

Microbial Quality Assessment of Marketed Paracetamol Syrups in Kabul, Afghanistan

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ABSTRACT

Paracetamol syrup is widely used in pediatric care as an antipyretic and analgesic. Microbial contamination of pharmaceutical dosage forms poses significant risks to patient safety. This cross-sectional study included 60 paracetamol syrup samples representing 22 brands available in the Kabul market, including 36 domestic and 24 imported products. We performed microbiological assessments, including colony counts, identification of bacterial and fungal isolates, and screening for prohibited pathogenic microorganisms, according to WHO standards. Microbial quality evaluation demonstrated contamination rates of 44% in domestic samples and 33% in imported samples. Among the contaminated samples, the microbial load ranged from 910 to 2497 CFU/mL. The lowest contamination levels were documented in company I (domestic) and company B (imported). Predominant isolates included *Corynebacterium* spp. (20%), *Bacillus* spp. (10%), and yeasts (10%), with fungal contamination limited to company S. Although most samples complied with Pharmacopeial limits, the presence of highly contaminated brands available in the Kabul market indicates gaps in GMP adherence, raw material quality control, and storage practices. Strengthened regulatory oversight and routine quality monitoring are essential to ensure the microbiological safety of liquid pharmaceutical preparations.

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INTRODUCTION

Pharmaceutical dosage forms are generally divided into sterile and non-sterile categories based on their intended method of administration and clinical use (Ratajczak et al., 2015). Some medications are sterile products, such as injectable preparations, inhaled medications, and ophthalmic solutions; these pharmaceutical products must be free of microorganisms because they are administered directly into the body (Jimenez, 2007). In contrast, some regulatory organizations have established specific microbiological acceptance criteria for non-sterile pharmaceutical products (NSPs), such as tablets or other solid oral formulations,

liquid dosage forms, and topical preparations; therefore, these products are not sterilized after manufacture (Ratajczak et al., 2015).

Oral liquid dosage forms, especially syrups, are widely used among children and elderly patients due to their pleasant taste, ease of administration, and high acceptability (Bajaj et al., 2012; Gvozdeva & Staynova, 2025). Although most syrups are formulated as multidose preparations, repeated use may increase the risk of secondary contamination. Furthermore, antimicrobial preservatives are incorporated into formulations to inhibit microbial growth; however, their effectiveness may be affected by interactions with formulation components, inappropriate storage conditions, and packaging systems (Bajaj et al., 2012; Denyer, 2011).

Microbial quality must be carefully managed and monitored throughout the entire pharmaceutical production cycle, including formulation, manufacturing, packaging, storage, transportation, and distribution. As a result, microbiological quality is recognized globally as a critical quality attribute (CQA) (Clontz, 2008). Microbial contamination directly affects pharmaceutical dosage forms and their therapeutic efficacy, compromising safety and quality; therefore, this is a serious and ongoing threat to global public health. (Noor et al., 2015; Tyski et al., 2025). Microbial contamination may alter physicochemical properties, reduce therapeutic efficacy, and potentially increase product toxicity (Kamil & Lupuliasa, 2011). Microorganisms can degrade active ingredients and excipients in pharmaceutical systems through chemical, physical, and microbiological pathways. (Tavares et al., 2020). Even low levels of microbial contamination can lead to clinically important outcomes, particularly when pathogenic organisms are present in the dosage form. (Ratajczak et al., 2015). Therefore, upholding strict microbiological standards is crucial to guarantee that pharmaceutical products stay stable, effective, and safe for human consumption.

The United States Pharmacopeia (USP) and the European Pharmacopeia (EP), which are among the international regulatory frameworks in the pharmaceutical sector, have provided some standards to ensure microbial levels in the final product, including the total microbial count and the total yeast and mold count (United States Pharmacopeial Convention, 2019) (EP, 2010).

These pharmacopeial standards are increasingly incorporated into contemporary pharmaceutical development approaches, especially Quality-by-Design (QbD), which integrates quality metrics into the early phases of product design and formulation development. (Namjoshi et al., 2020). Human and environmental sources, such as water supply systems, factory equipment, raw materials, air supply systems, surfaces, and personnel involved in the production process, may contribute to microbial contamination in pharmaceutical factories (Sandle, 2016; WHO Expert Committee on Specifications for Pharmaceutical Preparations). Pharmaceutical environmental control systems in non-sterile production facilities might not be sufficiently robust; thus, microorganisms could survive and persist in these environments (Kramer et al., 2006). If good manufacturing practices (GMP) are not adequately adhered to in non-sterile manufacturing facilities, or if cleaning and sanitation procedures, environmental controls, and personnel hygiene practices are

inadequate, there could be risk of ongoing cross-contamination between batches due to the presence of microorganisms or microbial biofilms on the surfaces of equipment and instruments (Denyer, 2011; Sandle, 2016).

