International Journal of Food Science and Nutrition
www.foodsciencejournal.com
E-ISSN: 2455-4898
Received: 02-10-2026, Accepted: 01-11-2026, Published: 16-11-2026
Volume 11, Issue 4, 2026, Page No. 171-175

Development and quality evaluation of the vegetable powder-based bouillon cubes: A comparative study with conventional flavoured products

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DOI: https://doi.org/10.66856/ijfsn.2026.11.4.11151

Abstract
Bouillon cubes are widely used as convenient flavour enhancers in household cooking. However, most commercial products contain high levels of salt and hydrogenated fats, raising concerns among health-conscious consumers. This study aimed to develop a novel vegetable powder-based bouillon cube using natural ingredients as a healthier alternative to conventional products. Tomato, pumpkin and mushroom powders were incorporated into four formulations, along with *Neolitsea cassia* leaf extract as the natural binder. The dispersibility, moisture content and antioxidant capacity were evaluated against a commercially available bouillon cube to identify the optimum formulation. Sensory evaluation was conducted for both the cubes and their application in soup and noodle dishes. The results demonstrated that ingredient composition and particle size distribution significantly influenced dispersion characteristics. The formulation containing the highest proportion of tomato powder and the lowest proportion of pumpkin powder exhibited the shortest dissolution time in hot water (31.67 ± 1.53 s). Although the novel cubes recorded higher moisture contents than the commercial counterpart due to the use of fresh vegetable-derived ingredients, this contributed positively to flavour quality of the dish. Among the formulations, the cube containing the highest levels of tomato and mushroom powders exhibited the strongest antioxidant activity, achieving ABTS and DPPH radical scavenging activities of 90.96 ± 1.18% and 44.43 ± 0.57%, respectively. Sensory evaluation revealed no significant differences between the developed and commercial cubes, while dishes prepared using the novel cube received higher consumer preference ratings. Overall, the study demonstrates the potential of vegetable powder-based bouillon cubes as a nutritious, antioxidant-rich and consumer-acceptable alternative to conventional products.

Keywords: Bouillon cube, vegetable powder, natural binder, antioxidant activity, health-conscious

Introduction
Over the past few decades, with the general improvement in living conditions of people, the consumer preferences related to food habits have changed significantly. Consumers seek out food products with a combination of functional or nutritious elements such as dietary fiber, protein, micro-nutrients or substances with strong antioxidant action, along with an eye-catching appearance and appealing flavours [1]. Functional food like fresh fruits and vegetables (F&V), together with the bio-active substances they contain, have the potential to contribute to the global development of healthy communities [2]. Consumption of food prepared using F&V can strengthen the body's innate and adaptive immune systems in place of eating fast food that are high in saturated fats and harmful cholesterol [3]. On the other hand, with the rising cases of malnutrition and micro nutrient deficiencies among women and children in many developing countries, fortification of popular food items with micro nutrients and functional ingredients can tackle the issue up to a certain extent [4].
Regarding food wastage, F&V make up to around 42% of all commodities consumed worldwide [5]. Value-added product development is one of the promising techniques that can be practiced to minimize these losses during post harvest stage. Value addition is a marketing approach motivated by the requirements and inclinations of the consumer, in making a food commodity more desirable to consumers while increasing its economic value [6]. Therefore, finding ways to process F&V effectively to create products that are more affordable, sustainable and environmentally beneficial are urgently needed [5]. At present, the consumption of dried F&V powders has become very popular in the food sector due to various applications such as natural colourant, flavouring agents and as functional food additives to enhance the nutritional profile of food [7].
Bouillon cube, also known as stock cube or spice cube is an instant food product that is typically used as a ready to eat taste enhancer in both western and non-western cooking, mainly in soups, curries, sauce, rice and many other culinary dishes. Generally, they are composed of kitchen salt (40-70%), spices, sugar, herbs, flavours and yeast extract with hydrogenated fats as binders [8]. At present, bouillon cubes have become a culinary culture in many parts of the world including Asia. The major issue in the use of conventional cubes available in the market is the addition of significantly high concentrations of salts and hydrogenated fats, added as flavour enhancers and preservatives. The use of hydrogenated fats as a cube binder and monosodium glutamate as a taste enhancer leads to many health risks associated with regular consumption [8]. Also, synthetic flavour compounds like monosodium glutamate are not recommended for consumption by children [9]. Therefore, use of alternative natural functional ingredients with no health risks will be an ideal approach to win the attraction of health-conscious consumers.

