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Retail firm type and socio-demographic structure as determinants of the microbiological quality of traditional ready-to-eat food: the case of cig kofte in Türkiye

SEDAT ÖZCAN[1], YUSUF DOĞRUER[2]

[1]Department of Veterinary Medicine, Menemen Vocational School, Izmir Bakırçay University, Izmir, Türkiye
[2]Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Selçuk University, Konya, Türkiye

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Özcan S., Doğruer Y.

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Summary

This study evaluated the physicochemical and microbiological quality of cig kofte – a widely consumed ready-to-eat traditional product in Türkiye – and investigated whether the district-level sociodemographic structure and the type of the retail firm are systematic determinants of contamination levels. A total of 150 samples were collected from eight retail firm categories across three socioeconomically distinct districts of the Konya province (Selçuklu, Meram and Karatay) using a repeated cross-sectional design with outlet rotation. Samples were analysed for moisture content, pH, total aerobic mesophilic bacteria (TAMB), *Micrococcus–Staphylococcus* group, coliform bacteria and yeast–mold. Mean values were as follows: moisture 50.53 ± 4.26%, pH 4.91 ± 0.18, TAMB 5.11 ± 0.63 log CFU/g (prevalence 100%), *Micrococcus–Staphylococcus* 3.84 ± 0.74 log CFU/g (98%), coliform 1.48 ± 1.09 log CFU/g (69.3%) and yeast–mold 2.67 ± 1.40 log CFU/g (82%). Two-way non-parametric analysis (Scheirer–Ray–Hare test) revealed that TAMB and yeast–mold showed significant variation primarily at the district level, while *Micrococcus–Staphylococcus*, pH and moisture varied significantly at the firm-type level. Coliform bacteria were significantly associated with both district and firm type as independent additive effects, with no significant interaction between the two factors. The higher-income district of Meram and factory-sealed chain-market formats consistently exhibited the most favourable microbiological profiles. These findings suggest that microbiological quality may be associated with structurally distinct factors operating at both the district and firm level. Effective food safety management may therefore require differentiated, level-specific interventions – including district-level infrastructure improvements and firm-level personnel hygiene standardisation – rather than uniform enforcement across all retail settings.

Keywords: demographic structure, food safety, ready-to-eat foods, raw meatballs (Turkish cig kofte)

Rapid technological developments, globalization, changing working conditions, time constraints and socioeconomic factors have increased consumer demand for ready-to-eat foods (42). As a result, consumers increasingly prefer street foods and other ready-to-eat foods as alternatives to home-cooked or restaurant meals (45). In Türkiye, commonly consumed street foods include döner, kebab, fish sandwiches, kokorec, hamburgers and raw meatball (cig kofte). Surveys conducted in different cities indicate that cig kofte is among the most frequently chosen street food products (7, 32,44).

Cig kofte is a traditional Turkish ready-to-eat product prepared without heat treatment by kneading fine bulgur with spices, tomato paste, and various aromatic ingredients, such as onion, garlic, vegetable oil, water and lemon juice. The product may be prepared in both meat-containing and meatless formulations and is typically consumed together with greens, such as parsley, lettuce and green onion (4, 8, 27, 41). In recent years, industrial production of cig kofte has increased considerably. According to the Turkish Standards Institute (TSE) TS 13804 (36) standard, industrially produced meatless cig kofte is prepared using standardized formulations and distributed vacuum-packaged to retail outlets through franchised sales systems (6).

The product has historical roots dating back centuries (1), and five regional varieties have been officially registered by the Turkish Patent and Trademark Office (35, 39). Traditionally prepared in households and for special occasions, cig kofte is now widely marketed through diverse retail channels, including street food vendors, supermarkets, fast-food franchise outlets and fine dining restaurants. The product has gained widespread popularity across Türkiye, particularly in southeastern Anatolia, and has expanded into international markets in Europe, the Middle East, Russia and parts of Asia (17). It is estimated that cig kofte is currently sold at approximately 40,000 retail outlets across Türkiye (9, 39).