In a pharmaceutical formulation, physicochemical parameters such as pH, water activity, and the effectiveness of preservatives have a strong influence on microbial growth and survival, so if there is a suboptimal or standard formulation with inadequate preservative systems, the risk of microbial proliferation and growth, product degradation, and production of toxic metabolites increases significantly (Bajaj et al., 2012). In addition, evidence shows that raw material quality, the production environment, and storage conditions contribute to microbial contamination of the final product (Jimenez, 2007; Sandle, 2016).

During the shelf life of pharmaceutical preparations, microorganisms may survive and multiply under favorable conditions, leading to physicochemical changes in formulations, including fermentation, turbidity, gas production, unpleasant odor, and discoloration (Kamil & Lupuliasa, 2011). Microbial contamination can also degrade active pharmaceutical ingredients and excipients, potentially reducing therapeutic efficacy and leading to harmful metabolites that may pose health risks to patients (Ratajczak et al., 2015). Therefore, strict microbiological control measures throughout drug production and distribution are essential to minimize contamination risks (Clontz, 2008). Pathogenic microorganisms such as *Escherichia coli*, *Salmonella* species, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* in pharmaceutical products may further contribute to serious health problems, including gastrointestinal and systemic infections.

According to the European Pharmacopeia (2010), oral pharmaceutical dosage forms should comply with specified microbiological quality criteria, including a Total Aerobic Microbial Count (TAMC) of no more than 10^2 CFU/mL and a Total Yeast and Mold Count (TYMC) of no more than 10^1 CFU/mL. In addition, *Escherichia coli* and *Salmonella* spp. must be absent in 1 g or 1 mL of the product (EP, 2010).

Similarly, the United States Pharmacopeia (USP) provides microbiological acceptance criteria for non-sterile pharmaceutical products, including limits for TAMC and TYMC and the absence of specified objectionable microorganisms, depending on the route of administration and category (USP, 2019).

Afghanistan has experienced decades of conflict, which significantly affected the healthcare system, including pharmaceutical regulation and quality assurance. Inadequate regulatory oversight, limited pharmaceutical quality control practices, and insufficient qualified personnel in pharmaceutical practice may affect the quality of both locally manufactured and imported medicines, especially liquid dosage forms. Even under these circumstances, domestic manufacturing companies and companies that import medicines from other countries play an important role in meeting the country's pharmaceutical needs.

Paracetamol syrup is one of the most commonly used dosage forms and is widely available in Kabul's pharmaceutical markets. Studies in other countries have reported

microbial contamination in certain non-sterile pharmaceutical products, such as paracetamol syrup, raising concerns about product quality and patient safety, especially in children. Until now, no published study has assessed the microbiological quality of paracetamol syrup marketed in Kabul city.

Therefore, this study evaluated the microbiological quality of paracetamol syrups available on the pharmaceutical market in Kabul, Afghanistan. Specifically, it assessed the total aerobic microbial count (TAMC), total yeast and mold count (TYMC), and the presence of pathogenic microorganisms. It compared the results with the microbiological acceptance criteria established by international regulatory authorities. The results provide baseline data on the microbiological quality of paracetamol syrups and may support future pharmaceutical quality assurance and regulatory monitoring efforts in Afghanistan.

METHODS AND MATERIALS

Study Area

Kabul is Afghanistan's capital and largest city, with a large pharmaceutical market supplied by both locally manufactured and imported medicines. The study was conducted in community pharmacies located across different districts of Kabul to obtain representative samples of paracetamol syrup available to consumers.

Study Design and Sample Collection

This cross-sectional study was conducted between March and October 2025. We included 60 paracetamol syrup samples representing 22 commercial brands available in the pharmaceutical market of Kabul, Afghanistan. We randomly collected samples from community pharmacies in different districts of Kabul city. We selected products with different manufacturing dates to ensure representativeness of market variability.