The aim of this study was to develop a bouillon cube using dried vegetable powders, with a focus on meeting consumer preferences for healthy food. Incorporating health-promoting alternative plant binders in cube production along with the development of umami taste by using natural ingredients is the novel approach of the research, by which the health dangers posed by the synthetic commercial products are avoided.

Methodology

Preparation of raw materials: Ripe tomato (*Solanum lycopersicum* L) and American oyster mushrooms were procured from a local farmer. After a preliminary cleaning process, tomatoes and mushrooms were sliced into uniform thin slices and subjected to dehydration in a heat pump dryer (WKD6070W, China). Dried specimens were ground to a fine powder, with an emphasis on particles no larger than 210 micrometers using a domestic mixer grinder and standard sieves. Similarly, pumpkin (*Cucurbita* spp.) of fully matured stage were purchased from local markets. Pumpkins were well washed using tap water to remove impurities and then cut into halves to remove the peel, seeds and fibrous strands. Then the halves were cut into thin uniform slices (2 cm×2 cm) and subjected to steam blanching (at 100 °C for 4 minutes) followed by overnight drying at 45 °C using a forced convection oven (LDO-150F, Indonesia). The dried sample was powdered to particles no larger than 210 micrometers. For further enhancement of the flavour, leeks, carrot, garlic and onion were dried overnight at 50 °C using a forced convection oven (LDO-150F, Indonesia). Before dehydration, carrots were cut into shreds while leeks were cut into quite large pieces to avoid dissolving, followed by steam blanching at 100 °C for 4 minutes and 3 minutes respectively. All prepared vegetable powders and flakes were stored in hermetically sealed polypropylene containers at 4 °C temperature until further used for the product development.

Neolitsea cassia leaf extract was used as the natural binding agent of the bouillon cubes. Leaves were fragmented into small pieces and blended with a modest quantity of water. Plant extract was obtained by filtering the blended product through a cotton cloth while applying a slight pressure [10].

Preparation of the bouillon cubes: Cube formulation using tomato, pumpkin and mushroom powder was carried out following predefined ratios established using Taguchi Orthogonal Array design L4 (2^3), which includes 3 factors at 2 levels of concentration.

Table 1: Blending ratios of tomato, mushroom and pumpkin powder in preparation of bouillon cubes

	Tomato	Mushroom	Pumpkin
Ratio 1 (R1)	1	1	1
Ratio 2 (R2)	1	2	2
Ratio 3 (R3)	2	1	2
Ratio 4 (R4)	2	2	1

Numbers stand for the ratios in blending the vegetable powders. Value 1 represents 5g and value 2 represents 10g of respective vegetable powder.

All four combinations of cubes contained the same amount of the remaining ingredients, corresponding to the typical composition of the bouillon cubes available in the market. Preparation of the bouillon cubes was done following a procedure outlined in literature with a few minor modifications [9]. Initially, the correct proportions of all dry ingredients were mixed with the binding agent, *Neolitsea cassia* leaf extract. The resultant wet mixture was evened out using an electronic homogenizer (FJ300-SH, China), followed by cooking in a nonstick pan for 15 minutes over a low flame while being continuously mixed until obtaining the desired state of dryness. The hot mixture was spread evenly on a tray lined with parchment paper and subsequently stored in the freezer for 10 to 12 hours to achieve the desired consistency of bouillon cubes. Finally, the solid composite was divided into uniform cubes of 10g (2cm×2cm×1cm), and each single cube was encased in aluminum foil and later stored in hermetically sealed containers, keeping them refrigerated at 4 °C until used for further analysis.