Food hygiene and safety remain major global public health concerns because of foodborne disease outbreaks associated with inadequate practices throughout the food chain (24). Surveillance data from the Centres for Disease Control and Prevention (CDC) and the European Food Safety Authority (EFSA) indicate that ready-to-eat foods are frequently implicated in such outbreaks (16). The microbiological safety of cig kofte depends largely on the quality of raw materials and the effectiveness of hygiene practices throughout production, distribution and retail handling (4). Because the product is prepared without thermal processing and involves extensive manual handling, insufficient hygiene control may increase the risk of microbial contamination and consequently pose public health risks (10, 12, 40). Therefore, identifying factors that influence contamination levels at the retail stage is essential for improving food safety management and consumer protection.

Numerous studies have evaluated the microbiological quality of cig kofte, mainly reporting contamination levels (2, 12-14, 17, 21). In addition, some studies on ready-to-eat foods have examined the influence of retail firm characteristics or demographic differences across regions (20, 25, 26). However, studies evaluating the combined effect of retail firm type and socio-demographic structure on the microbiological quality of ready-to-eat foods remain limited. Therefore, this study aimed to evaluate the physicochemical and microbiological quality of cig kofte, one of the most widely consumed traditional ready-to-eat foods in Türkiye, and to determine whether socio-demographic structure and retail firm type are associated with differences in microbiological quality at the retail level.

Material and methods

Study design and sampling. This study evaluated the physicochemical and microbiological quality of cig kofte sold at retail outlets across three central districts of the Konya province (Selçuklu, Meram and Karatay) selected based on their distinct socioeconomic and demographic profiles. Meram is characterised by higher-income residential populations; Selçuklu is inhabited by middle-income groups, including civil servants and university students; whereas the population of Karatay consists of lower-income residents with a higher concentration of internal migrants. This classification is supported by urban quality-of-life assessments, in which Meram ranked highest and Karatay lowest across environmental, physical and social criteria (38, 43).

A total of 150 samples were collected from eight retail firm categories across three districts between October 2022 and March 2023. Sampling was conducted in multiple rounds. Within each round, a single sample was obtained per outlet, and no outlet was sampled more than once. For open-display outlets (F1-F5), approximately 150-200 g of product was collected, while for packaged product outlets (F6-F8), one commercially sealed package (500 g or 1 kg) was purchased from the retail shelf as available. Different outlets within the same firm category were preferentially targeted across successive rounds to maximise coverage of distinct physical locations, with sample counts per cell reflecting the retail availability of each firm type in each district (Tab. 1). All samples were placed in sterile polyethylene bags, transported to the laboratory under refrigerated conditions and subjected to microbiological and physicochemical analyses on the day of collection.

Firms F1-F4 represented four tiers of branded franchise companies with centralised bulk production facilities supplying meatless cig kofte to branch outlets for open counter display, differentiated by production scale (estimated monthly output: 80-300 tonnes). LSP (local sales points) comprised unbranded independent outlets preparing product on-site without standardised cold-chain protocols. LCM, NCM and ICM firms supplied factory-sealed packaged cig kofte through refrigerated retail shelves of local, national and international chain markets, respectively; no active ICM outlet was identified in Karatay during the sampling period. Estimated monthly production volumes are provided in Table 1 for contextual characterisation of the operational scale.

Physicochemical analysis. Moisture content was determined by oven-drying 10 g of sample at 100 ± 5°C to constant weight and expressed as percentage (%) (18).

For pH determination, 10 g of sample was homogenized with 90 mL of distilled water, and pH was measured using a calibrated digital pH meter according to standard procedures (18).

Microbiological analyses. For microbiological analyses, 25 g of each sample was aseptically transferred into sterile stomacher bags containing 225 mL of Buffered Peptone Water and homogenized. Serial decimal dilutions were prepared and plated by standard culture techniques (19). Results were expressed as log CFU/g.

Total aerobic mesophilic bacteria (TAMB) were counted on Plate Count Agar (PCA; Merck, Germany) by the pour plate technique and incubated at 37°C for 24-48 h (3).

Micrococcus–Staphylococcus counts were determined on Mannitol Salt Agar (MSA; Merck, Germany) by the pour plate method and incubated at 37°C for 24-48 h. Characteristic yellow colonies surrounded by zones were counted (3).