We labeled each sample anonymously (A–M) at the point of collection and transported it to the Microbiology Laboratory, Faculty of Pharmacy, Kabul University within three hours under cold-chain conditions (1–4 °C) to minimize microbial proliferation during transport. Upon arrival, all samples were inspected for package integrity and stored under refrigerated conditions (2–8 °C) until microbiological analysis. Following analysis, the remaining portions of each sample were retained as reference samples under the same refrigerated conditions (2–8 °C).

Of the 60 samples collected, 36 (60%) were locally manufactured, and 24 (40%) were imported from Pakistan and India. For each sample, we recorded the manufacturing date, expiry date, batch number, and manufacturer's address to verify product identity and ensure traceability. We collected two samples from each selected batch, and included one to three batches for each commercial brand. The characteristics of the collected samples are presented in Table1.

Table 1 . Characteristics of paracetamol syrup samples included in the study

No.	Company Code	Samples code	Country Manufacture	Sample per Batch (n)	Total Samples per Company	Manufacturing Date Recorded	Expiry date recorded	Batch No. Recorded
1	A	A1	Pakistan	2	6	+	+	+
2	A	A2	Pakistan	2		+	+	+
3	A	A3	Pakistan	2		+	+	+
4	B	B1	Pakistan	2	6	+	+	+
5	B	B2	Pakistan	2		+	+	+
6	B	B3	Pakistan	2		+	+	+
7	C	C1	Afghanistan	2	4	+	+	+
8	C	C2	Afghanistan	2		+	+	+
9	D	D1	Pakistan	2	4	+	+	+
10	D	D2	Pakistan	2		+	+	+
11	E	E1	Afghanistan	2	6	+	+	+
12	E	E2	Afghanistan	2		+	+	+
13	E	E3	Afghanistan	2		+	+	+
14	F	F1	Afghanistan	2	2	+	+	+
15	G	G1	Afghanistan	2	2	+	+	+
16	H	H1	Afghanistan	2	2	+	+	+
17	I	I1	Afghanistan	2	2	+	+	+
18	J	J1	Afghanistan	2	2	+	+	+
19	K	K1	Afghanistan	2	2	+	+	+
20	L	L1	Afghanistan	2	2	+	+	+
21	M	M1	Afghanistan	2	2	+	+	+
22	N	N1	Afghanistan	2	2	+	+	+
23	O	O1	Afghanistan	2	2	+	+	+
24	P	P1	Afghanistan	2	2	+	+	+
25	Q	Q1	Afghanistan	2	2	+	+	+
26	R	R1	Afghanistan	2	2	+	+	+
27	S	S1	India	2	2	+	+	+
28	T	T1	India	2	2	+	+	+
29	U	U1	India	2	2	+	+	+
30	V	V1	India	2	2	+	+	+

Microbiological Analysis of Paracetamol Syrup Samples: Assessment of Microbial Quality and Total Microbial Count

Total Aerobic Microbial Count (TAMC) and Total Yeast and Mold Count (TYMC) were determined through microbial enumeration. Briefly, 10 mL of each syrup sample was aseptically transferred into 90 mL of Trypticase Soy Broth (Merck, Germany) or sterile buffered peptone water and thoroughly homogenized. Prepared serial tenfold dilutions as needed to achieve countable ranges. For bacterial enumeration, 0.1 mL aliquots were spread onto Tryptic Soy Agar (TSA; Oxoid, UK), while for fungal enumeration, Sabouraud Dextrose Agar (SDA; Oxoid, UK) supplemented with chloramphenicol was used.

The TSA plates were incubated at 35–37 °C for 48–72 hours, while the SDA plates were kept at 25 °C for 5–7 days with daily observation. After incubation, visible colonies were counted,

and results were recorded as mean colony-forming units per milliliter (CFU/mL). To ensure accuracy, reproducibility, and the absence of contamination, all experiments were performed in triplicate under Good Laboratory Practice (GLP) conditions, including negative controls in each batch (Clontz, 2009).