Dispersibility of the bouillon cubes: Visual observation of the time required for the cube particles to get completely dispersed in boiling water was tested [8]. One cube was added to a beaker with 300 mL of boiling water and stirred continuously (100 rpm) using a magnetic stirrer until complete dispersion of the cube, measuring the time taken in seconds. The dispersibility parameter of the commercial soup cube was measured following the same procedure.

Moisture content: The moisture content of the bouillon cubes was determined using AOAC 2019 International standard method.

***In vitro* Antioxidant analysis of the bouillon cubes:** Initially, ethanolic extracts of bouillon cube samples were prepared [8]. First, the cubes were dried at 40 °C for 24 hours and well grounded. Then, 10 g of powdered samples of each cube were extracted using 100 ml of absolute ethanol at room temperature, shaking in an orbital shaker for 4 hours followed by centrifugation at 1000 rpm for 1 hour. The supernatants were stored at -20 °C until further analysis. DPPH (2, 2-diphenyl-1-picrylhydrazyl) reducing activity was assessed of the prepared sample [11]. An equal volume of each cube extract (100 µl) was mixed with 1 ml of ethanolic DPPH while the blank solution was prepared by mixing 100 µL absolute ethanol with 1 mL DPPH. After 30 minutes of incubation in the dark, the absorbance of the samples was measured at 517 nm, using a spectrophotometer. The antioxidant activity of a commercially available bouillon cube was also measured for better comparison.

The 2,2-azinobis (3-ethylbenzthiazoline-6-sulfunic acid) radical (ABTS) scavenging activity too was done determine the antioxidants [12]. Firstly, ABTS stock solution was prepared by reacting equal quantities of aqueous solutions of 7 mM ABTS with 2.45 mM potassium persulfate and stored in the dark at room temperature for 16 hours allowing the generation of ABTS free radicals. Freshly prepared ABTS stock solution was diluted using methanol to absorption of 0.700 ± 0.050 at 734 nm. Next, 2 mL of the diluted ABTS solution was mixed with 100 µl of the extract of each bouillon cube, allowing the mixture to incubate at room temperature in the dark for exactly 6 minutes. The absorbance of the samples was measured at 734 nm using a spectrophotometer (Model GIOS UV-Vis) using 2 mL DPPH in 100 µl absolute ethanol as the control.

A similar procedure was followed and triplicated for each cube extract. Free radical scavenging activity of a known

concentration of the bouillon cubes under each assay was calculated as the percentage inhibition of the free radicals (DPPH and ABTS) using the equation given below, where $A_{control}$ is the absorbance of the control and A_{sample} is the absorbance of the cube extracts.

Radical scavenging activity (%) = **{(**$A_{control}$ - A_{sample}) / $A_{control}$} x 100

Sensory evaluation: Sensory evaluation was carried out only for the best bouillon cube selected out of the four combinations (R1, R2, R3 and R4) tested above. A commercial bouillon cube was used for the comparison. A bouillon cube, a broth, and a noodle prepared adding the bouillon cubes were tested with a semi-trained panel of 30 panelists. Broth was prepared by dissolving one cube (10 g) in 500 mL of boiling water. Before serving, the broth was allowed to cool down to 40 °C. In preparing noodles, a plain instant noodle (70 g) was cooked in boiling water for 10 minutes, and removed the excess water, followed by mixing with one cube (10 g) to add flavour. Sensory analysis was conducted in terms of colour, aroma, texture, appearance, flavour and aftertaste, using a 9 points hedonic scale.

The shelf life of the best bouillon cube was assessed under two different storage conditions, namely, ambient storage (28 ± 3 °C) and refrigerated storage (4 °C). Ten cubes (10 g each) were stored at ambient conditions in hermetically sealed containers and assessed for sensory properties once a week over 3 months. Similarly, ten cubes were stored at refrigerated conditions and tested once a month over 6 months.

Statistical analysis: All data were statistically assessed using IBM SPSS Statistics 21 software and Microsoft Excel version 2016. Mean ± standard deviation values of triplicated results under each experiment were used to calculate the significant difference and were analyzed by One-Way ANOVA mean comparison with the control at a confidence level of $P < 0.05$.