Coliform bacteria were counted on Violet Red Bile Agar (VRBA; Merck, Germany) by the double-layer pour plate

Tab. 1. Distribution of samples by district and retail firm type, with estimated monthly production volume and operational characterisation

No	Firm type	Operational scale	Number of samples by district				Est. monthly production (t)**	Production and distribution model
			Selçuklu	Meram	Karatay	Total		
1	F1 (franchise 1)	Mid-scale franchise	10	7	7	24	100-200	Centralised bulk production; numerous small-format outlets; open display
2	F2 (franchise 2)	Small-scale franchise	7	3	3	13	80-100	Centralised bulk production; numerous small-format outlets; open display
3	F3 (franchise 3)	Large-scale franchise	13	3	9	25	200-300	Centralised bulk production; numerous small-format outlets; open display
4	F4 (franchise 4)	Mid-large franchise	10	6	4	20	100-200	Centralised bulk production; numerous small-format outlets; open display
5	LSP (local sales point)	Unbranded local outlet	12	9	6	27	0.5-3	On-site or near-site daily preparation; open counter display
6	LCM (local chain market)	Packaged – local chain	4	7	4	15	2-3	Factory-sealed; short local distribution; refrigerated shelf
7	ICM (international chain market)	Packaged – international chain	5	3	–*	8	20-30	Factory-sealed; standardised international cold chain; refrigerated shelf
8	NCM (national chain market)	Packaged – national chain	11	5	2	18	80-100	Factory-sealed; national distribution network; refrigerated shelf
	Total		74	43	35	150		

Abbreviations: F1-F4 – franchise firm types of different operational scales; LSP – local sales point; LCM – local chain market; ICM – international chain market; NCM – national chain market. * No active ICM outlet was identified in Karatay during the sampling period (October 2022–March 2023). ** Estimated monthly production volume per firm type. Values represent approximate output ranges based on declarations obtained from firm representatives at the time of sampling and publicly available corporate disclosures. Figures represent the estimated total monthly production volume of each firm category across all branches in Türkiye. LSP values represent the estimated combined monthly output of the outlets sampled.

technique and incubated at 30°C for 24-48 h. Red colonies (2-3 mm in diameter) were counted (37).

Yeast and mold counts were determined on Potato Dextrose Agar (PDA; Merck, Germany) after incubation at 22°C for 4-5 days (3).

Statistical analysis. Prior to analysis, normality was assessed using the Shapiro-Wilk test, and variance homogeneity was determined by Levene's test. As five of six parameters violated the normality assumption ($p < 0.05$), non-parametric methods were applied throughout. Group comparisons were performed using the Kruskal-Wallis test with Dunn-Bonferroni post-hoc corrections. The Scheirer-Ray-Hare two-way non-parametric ANOVA was used to simultaneously assess district, firm-type and interaction effects, and the Mann-Whitney U test was applied for packaged versus unpackaged comparisons. Spearman rank correlation was performed for exploratory purposes without multiple comparison correction. Marginally significant associations should be interpreted with caution. Statistical significance was set at $p < 0.05$. Analyses were performed using SPSS 22.0 (IBM Corp.) and R 4.3 (rcompanion package).

Results and discussion

A total of 150 cig kofte samples were collected from eight retail firm categories in three socio-demographically distinct districts of the Konya province. The central objective was to determine whether the district-level socio-demographic structure and the retail firm type constitute systematic determinants of microbiological and physicochemical quality in this ready-to-eat product.

Packaged products (from international, national and local chain markets; n = 41) and unpackaged open-display products (from franchise and local sales point outlets; n = 109) did not differ significantly in TAMB, *Micrococcus–Staphylococcus*, yeast–mold counts or pH (all $p > 0.05$; Tab. 2). However, packaged products exhibited significantly lower coliform counts (1.09 ± 1.12 vs. 1.62 ± 1.05 log CFU/g; $p = 0.010$) and a higher moisture content (52.29 ± 4.05% vs. 49.87 ± 4.17%; $p < 0.001$; Tab. 2). Coliform counts were lower in packaged products, possibly reflecting