Isolation and Identification of Microorganisms

Microbial identification was performed using selective and differential culture media following serial tenfold dilutions (10^{-1} – 10^{-3}). Blood agar was used as a general-purpose medium, while Mannitol Salt Agar (MSA) was used for the isolation of Gram-positive cocci, MacConkey Agar (MCA) for Gram-negative bacteria, and Sabouraud Dextrose Agar (SDA) for the isolation of yeasts and molds. The inoculated media were incubated under appropriate conditions: bacterial cultures at 37 °C for 24–48 hours and fungal cultures at 25 °C for 72–96 hours. Representative colonies were subsequently subcultured to obtain pure isolates for further analysis. Microorganisms were identified based on a combination of colony morphology, Gram staining, and Lactophenol cotton blue staining for fungal structures (Leboffe & Pierce, 2021; Moubasher, 1993). In addition, we performed a series of standard biochemical tests, including catalase and oxidase tests, Triple Sugar Iron (TSI) agar reactions, citrate utilization, urease test, indole test, Methyl Red/Voges-Proskauer (MR-VP) tests, and the Motility test. All experimental procedures were conducted under strict aseptic conditions, in accordance with established microbiological contamination control guidelines, to prevent cross-contamination and ensure reliable results (USP <61>).

Statistical analysis

The data were analyzed using IBM SPSS Statistics (version 24.0, 2016). We evaluated differences in microbial counts and the distribution of isolated microorganisms using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

FINDINGS

This study investigated the microbiological quality of commercially available paracetamol syrup collected from the pharmaceutical market in Kabul city, Afghanistan. We analyzed 60 samples representing 22 brands to assess microbial load, including total aerobic microbial count (TAMC), total yeast and mold count (TYMC), and the presence of specified microorganisms. Out of the total 60 paracetamol syrup samples analyzed, 24 samples (40%) were found to be microbiologically contaminated, while 36 samples (60%) showed no detectable microbial growth. Among the 36 locally manufactured samples, 16 (44.4%) were contaminated, whereas 20 (55.6%) were free of contamination. In contrast, 8 (33.3%) imported samples were contaminated, and 16 (66.7%) showed no microbial growth.

The microbial load ranged from 0 to 4.805×10^3 CFU/mL. The highest fungal contamination was observed in Company C1, while the highest bacterial contamination was detected in Company Q1.

The identified microorganisms included *Corynebacterium* spp., *Bacillus* spp., and yeast. Several samples exceeded the acceptable microbial limits defined by the USP convention, particularly for total aerobic microbial count and total yeast and mold count (Table 2).

Table 2. Microbial contamination of paracetamol syrup brands available in Kabul market

No.	Company Code	Samples code	Country	Number of samples	Mean colony count in samples (CFU/mL)	Identified microorganism	USP limit
1	A	A1	Pakistan	2	0	-	-
2	A	A2	Pakistan	2	0	-	-
3	A	A3	Pakistan	2	0	-	-
4	B	B1	Pakistan	2	0	-	-
5	B	B2	Pakistan	2	0	-	-
6	B	B3	Pakistan	2	3.40×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
7	C	C1	Afghanistan	2	4.805×10^3	Yeast	<10 CFU/mL (fungi)
8	C	C2	Afghanistan	2	1.90×10^2	Yeast	<10 CFU/mL (fungi)
9	D	D1	Pakistan	2	6.60×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
10	D	D2	Pakistan	2	2.50×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
11	E	E1	Afghanistan	2	0	-	-
12	E	E2	Afghanistan	2	0	-	-
13	E	E3	Afghanistan	2	0	-	-
14	F	F1	Afghanistan	2	0	-	-
15	G	G1	Afghanistan	2	0	-	-
16	H	H1	Afghanistan	2	0	-	-
17	I	I1	Afghanistan	2	1.10×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
18	J	J1	Afghanistan	2	1.30×10^2	<i>Bacillus</i> spp.	<100 CFU/mL (bacteria)
19	K	K1	Afghanistan	2	0	-	-
20	L	L1	Afghanistan	2	1.10×10^2	<i>Bacillus</i> spp.	<100 CFU/mL (bacteria)
21	M	M1	Afghanistan	2	3.75×10^2	<i>Bacillus</i> spp.	<100 CFU/mL (bacteria)
22	N	N1	Afghanistan	2	0	-	-
23	O	O1	Afghanistan	2	3.70×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
24	P	P1	Afghanistan	2	0	-	-
25	Q	Q1	Afghanistan	2	5.75×10^2	<i>Corynebacterium</i> spp.	<100 CFU/mL (bacteria)
26	R	R1	Afghanistan	2	0	-	-
27	S	S1	India	2	9.10×10^2	Yeast	<10 CFU/mL (fungi)
28	T	T1	India	2	0	-	-
29	U	U1	India	2	0	-	-
30	V	V1	India	2	0	-	-

Note. CFU/mL, colony-forming units; USP, United States Pharmacopeia

Among the locally manufactured samples, quantitative microbial analysis (expressed as CFU/mL) showed that Company C had the highest contamination level. The total colony count in its four contaminated samples reached 9,990 CFU/mL, with a mean value of 2.497×10^3 CFU/mL, accounting for approximately 74.5% of the total microbial load among contaminated local brands. Following Company C, Companies Q, M, and O showed progressively lower mean contamination levels. Company I had the lowest contamination among local brands (mean: 110 CFU/mL).

