in lightness and hue angle (red–yellow) with decreased chromaticity or saturation [30].

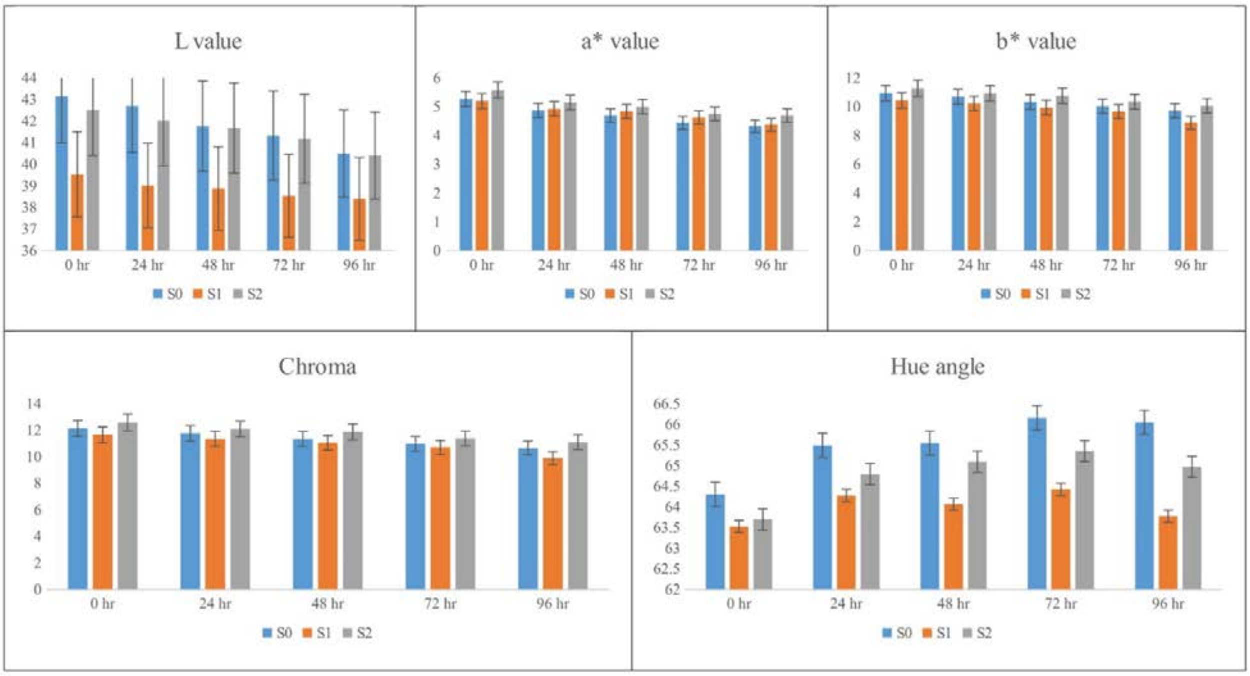

Figure 1. Interaction effect of treatments and storage intervals on color tonality of chicken soup prototypes.

3.2.2. pH, acidity, TSS and TPC

The statistical analysis showed significant effect of treatments on TSS and TPC (total polyphenol content) while non-substantial impact of samples was noted on pH and acidity. However, storage affected significantly on pH, acidity, TSS and TPC. Over storage, means showed significant decrease in pH from 6.15 ± 0.26 to 5.18 ± 0.24 hence increase in acidity from 0.28 ± 0.015 to 0.34 ± 0.015. Regarding TSS, S_2 presented maximum value (23.43 ± 1.23 ºbrix) followed by S_1 (22.75 ± 1.24 ºbrix) and S_0 (21.10 ± 1.05), whereas obvious decrement was noted over storage from 23.79 ± 1.22 to 21.13 ± 1.13 ºbrix. Mean squares for TPC portrayed significant improvement in green tea extract carrying products; S_1 (46.66 ± 2.39 mg GAE/100 mL) and S_2 (49.19 ± 2.36 mg GAE/100 mL) as compared to control sample (18.19 ± 0.89 mg GAE/100 mL). Further, significant decline in TPC was recorded throughout storage period from 39.43 ± 1.98 to 36.02 ± 1.82 mg GAE/100 mL.

Table 4. Effect of treatments on physicochemical attributes of chicken soup prototypes.