Results and Discussion

The dispersibility of the bouillon cubes, moisture content and antioxidant analysis were carried out compared to the commercial bouillon cube, to identify the optimum ratio out of the four combinations. The dispersion time of the commercial bouillon cube in hot water was significantly lower (28.33±0.58s) than the developed cubes (Table 2). This is due to the addition of additives which facilitates the quicker dissolution aid in breaking the cube when added to hot liquids [13]. Particle size and the uniformity of the composition of the ingredients influenced the high dispersion time of novel bouillon cubes. Among the novel cubes, R4 with a high portion of tomato and a low in pumpkin demonstrated the lowest time to dissolve completely in hot water (31.67±1.53s). Tomato powder contains more water-soluble compounds which aid in dissolving well in water readily dissolving the flavour and colour [14]. Comparatively, mushrooms and pumpkins contain more insoluble fiber resulting sedimentation or non-dissolved particles, even though the powders are finely ground [15].

The moisture content of a bouillon cube is one of the most important parameters which guarantee its shelf life and ensure the best quality including flavour and stability [16]. The moisture content of the commercial bouillon cubes was significantly lower (2.28±0.01%) than the developed cubes (Table 2). Due to the fresh ingredients used in processing, novel cubes reported a high moisture content that can adversely impact extended shelf life, but the extra moisture promoted the fresh flavour and healthier product, which was the ultimate objective of this phase of the research. The lowest moisture content among the developed cubes was R1 (7.08±0.19%) which contains equal composition of all three ingredients while high moisture retention was reported when increasing the proportion of pumpkin and/or mushroom [15].

As illustrated in Table 3, the antioxidant analysis results notably indicated that the bouillon cubes with high tomato proportion inhibited the free radical generation at an advanced rate than the others. Antioxidants are abundant in tomatoes by nature such as lycopene and vitamin C, and they become concentrated when the fruit is dried to form powder [17]. Ratio 4 with the highest tomato and mushroom powder content was the most effective radical scavenger with significantly high RSA% values for both ABTS (90.96±1.18%) and DPPH (44.43±0.57%) assays, following the R3 and R1, respectively. Comparatively lower radical scavenging activity of 80.19±0.4% (ABTS) and 18.20±0.96% (DPPH) was reported in the commercial cube. Commercial bouillon cubes may not be significant sources of antioxidants as their primary aim is to provide flavor and seasoning to dishes. Hence, the incorporation of fresh vegetable powder is a real value addition in bouillon cube production.

According to sensory evaluation (Table 4), the highest sensory profile was reported by the commercial bouillon cube, however, there was no significant difference identified between the commercial product and the novel product. But once the cube was added in a soup and a noodle dish, a notable preference for the sensory profile of the developed novel cube was reported against the commercial product. Except for the aroma, significantly higher rank values were given by the panelists for colour, flavour, after taste and the appearance of the soup and noodles prepared using the alternative novel cube. In terms of soup, aftertaste and colour were the most popular attributes of the developed novel cube while in noodles, colour and appearance were the most popular attributes which boosted the overall acceptance against the commercial cube.

Overall, the sensory profile was reduced over storage time. The rate of change of mean rank values of the sensory attributes was slower in the samples stored at refrigerated temperature in comparison to the samples stored in ambient conditions. The oxidation processes that can deteriorate the flavours, colours, and fragrances of the bouillon cube are slowed down by the low temperature maintained at refrigeration storage [18]. Ambient conditions, especially in the presence of oxygen and light, can accelerate oxidation processes, leading to faster deterioration of sensory attributes. During ambient storage, significant changes in colour, aroma, texture, appearance and overall acceptance were reported on day 28, Received: 02-10-2026, Accepted: 01-11-2026, Published: 16-11-2026 28, day 21, day 21 and day 21 respectively.

R1	R2	R3	R4
			
1:1:1	1:2:2	2:1:2	2:2:1

Fig 1: Bouillon cubes prepared using different combinations of vegetable powder. The ratios given are of tomato: mushroom: and pumpkin respectively.

