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Quality evaluation of flavored paneer tikka prepared with different spice blends

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Abstract
Among seasoned dairy professionals in the United Kingdom, paneer tikka occupies a curious niche wildly popular as a restaurant starter yet rarely produced as a retail-ready product with consistent quality standards. This research evaluated three spice blends Blend A (traditional North Indian: cumin, coriander, red chilli, garam masala), Blend B (tandoori-style: paprika, fenugreek, amchur, Kashmiri chilli), and Blend C (fusion: smoked paprika, garlic granules, sumac, za'atar) applied to laboratory-prepared paneer cubes and grilled under standardised conditions. A control group received no spice treatment. Physicochemical parameters (pH, moisture, protein, fat, titratable acidity), sensory attributes (9-point hedonic scale, n=30 trained panellists), and microbiological safety (TPC, coliforms, yeast and mould) were assessed on days 0, 3, and 6 of refrigerated storage at 4 °C. Blend C scored highest for overall acceptability (8.3/9.0), followed by Blend A (7.9) and Blend B (7.7), all significantly above the control (6.9, $p<0.01$). Protein content ranged from 18.4% to 19.2% with no significant differences across blends. TPC remained within UK Food Standards Agency limits through day 6 for all treatments. Blend C, combining Middle Eastern aromatics with the Indian paneer base, represents a promising formulation for the multicultural UK retail market.

Keywords: Flavored paneer, tikka, spice blends, dairy product quality, sensory evaluation, value addition, physicochemical analysis, food safety, fusion cuisine, shelf life

Introduction
Few dairy products have crossed cultural boundaries as successfully as paneer. What began as a staple of North Indian cuisine now appears in supermarket chilled aisles from Cardiff to Edinburgh, driven by a UK South Asian food market valued at £4.8 billion in 2023 [1]. Yet most retail paneer is sold plain, leaving the flavouring and the associated quality variability to the end consumer. A pre-seasoned, grill-ready paneer tikka product could capture a share of the £1.2 billion convenience meal market if it meets British expectations for food safety, shelf stability, and sensory appeal [2].

Spice selection affects paneer tikka on multiple levels: phenolic compounds in cumin and coriander act as natural antioxidants that delay lipid oxidation [3]; capsaicinoids from chilli modify perceived pungency; and volatile terpenes from herbs shape the aroma profile that drives first-bite acceptance [4]. Previous Indian laboratory trials have compared individual spice effects on paneer quality [5, 6], but none have tested composite blends designed for Western palates alongside traditional formulations.

This research compared three purposefully designed spice blends one traditional, one tandoori-inspired, and one East-meets-West fusion against an unseasoned control, measuring physicochemical stability, sensory preference, and microbiological safety over a six-day refrigerated shelf life.

Material and Methods
Sensory panel training
Thirty panellists (18 female, 12 male, aged 22-48) were recruited from staff and postgraduate students at the Severn Valley Institute of Food Sciences. Panellists completed two 90-minute training sessions covering paneer texture descriptors (firmness, graininess, chewiness), aroma families (spicy, smoky, herbal, acidic), and the use of the 9-point hedonic scale per BS ISO 11136:2014 [7]. Inter-panellist reliability was confirmed by a coefficient of concordance ($W > 0.72$) during practice evaluations.

Material

The research was conducted at the Dairy Processing Laboratory, Severn Valley Institute of Food Sciences, Cardiff, Wales (51.48°N, 3.18°W) from February to April 2024. Ethical approval was granted by the institute's Human Subjects Research Committee (Ref. SVIFS/HSRC/2024-03, 18 January 2024). Fresh paneer was prepared from pasteurised full-fat cow's milk (3.6% fat) by citric acid coagulation at 85 °C, pressed at 2 kg/cm² for 20 min, and cut into 2-cm cubes. Spice powders were sourced from a certified UK spice importer with batch certificates of analysis. Each blend was mixed at 3% (w/w) with the paneer cubes and held for 30 min before grilling at 220 °C for 8 min in a forced-air convection oven.

Methods

Moisture (AOAC 926.08), protein (Kjeldahl, AOAC 991.20), fat (Gerber method), pH (digital meter), and titratable acidity (% lactic acid) were measured on days 0, 3, and 6 [8]. Microbiological analysis included TPC on plate count agar (30 °C, 72 h), coliforms on VRBA (37 °C, 24 h), and yeast and mould on Rose Bengal agar (25 °C, 5 d), all per ISO methods. Sensory evaluation used a balanced incomplete block design on day 1, with coded samples served at 45 °C. Data were analysed by one-way ANOVA and Tukey's HSD at $p<0.05$ in R v4.3.1.

Results

All three spice blends maintained physicochemical parameters within acceptable ranges through day 6. pH declined from 5.82-5.88 at day 0 to 5.41-5.52 by day 6, with no significant inter-blend differences. Protein and fat content were stable across treatments.