Treatments	Physicochemical attributes			
	pH	Acidity	TSS (ºB)	TPC (mg GAE/100mL)
S_0	5.66 ± 0.27	0.30 ± 0.013	21.10 ± 1.05^b	18.19 ± 0.89^c
S_1	5.68 ± 0.27	0.31 ± 0.016	22.75 ± 1.24^a	46.66 ± 2.39^b
S_2	5.60 ± 0.26	0.32 ± 0.016	23.43 ± 1.23^a	49.19 ± 2.36^a

Note: Data values represent mean ± SD (n = 3); Values containing different alphabets are significant ($p < 0.05$); S_0 (control soup without green tea extract); S_1 (soup carrying 3% acetonic green tea extract); S_2 (soup carrying 2.5% supercritical CO_2 green tea extract); TPC (Total Phenolic Content); TSS (Total Soluble Solid).

Table 5. Impact of storage on physicochemical attributes of chicken soup prototypes.

Parameters	Storage intervals (Hours)				
	0	24	48	72	96
pH	6.15 ± 0.26^{a}	5.95 ± 0.24^{a}	5.58 ± 0.27^{ab}	5.37 ± 0.25^{b}	5.18 ± 0.24^{b}
Acidity	0.28 ± 0.015^{d}	0.29 ± 0.014^{cd}	0.31 ± 0.014^{bc}	0.33 ± 0.016^{ab}	0.34 ± 0.015^{a}
TSS (°B)	23.79 ± 1.22^{a}	23.06 ± 1.19^{ab}	22.34 ± 1.15^{abc}	21.81 ± 1.12^{bc}	21.13 ± 1.13^{c}
TPC (mg GAE/100mL)	39.43 ± 1.98^{a}	38.95 ± 1.93^{a}	38.20 ± 1.89^{a}	37.47 ± 1.84^{ab}	36.02 ± 1.82^{b}

Note: Data values represent mean ± SD ($n = 3$); Values containing different alphabets are significant ($p < 0.05$); TPC (Total Phenolic Content); TSS (Total Soluble Solid).

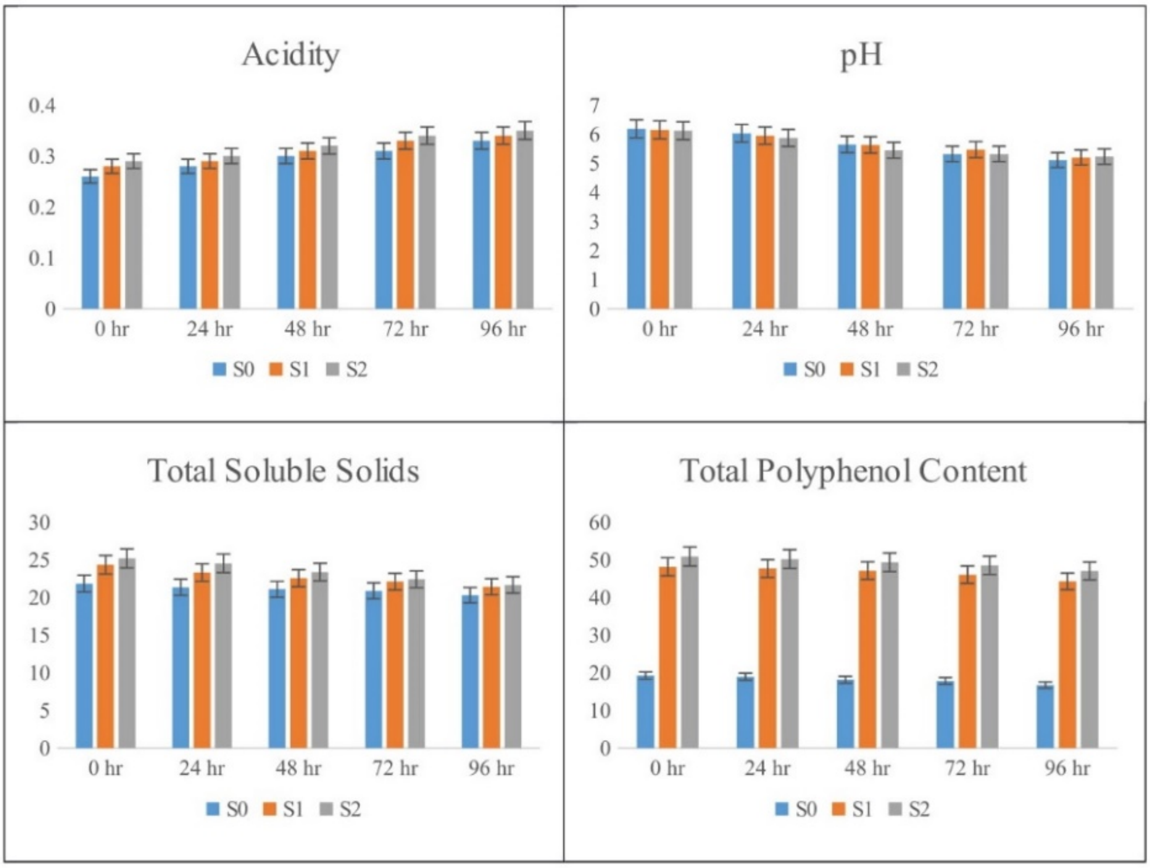

Figure 2. Interaction effect of treatments and storage intervals on physicochemical attributes of chicken soup prototypes.