Among the imported brands, Company S, India (manufacturer), recorded the highest microbial contamination, with a total load of 1,820 CFU/mL across its two contaminated samples (mean: 910 CFU/mL), accounting for 33.3% of the total microbial load among imported brands. Company D, Pakistan (manufacturer), ranked second (mean: 455 CFU/mL), whereas Company B, Pakistan (manufacturer), showed the lowest contamination level (mean: 340 CFU/mL) (Table 3).

Table 3. Average Microbial Contamination of Paracetamol Syrup brands (CFU/mL)

Rank	Company cod	Country	No. of samples	Total CFU/mL	Average CFU/mL	Bacterial and Yeast Contamination percentage)
1	C	Afghanistan	4	9990	2497	56.34%
2	S	India	2	1820	910	10.26%
3	D	Pakistan	4	1820	455	10.26%
4	Q	Afghanistan	2	1150	575	6.48%
5	M	Afghanistan	2	750	375	4.23%
6	O	Afghanistan	2	740	370	4.17%
7	B	Pakistan	2	680	340	3.83%
8	L	Afghanistan	2	300	150	1.69%
9	J	Afghanistan	2	260	130	1.46%
10	I	Afghanistan	2	220	110	1.24%

Among the identified microorganisms, *Corynebacterium* spp. was the most frequently isolated bacterial species, detected in 12 cases (20%), followed by yeasts in 6 cases (10%) and *Bacillus* spp. in 6 cases (10%). The highest prevalence of *Corynebacterium* spp. was observed among locally manufactured brands, particularly in Companies C, I, O, and Q, whereas *Bacillus* spp. contamination was detected in Companies J, L, and M. Yeast contamination was observed exclusively in Company S, India (manufacturer), among the imported brands (Tables 1 and 4).

Table 4. Types and Frequency of Microorganisms Isolated from Paracetamol Syrup Samples

Microorganism	No. of isolates	Percentage of Total Samples (n=60)
<i>Corynebacterium</i> spp.	12	20%
Yeast	6	10%
<i>Bacillus</i> spp.	6	10%
Samples without growth	36	60%
Total	60	100%

Overall, contamination rates indicated that Afghan syrup brands had the highest contamination (50%), followed by Pakistani (40%) and Indian (20%) brands. Chi-square analysis demonstrated no statistically significant association between brand origin and contamination status ($\chi^2 = 4.35$, $df = 2$, $p = 0.114$). Although Afghan brands had a higher numerical contamination rate, the difference was not statistically significant ($p > 0.05$) (Table 5).

Table 5. Microbial Contamination status of syrup samples by brand origin

Origin	No. of samples by origin	Contaminated	Not contaminated	Contamination Rate	χ^2	df	p-value
Afghanistan	20	10	10	50%	4.35	2	0.114
Pakistan	10	4	6	40%			
India	10	2	8	20%			
Total	40	16	24	40%			

DISCUSSION

Microbial contamination of pharmaceutical products has concerned regulatory agencies and the pharmaceutical industry since the 1960s, especially for non-sterile preparations such as oral syrups. Pathogenic microorganisms in products affect quality and pose potential risks to patients (Santos et al., 2018).

This study on microbial contamination of paracetamol syrup samples collected from a pharmaceutical market in Kabul, Afghanistan, found that 40% of the samples were contaminated with bacteria and/or fungi. This result highlights the inadequate monitoring of good manufacturing practices in the country's pharmaceutical factories or systems. *Corynebacterium* species, *Bacillus* species, and yeast were among the main contaminants in these paracetamol syrup dosage form samples, consistent with environmental and human-associated microbiota (Grice & Segre, 2011).