Table 2: The dispersibility and the moisture content of the novel and commercial bouillon cubes

Bouillon cube (10g)	Dispersibility (in seconds)	Moisture content %
R1	35.00 ± 1.00^{c}	7.08 ± 0.19^{c}
R2	46.33 ± 1.53^{a}	8.84 ± 0.35^{b}
R3	41.33 ± 1.15^{b}	9.83 ± 0.35^{a}
R4	31.67 ± 1.53^{d}	7.70 ± 0.17^{c}
Commercial Cube	28.33 ± 0.58^{e}	2.28 ± 0.01^{d}

Values that do not share a letter within a column are significantly different ($p<0.05$). Bouillon cube ratios R1 is 1:1:1, R2 is 1:2:2, R3 is 2:1:2 and R4 is 2:2:1 of tomato: mushroom: and pumpkin respectively.

Table 3: ABTS and DPPH Radical Scavenging Activity % of novel and commercial bouillon cubes.

Bouillon cube (100 µL cube extract)	ABTS Radical Scavenging Activity %	DPPH Radical Scavenging Activity %
R1	88.56 ± 0.45^{b}	19.86 ± 0.57^{c}
R2	66.74 ± 0.71^{d}	13.79 ± 0.46^{d}
R3	87.40 ± 0.32^{b}	26.71 ± 0.90^{b}
R4	90.96 ± 1.18^{a}	44.43 ± 0.57^{a}
Commercial Cube	80.19 ± 0.45^{c}	18.20 ± 0.96^{c}

Values that do not share a letter within a column are significantly different ($p<0.05$). Bouillon cube ratios R1 is 1:1:1, R2 is 1:2:2, R3 is 2:1:2 and R4 is 2:2:1 of tomato: mushroom: and pumpkin respectively.

Table 4: Mean rank values of the sensory attributes measured for commercial and developed novel bouillon cubes and flavoured soup and noodles prepared using the same bouillon cubes.

Sensory attribute	Commercial product			Developed Novel product		
	Cube	Soup	Noodles	Cube	Soup	Noodles
Colour	7.43 ± 1.0^{a}	6.67 ± 1.4^{c}	6.73 ± 0.9^{e}	7.23 ± 0.7^{a}	7.83 ± 0.8^{b}	8.03 ± 0.8^{d}
Aroma	7.23 ± 1.4^{a}	6.87 ± 1.3^{b}	7.10 ± 0.9^{d}	6.93 ± 0.9^{a}	7.43 ± 1.0^{b}	7.50 ± 0.6^{d}
Appearance	7.53 ± 0.9^{a}	6.67 ± 1.1^{c}	6.60 ± 1.1^{e}	7.10 ± 0.9^{a}	7.60 ± 0.9^{b}	7.90 ± 1.0^{d}
Texture	7.17 ± 1.2^{a}	NA	NA	6.73 ± 1.0^{a}	NA	NA
Flavour	NA	7.20 ± 1.3^{c}	7.00 ± 1.1^{e}	NA	7.83 ± 0.9^{b}	7.70 ± 1.1^{d}
After Taste	NA	7.20 ± 1.4^{c}	6.93 ± 1.0^{e}	NA	7.90 ± 0.9^{b}	7.77 ± 0.9^{d}
Overall acceptance	7.33 ± 1.0^{a}	7.17 ± 0.9^{c}	7.13 ± 0.8^{e}	7.07 ± 0.8^{a}	8.03 ± 0.9^{b}	7.93 ± 0.7^{d}

Values that do not share a letter within a row for similar products are significantly different ($p<0.05$).

Conclusion

By creating bouillon cubes from dried vegetable powders and plant binders, the study tapped into the growing market of health-conscious consumers. These value-added products showed promising results in sensory evaluations and demonstrated significant antioxidant activities. The findings support the potential for scaling up these solutions to enhance the shelf life and marketability of fresh agricultural commodities and thereby improve the socio-economic value for farmers and distributors in developing countries.

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