Tab. 2. Comparison of unpackaged (F1-F5) and packaged (F6-F8) cig kofte in terms of physicochemical and microbiological parameters (mean ± SD)

	n	TAMB (log CFU/g)	*Micrococcus–Staphylococcus* (log CFU/g)	Coliform (log CFU/g)	Yeast–mold (log CFU/g)	pH	Moisture (%)
Unpackaged (F1-F5)	109	5.10 ± 0.61	3.85 ± 0.75	1.62 ± 1.05	2.71 ± 1.33	4.91 ± 0.16	49.87 ± 4.17
Packaged (F6-F8)	41	5.14 ± 0.70	3.82 ± 0.72	1.09 ± 1.12	2.58 ± 1.58	4.93 ± 0.22	52.29 ± 4.05
Mann-Whitney p	–	0.886 ns	0.733 ns	0.010 *	0.796 ns	0.619 ns	< 0.001 ***

Explanations: Mann-Whitney U test (two-sided). * – $p < 0.05$; *** – $p < 0.001$; ns – not significant reduced post-production manual contact during retail sale (31). Packaging may therefore reduce contamination pathways without influencing parameters primarily associated with production and storage conditions.

District-level analysis revealed significant differences across districts for TAMB, coliform and yeast–mold (H = 14.06, p < 0.001; H = 13.60, p = 0.001; H = 8.71, p = 0.013; Tab. 3). In contrast, *Micrococcus–Staphylococcus* counts, pH and moisture content did not differ significantly by district. Meram, the district with higher-income residents and the highest urban quality-of-life ranking (43), had the lowest TAMB (4.79 ± 0.75 log CFU/g, Group b) and coliform counts (0.88 ± 1.13 log CFU/g; 41.5% positive prevalence, Group b) among the three districts (Tab. 3). Yeast–mold counts were highest in Selçuklu (3.05 ± 1.15 log CFU/g, Group a) and lowest in Karatay (2.02 ± 1.64 log CFU/g, Group b). These differences may reflect not only the socioeconomic status, but also variations in infrastructure, retail density and local inspection capacity (20, 33, 34). TAMB values were similar to those reported by recent studies (5, 14) but lower than those in earlier reports (11, 13, 30). This difference may be related to changes in production hygiene following the adoption of TSE TS 13804 (36). Previous research has also highlighted raw material quality and cold-chain management as contributing factors (21, 28, 29).

Firm-type analysis revealed significant differences in *Micrococcus–Staphylococcus*, coliform, moisture and pH (H = 42.89, p < 0.001; H = 32.69, p < 0.001; H = 36.86, p < 0.001; H = 19.78, p = 0.006; Tab. 4). *Micrococcus–Staphylococcus* counts ranged from 3.11 ± 1.05 log CFU/g in large-scale franchise outlets (F3, Group D) to 4.38 ± 0.45 log CFU/g in small-scale franchise outlets (F2, Group A; Tab. 3). The high within-firm variability of F3 (SD = 1.05), despite its lowest mean, may suggest inconsistent branch-level hygiene implementation (13, 17).

Coliform counts were lowest in international chain market outlets (0.71 ± 0.98 log CFU/g, Group C) and national chain market outlets (0.93 ± 1.01, Group C), and highest in small-scale franchise outlets (2.22 ± 0.82, Group A) and large-scale franchise outlets (F3; 2.12 ± 0.98, Group AB; Tab. 3). This pattern may suggest that

Tab. 3. Descriptive statistics for physicochemical and microbiological parameters by district and firm type (mean ± SD)