Environmental contamination during production, packaging, or post-production handling is generally due to spore-forming *Bacillus* species, which are frequently detected in air, dust, and other production environments (Sandle, 2016). Therefore, exposure to an unfavorable environment and poor hygiene control are among the main factors contributing to microbial contamination in non-sterile drug forms (Ratajczak et al., 2015). The present study also showed that paracetamol syrups were contaminated with these spore-forming bacteria, indicating that non-sterile drugs, especially syrups available in the Kabul pharmaceutical market, may still be contaminated due to inadequate hygiene controls during production, packaging, or handling.

The present study found higher microbial contamination in domestically produced products than in imported brands, but the difference was not statistically significant. Comparing these results with international studies highlights both similarities and regional differences. For example, in a similar study, Jazmati et al. (2022) reported a lower contamination rate than the present results (26%) in contaminated syrups from Syria, while

a similar study conducted by Jamil (2017) showed a contamination rate of 33% in Pakistani syrups, which is close to the present results.

In contrast, a similar study conducted in Bangladesh showed significantly higher contamination rates (up to 89%) than the present study, indicating major deficiencies in pharmaceutical quality control systems in some developing countries (Noor et al., 2015). Similarly, in African regions, opportunistic and multidrug-resistant pathogens such as *Staphylococcus aureus* and *Pseudomonas* spp. have also been documented, which could pose a public health risk through contamination of these products. Fortunately, the present study did not document such pathogens (Myemba et al., 2022; Omebije et al., 2023; Osungunna et al., 2016). Similarly, in a report from Tanzania, Mimba et al. (2022) documented contamination of syrups with *Pseudomonas aeruginosa* and *Aspergillus flavus*, further underscoring the global nature of this issue.

Non-compliance with Good Manufacturing Practices (GMP) in pharmaceutical manufacturing, especially for pediatric formulations, has been consistently associated with increased microbial contamination and reduced product safety (Murtaza et al., 2022). This can even include multidrug-resistant pathogens (Mugoyela et al., 2010). In general, the present study showed microbial contamination in all brands, both domestic and foreign, imported into the Afghan market. Based on previous studies, microbial contamination of oral liquid drugs is a global problem, not a local phenomenon. Although the results of microbial contamination vary in different regions, the main determinants - poor or inadequate adherence to good manufacturing practices, environmental exposure, and inappropriate storage conditions - still play a significant role. Therefore, it is recommended to strengthen the development and implementation of strict regulations and monitor the implementation of good manufacturing systems, improve environmental monitoring, and establish continuous monitoring of pharmaceutical products in the Kabul pharmaceutical market, among the necessary measures to ensure the safety and microbial quality of non-sterile pharmaceutical products, especially paracetamol syrup.

CONCLUSION

Paracetamol syrup is widely used among children worldwide; however, several studies have reported poor microbiological quality, indicating possible deficiencies in manufacturing practices and microbiological control under good manufacturing practice frameworks (Opoku & Nyanor, 2019; Osungunna et al., 2016). This study aimed to evaluate microbial contamination in paracetamol syrup available in the pharmaceutical market of Kabul city. The findings of these studies emphasize that out of all paracetamol syrup samples obtained from the Kabul pharmaceutical market, 60% (36 samples) had no microbial growth, which included both imported and domestic brands, thus indicating relative compliance with GMP standards and microbiological quality during and after production, this is not sufficient, and more GMP regulations should be followed. In general, microbial contamination is present in all brands, both domestic and foreign, imported into the Afghan market; considering the

previous studies mentioned, it can be concluded that microbial contamination of oral liquid preparations is a global problem, not a local phenomenon. Therefore, it is recommended to strengthen the development and implementation of strict regulations and monitoring the implementation of good manufacturing systems, improve environmental monitoring, and establish continuous monitoring of pharmaceutical products in the Kabul pharmaceutical market, among the necessary measures to ensure the safety and microbial quality of non-sterile pharmaceutical products, especially paracetamol syrup.

Authors' Contributions

M.A. Bahaduri contributed to the conception and design of the study, development of the research methodology, scientific supervision, laboratory guidance, data interpretation, and critical revision of the manuscript. S.M. Habibi and M.O. Oryakhil contributed to sample collection, laboratory investigations, experimental procedures, data recording, and preparation of the initial manuscript draft. All authors reviewed, revised, and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that there are no financial, personal, or professional conflicts of interest related to the research, authorship, and publication of this article.

Data Availability Statement

The datasets generated and/or analyzed during this study are available from the corresponding author upon reasonable request

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