Previously, [31] determined that increase in proportion of green tea extract have been found to decrease in pH during storage ultimately protects from browning reactions. Later, [29] determined the pH of chicken to be approximately 6.0 that was not affected significantly with the inclusion of different plant extracts including green tea extract and grape seed extract. Considering total polyphenols, EGCG and other catechins are considered more stable in acidic environment. Moreover, temperature even above 85 ℃ is regarded as safe for green tea catechins, considering time factor [32]. One of their peers, Wu et al. observed the total phenolic contents of 27 commercial drinks involving 10 varieties of green and oolong tea and 7 varieties of black tea. They found maximum phenolic contents in green tea based commercial drink, ranging from 345 ± 60 to 596 ± 85 μg/mL followed by oolong tea (from 233 ± 6 to 480 ± 17 μg/mL) and black tea (from 130 ± 0.2 to 323 ± 13 μg/mL) [33].

3.3. Sensory response

Mean squares regarding sensory perspectives of chicken soup explicated non-significant effects of treatments on color, flavor, texture and overall-acceptability except on taste. However, storage impacted momentously on flavor, taste, texture and overall-acceptability excluding color. Means regarding color of green tea chicken soup showed marginally non-significant impact of treatments on color rating from 6.90 ± 0.32 to 7.25 ± 0.37, whereas storage impacted slightly on color from 7.43 ± 0.37 (0 hr) to 6.71 ± 0.29 (96 hr). The treatments affected on flavor score of green tea chicken soup to a minor extent, varying from 7.01 ± 0.30 to 7.29 ± 0.28. On the other hand, storage imparted momentous decline in flavor score from initiation (7.35 ± 0.35) to termination (6.77 ± 0.27) of study. The highest score for taste of green tea chicken soup were allotted to S_2 (7.14 ± 0.31) followed by S_0 (7.08 ± 0.36) and S_1 (6.97 ± 0.32), whereas taste score reduced significantly from 7.37 ± 0.36 to 6.70 ± 0.31 at 0 & 96 hr, respectively. Different treatments affected non-significantly on texture of green tea chicken soup however, storage led to momentous decline in texture from 7.46 ± 0.35 to 6.67 ± 0.28. The effect of treatments on overall acceptability of green tea chicken soup was non-momentous though, storage showed a momentous decline in overall acceptability from 7.45 ± 0.35 to 6.73 ± 0.26 over the storage period.

Table 6. Effect of treatments on sensory aspects of chicken soup prototypes.

Treatments	Sensory aspects				
	Color	Flavor	Taste	Texture	Overall-acceptability
S_0	7.25 ± 0.37	7.01 ± 0.30	7.08 ± 0.36^a	7.17 ± 0.32	7.00 ± 0.32
S_1	6.90 ± 0.32	7.17 ± 0.30	6.97 ± 0.32^b	7.16 ± 0.32	7.17 ± 0.33
S_2	7.09 ± 0.28	7.29 ± 0.28	7.14 ± 0.31^a	7.09 ± 0.31	7.29 ± 0.32

Note: Data values represent mean±SD (n = 3); Values containing different alphabets are significant ($p < 0.05$); S_0 (control soup without green tea extract); S_1 (soup carrying 3% acetonic green tea extract); S_2 (soup carrying 2.5% supercritical CO_2 green tea extract).

Table 7. Impact of storage on sensory aspects of chicken soup prototypes.

Parameters	Storage intervals (Hours)				
	0	24	48	72	96
Color	7.43 ± 0.37	7.31 ± 0.36	7.08 ± 0.34	6.87 ± 0.28	6.71 ± 0.29
Flavor	7.35 ± 0.35^a	7.24 ± 0.33^a	7.16 ± 0.32^a	6.99 ± 0.28^{ab}	6.77 ± 0.27^b
Taste	7.37 ± 0.36^a	7.25 ± 0.33^a	7.11 ± 0.34^a	6.89 ± 0.32^{ab}	6.70 ± 0.31^b
Texture	7.46 ± 0.35^a	7.31 ± 0.32^a	7.23 ± 0.34^a	7.04 ± 0.30^{ab}	6.67 ± 0.28^b
Overall-acceptability	7.45 ± 0.35^a	7.34 ± 0.33^a	7.27 ± 0.32^a	6.98 ± 0.28^{ab}	6.73 ± 0.26^b

Note: Data values represent mean ± SD (n = 3); Values containing different alphabets are significant ($p < 0.05$).