	Moisture (%)	pH	TAMB (log CFU/g)	*Micrococcus–Staphylococcus* (log CFU/g)	Coliform (log CFU/g)	Yeast–mold (log CFU/g)
By district						
Selçuklu (n = 74)	50.02 ± 3.88	4.91 ± 0.20	5.21 ± 0.55[a]	3.85 ± 0.72	1.73 ± 1.00[a]	3.05 ± 1.15[a]
Meram (n = 41)	50.53 ± 2.92	4.93 ± 0.12	4.79 ± 0.75[b]	3.74 ± 0.96	0.88 ± 1.13[b]	2.54 ± 1.39[ab]
Karatay (n = 35)	51.61 ± 5.95	4.90 ± 0.19	5.28 ± 0.51[a]	3.94 ± 0.43	1.64 ± 0.99[a]	2.02 ± 1.64[b]
By firm type						
F1 – Mid-scale (n = 24)	48.10 ± 2.51[C]	4.97 ± 0.11[AB]	5.24 ± 0.65	3.93 ± 0.29[CB]	1.46 ± 1.02[BC]	2.59 ± 1.34
F2 – Small-scale (n = 13)	53.13 ± 8.80[A]	5.04 ± 0.15[A]	5.42 ± 0.44	4.38 ± 0.45[A]	2.22 ± 0.82[A]	3.25 ± 1.29
F3 – Large-scale (n = 25)	50.64 ± 2.03[ABC]	4.90 ± 0.15[BC]	4.92 ± 0.55	3.11 ± 1.05[D]	2.12 ± 0.98[AB]	2.17 ± 1.47
F4 – Mid-large (n = 20)	49.71 ± 2.80[BC]	4.82 ± 0.18[C]	4.96 ± 0.61	4.02 ± 0.36[ABC]	1.27 ± 1.00[BC]	3.03 ± 1.49
LSP – Local (n = 27)	49.29 ± 3.48[BC]	4.86 ± 0.14[BC]	5.11 ± 0.63	4.09 ± 0.57[AB]	1.29 ± 1.05[BC]	2.81 ± 0.93
LCM – Local chain (n = 8)	51.53 ± 7.08[AB]	4.95 ± 0.15[AB]	5.28 ± 0.43	3.81 ± 0.20[CD]	2.14 ± 1.07[AB]	3.25 ± 0.62
ICM – Intl. chain (n = 15)	51.59 ± 2.01[AB]	4.95 ± 0.15[AB]	4.91 ± 0.83	3.58 ± 1.07[CD]	0.71 ± 0.98[C]	1.90 ± 1.90
NCM – Natl. chain (n = 18)	53.21 ± 3.62[A]	4.96 ± 0.22[AB]	5.26 ± 0.67	4.02 ± 0.40[ABC]	0.93 ± 1.01[C]	2.84 ± 1.44

Explanations: Lowercase superscript letters (a, b) denote significant differences between districts (Dunn-Bonferroni post-hoc, p < 0.05). Uppercase letters (A-D) denote significant differences between firm types (Dunn-Bonferroni, p < 0.05). Absence of superscripts: no significant effect detected for that parameter. All microbiological values in log CFU/g.

Tab. 4. Scheirer–Ray–Hare two-way non-parametric ANOVA: district effect, firm type effect and district × firm interaction for each parameter

Parameter	District H	District p	Sig.	Firm H	Firm p	Sig.	Interaction (D × F) p
TAMB (log CFU/g)	14.06	0.001	**	11.94	0.103	ns	0.592
Micrococcus–Staphylococcus (log CFU/g)	1.81	0.405	ns	42.89	< 0.001	***	0.914
Coliform (log CFU/g)	13.60	0.001	**	32.69	< 0.001	***	1.000
Yeast–mold (log CFU/g)	8.71	0.013	*	10.22	0.177	ns	0.463
pH	0.73	0.694	ns	19.78	0.006	**	0.026
Moisture (%)	1.97	0.374	ns	36.86	< 0.001	***	0.064

Explanations: H – Scheirer–Ray–Hare statistic (χ^2 approximation). * – p < 0.05; ** – p < 0.01; *** – p < 0.001; ns – not significant. Significant district × firm interaction (p < 0.05).