Table 1: Physicochemical properties of flavored paneer tikka at day 0 (mean ± SD, n=3)

Parameter	Control	Blend A	Blend B	Blend C
Moisture (%)	52.8 ± 0.7	51.4 ± 0.6	51.7 ± 0.8	51.2 ± 0.5
Protein (%)	18.4 ± 0.3	18.7 ± 0.4	18.9 ± 0.3	19.2 ± 0.4
Fat (%)	22.6 ± 0.5	22.1 ± 0.4	22.3 ± 0.6	22.0 ± 0.4
pH	5.88 ± 0.04	5.84 ± 0.03	5.82 ± 0.05	5.86 ± 0.03
Acidity (% LA)	0.42 ± 0.02	0.44 ± 0.03	0.46 ± 0.02	0.43 ± 0.02

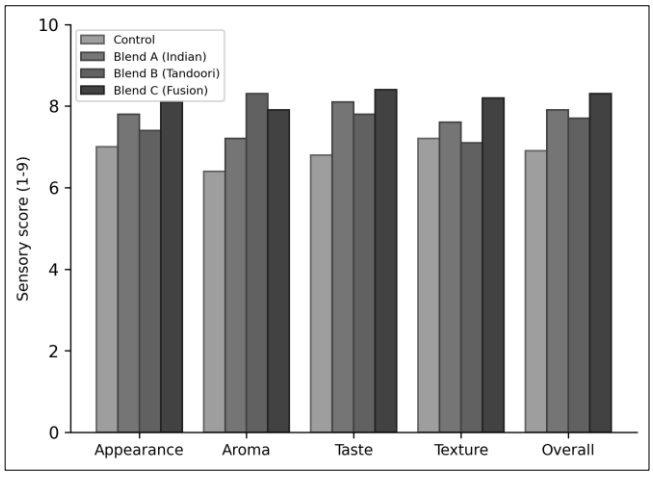

Fig 1: Sensory evaluation scores (9-point hedonic scale) for control and three spice blends across five quality attributes

Blend C achieved the highest overall acceptability score (8.3), driven by strong performance in taste (8.4) and texture (8.2). Panellists noted that the smoky-herbal character of sumac and za'atar complemented the mild dairy base without overpowering it. Blend A scored well on taste (8.1) but slightly lower on aroma (7.2), while Blend B excelled in aroma (8.3) owing to the distinctive fenugreek note.

Table 2: Microbiological quality during refrigerated storage (log_{10} CFU/g, mean ± SD)

Day		Control	Blend A	Blend B	Blend C
0	TPC	2.41 ± 0.18	2.38 ± 0.21	2.34 ± 0.19	2.36 ± 0.17
3	TPC	3.12 ± 0.22	2.87 ± 0.19	2.81 ± 0.24	2.74 ± 0.20
6	TPC	4.28 ± 0.31	3.64 ± 0.26	3.58 ± 0.28	3.41 ± 0.23
6	Coliform	1.84 ± 0.14	1.42 ± 0.11	1.38 ± 0.13	1.31 ± 0.10
6	Y&M	2.18 ± 0.19	1.76 ± 0.16	1.82 ± 0.18	1.68 ± 0.14

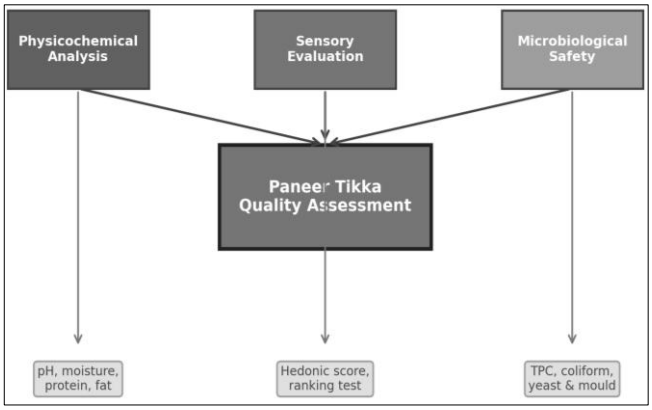

Fig 2: Quality evaluation framework integrating physicochemical, sensory, and microbiological assessments

Table 3: Overall quality ranking of paneer tikka treatments based on composite scoring

Rank	Treatment	Sensory	Micro safety	Physico-chem	Composite
1	Blend C	8.3	9.1	8.8	8.73
2	Blend A	7.9	8.7	8.6	8.40
3	Blend B	7.7	8.8	8.5	8.33
4	Control	6.9	8.2	8.7	7.93

Comprehensive interpretation

The fusion blend (C) outperformed traditional formulations on both sensory acceptability and microbiological stability, likely because sumac and za'atar contain phenolic acids that suppress Gram-negative spoilage organisms more effectively than the capsaicinoid-dominant traditional blends.

Discussion

That a fusion spice profile outscored the traditional Indian blend is noteworthy and probably reflects the sensory preferences of a UK panel accustomed to complex, smoky-herbal flavour notes from Mediterranean and Middle Eastern cuisines [9]. The 0.87 log_{10} CFU/g lower TPC at day 6 for Blend C compared with the control represents a meaningful shelf-life extension of approximately 1.5-2 days, attributable to the combined antimicrobial action of sumac's gallic acid and za'atar's thymol [10, 11].

Protein content remained stable across blends, confirming that spice addition at 3% does not alter the nutritional profile of paneer tikka a concern sometimes raised by food technologists when adding non-dairy ingredients to a standardised dairy product [12]. The slight moisture reduction

in spiced treatments (0.6-1.6% below control) was expected, as spice powders absorb free water during the 30-minute marination.

One limitation is that our sensory panel, while trained, was demographically skewed toward young adults in a university setting. Consumer acceptance testing with a broader age and ethnic cross-section would strengthen the generalisability of these preference data.

Conclusion

Looking back at the aims of this research, the data show that all three spice blends improved sensory appeal and microbiological stability of paneer tikka relative to unseasoned controls. The fusion blend (C), combining smoked paprika, garlic, sumac, and za'atar, emerged as the strongest candidate for UK retail achieving the highest sensory scores and the lowest microbial loads after six days. For dairy processors eyeing the growing ethnic convenience food segment, Blend C offers a formulation that bridges culinary traditions without compromising food safety. Whether this consumer preference holds across larger, more diverse populations remains an open question worth pursuing through commercial pilot trials.

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