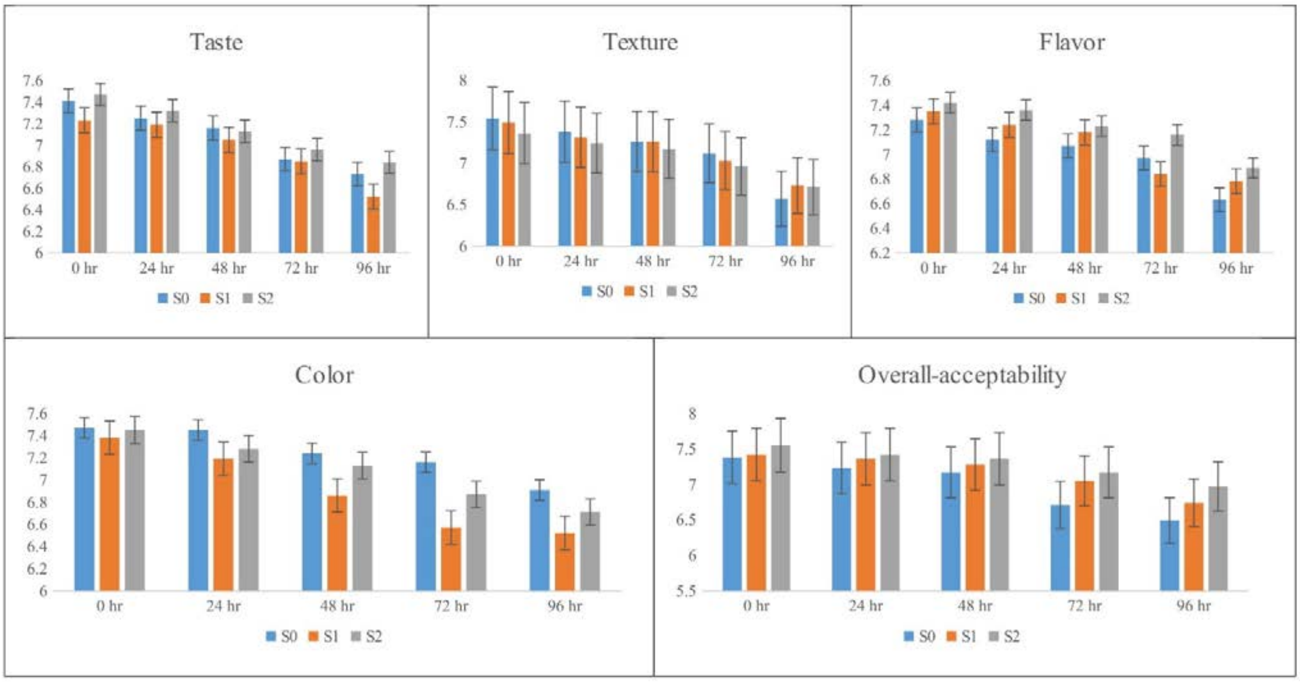

Figure 3. Interaction effect of treatments and storage intervals on sensory aspects of chicken soup prototypes.

The previous studies demonstrated mixed responses varying on product type and consumer preference. Earlier, Bañón et al. found improvement in tenderness and color of green tea extract based beef patties without producing any discoloration or off-flavor [30]. One of their peers found poor acceptability of green tea extract based candies [34]. Further, scientists presented positive role of green tea extract on UHT treated milk that control Maillard browning reaction hence enhances sensorial characteristics of the product [35]. Additionally, earlier researches reported effectiveness of green tea catechins in controlling acrylamide formation during frying of bread sticks. They further reported that sensory scoring of green tea treated bread sticks was better in terms of flavor and crispiness however, the impact of treatment was non-significant on sensory aspects [36].

4. Conclusions

Designer chicken soup enriched with supercritical fluid green tea extract has proven significantly higher polyphenolic content. Other perspectives were slightly affected by treatments excluding total soluble solids, hue angle of color and taste. On the other hand, storage imparted significant impact on physicochemical and sensorial characteristics of chicken soup. In the nutshell, supercritical fluid green tea extract based soup has shown an upper hand over conventional solvent green tea extract based counterpart however, effect of both extracts was minor except on polyphenol content and taste. Thus, green tea extract based designer chicken soup prototypes remain stable for 96 hr under refrigeration storage alongside, these are the best means to attain high phenolic content. Thus, it could be deduced that these designer soup prototypes have the ability to improve endogenous antioxidants in order to fight against free radical mediated oxidative stress.

Conflict of interest

The authors declare no conflict of interest.

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