Tab. 5. Spearman rank correlation matrix for six parameters (n = 150)

	TAMB	*Micro.–Staph.*	Coliform	Yeast–mold	pH	Moisture
TAMB	–	0.293***	0.135	0.254**	0.102	–0.048
Micrococcus–Staphylococcus (log CFU/g)	0.000***	–	–0.090	0.033	0.165*	–0.112
Coliform	0.101	0.272	–	0.133	0.014	–0.072
Yeast–mold	0.002**	0.691	0.104	–	0.001	–0.078
pH	0.214	0.044*	0.865	0.988	–	0.170*
Moisture	0.561	0.171	0.384	0.343	0.038*	–

Explanations: Upper triangle – Spearman r with significance symbol; lower triangle – p-value. * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. No correction for multiple comparisons was applied.

factory-sealed formats reduce post-production manual contact, whereas open-display franchise outlets may be more susceptible to potential faecal contamination during retail handling (13, 17, 21). National chain market outlets (53.21 ± 3.62%, Group A) and small-scale franchise outlets (F2; 53.13 ± 8.80%, Group A) showed the highest moisture values. All values complied with TSE TS 13804 (36), with the exception of small-scale franchise outlets, whose high SD may suggest branch-level formulation variability. pH was the only parameter for which a significant district × firm interaction was detected ($p = 0.026$; Tab. 4), suggesting that firm-type differences in pH were not consistent across districts. The underlying reasons for this pattern could not be established within the present study. As pH contributes to the intrinsic microbial stability of heat-treatment-free products (4, 17), this finding may warrant further investigation.

Spearman correlation analysis (Tab. 5) revealed four significant associations: TAMB–*Micrococcus–Staphylococcus* ($r = 0.293$, $p < 0.001$), TAMB–yeast–mold ($r = 0.254$, $p = 0.002$), *Micrococcus–Staphylococcus*–pH ($r = 0.165$, $p = 0.044$) and pH–moisture ($r = 0.170$, $p = 0.038$). These associations were modest in magnitude and should be interpreted with caution. Coliform counts were not significantly correlated with any other parameter (all $p > 0.10$; Tab. 5), which may suggest that coliform contamination followed a pathway independent of the other indicators measured in this study.

Collectively, these findings suggest that the microbiological quality of cig kofte varies according to both district-level and firm-type factors, although the specific mechanisms underlying these differences could not be determined within the scope of the present study. Different contamination indicators exhibited distinct patterns of variation, suggesting that a single explanatory factor is unlikely to account for all differences observed. From a food safety perspective, the results support the value of targeted monitoring and control strategies at both the retail and local levels. Further studies including detailed environmental, operational and supply-chain variables are needed to better elucidate factors influencing the microbiological quality of retail cig kofte.

Conclusions. The findings of this study suggest that microbiological and physicochemical quality may vary according to both district-level and firm-type factors. While some contamination indicators were primarily associated with district-level variation and others with firm type, coliform contamination was influenced by both factors, suggesting a more complex pattern of variation. The generally weak correlations between microbiological and physicochemical parameters further suggest that no single indicator may be sufficient to reflect overall product quality. These findings highlight the importance of considering both local retail conditions and firm-specific practices when designing food safety monitoring and quality control strategies for ready-to-eat cig kofte. Future studies involving direct environmental, operational and supply-chain measurements would help clarify mechanisms underlying the associations observed and support the development of more targeted risk-management approaches.

Limitations. Several limitations should be acknowledged. First, sampling was restricted to the autumn-winter period (October 2022–March 2023), and seasonal variation in microbial contamination was not assessed; therefore, the findings may not fully represent warmer periods of the year. Second, although outlet rotation was used and no outlet was sampled more than once, individual outlet identity was not recorded as a separate variable, precluding the application of mixed-effects models that could account for potential clustering within firm categories. Third, the district-level socio-demographic structure was treated as a proxy variable based on the income level and urban quality-of-life characteristics, and the contribution of individual socioeconomic or environmental factors could not be evaluated separately. Fourth, *Micrococcus–Staphylococcus* was counted at the group level without species confirmation or coagulase testing, and coliform analysis did not include *E. coli* differentiation. Finally, no pathogen-specific analyses, including *Salmonella*, *Listeria monocytogenes* or Shiga toxin-producing *E. coli*, and no antimicrobial resistance profiling were performed. Future studies involving seasonal sampling, outlet-level random effects and pathogen-targeted surveillance would provide a more comprehensive assessment of food safety risks associated with retail cig kofte.

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Correspondence: Sedat Özcan, Department of Veterinary Medicine, Menemen Vocational School, Izmir Bakırçay University, Izmir, Türkiye; e-mail: sedat.ozcan@bakircay.edu.tr