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Research Article

Evaluation of Microbiological Contamination of Black and Green Teas

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Abstract: The study aimed to determine the level of microbial contamination of black and green teas with different degrees of fragmentation. The microbiological analysis we conducted on 18 black and green teas available commercially on the market. Solutions were prepared from the weighed samples and then inoculated on sterile microbial media. Teas in bags proved to be the most polluted among the tested tea groups. Statistical analysis indicated significant differences in mycological contamination between black and green teas of various degrees of fragmentation. Green tea in bags manifested the highest fungal contamination - 9.3×10^3 CFU/g, significantly exceeding the other teas. Isolated fungi belonged to *Aspergillus* sp., *Cryptococcus* sp., *Rhizopus* sp., *Mucor* sp., *Penicillium* sp. and *Cladosporium* sp. The lowest number of fungi we observed in the group of green leaf teas - 1.7×10^2 CFU/g. We recorded the most significant number of Gram-positive bacteria in deciduous black tea - 1.8×10^3 CFU/g. The correlation between the degree of tea fragmentation and their microbial contamination has been demonstrated. Potentially pathogenic bacteria isolated from black and green tea can pose a threat to the health of consumers.

Keywords: Bacteria, black tea, fungi, green tea, microbial contamination

INTRODUCTION

The microflora of products with low water content, i.e., dried plants, is characterized by a wide variety of species in both qualitative and quantitative terms. Microbiological contamination of raw materials of plant origin can occur in two ways: primary and secondary. The primary microbial contamination of plants is determined mainly by the microflora which is naturally present on the plant's surface, the so-called epiphytic microflora. Other factors affecting this type of contamination include soil, dust and fertilizers (Cheng *et al*., 2013; Tournas and Katsoudas, 2008; Zweifel and Stephan, 2012). Negligence regarding appropriate hygienic habits and methods of cultivation and harvesting of plants as well as the selection of inappropriate conditions of drying, storage or transport lead to secondary contamination.

Having entered the gastrointestinal tract, potentially harmful microorganisms originating from soil or water, in direct contact with plants, may cause severe poisoning (Carraturo *et al*., 2018; European Medicines Agency (EMA), 2013; Stojanović *et al*., 2011; Omogbai and Ikenebomeh, 2013; Marin *et al*., 2013). Such biological hazards include mold producing dangerous mycotoxins. Literature data indicate high thermal stability of non-degradable mycotoxins subjected to the pasteurization process, even at high temperatures. The same applies to the majority of toxins produced by bacteria (Carraturo *et al*., 2018; Marin *et al*., 2013; Quadros Rodrigues *et al*., 2014; Sobieraj-Garbiak and Drożdzyńska, 2015).

The temperature of water poured onto tea leaves depends upon the type of tea. During the preparation of tea infusion with water at a temperature below boiling point, no germs are eliminated, including bacterial

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spores. Processed, dry tea leaves are susceptible to microbial contamination.

Thus, teas are a potential reservoir of microorganisms. They can be contaminated with a wide range of bacteria and fungi which pose a threat to consumers' health. The adverse health effect of microbial contamination is specifically associated with the ingestion of toxins produced by these pathogens (Mishra *et al*., 2006). Among the studies involving microbial contamination of dried plants, the most frequently examined products are spices. However, few researchers have devoted attention to dried tea leaves. Previous studies aimed at assessing the microbiological contamination of black and green teas indicate the poor microbial quality of these products (Steinka *et al*., 2011; Tournas and Katsoudas, 2008; Kosalec *et al*., 2009).

It is, therefore, necessary to examine the microbiological status of teas. There is a lack of current data on the microbial quality of teas. The present study aimed to determine the degree of microbial contamination of black and green teas of different degrees of fragmentation currently available on the market.

MATERIALS AND METHODS

The material that was subjected to microbiological analysis consisted of 18 black and green teas commonly available on the market. The exact characteristics of the material examined, taking into account the degree of fragmentation of black and green teas and their country of origin, are presented in Tables.

The individual teas were weighed into 10 g samples and placed in flasks containing sterile dilution liquid. Each sample was subjected to a leaching process for 5 min, followed by sedimentation for 15 min (PN-EN ISO 6887-4, 2017). The resulting stock solution was the basis for dilution and subsequent inoculation on appropriate media. Microbiological analysis included determination of the total number of mesophilic aerobic bacteria (enriched agar, BTL Ltd, Poland), total number of fungi (Sabouraud agar with chloramphenicol, BTL Ltd, Poland), total number of Gram-negative bacilli (MacConkey agar, BTL Ltd, Poland) and determining the total number of staphylococci (Chapman agar, BTL Ltd, Poland). The substrates used in the studies were incubated in the following conditions: the agar medium was incubated for 24 h at 37°C, followed by 72 h at 25°C, Sabouraud medium 5-7 days at 25°C, MacConkey medium for 24 h at 37°C and Chapman medium for 24 h at 37°C. All the analyses were duplicated.

After the incubation, the cultivated microbial colonies were counted and the results were presented in a form of the arithmetic Mean (M) and the Geometric Mean (GM) in 1 g of the analyzed material (CFU/g). The values were also expressed as a CFU (colony-forming unit) logarithm for individual tea samples (log CFU/g). On the basis of macroscopic and microscopic features after previous Gram staining, further species identification was conducted using biochemical API tests (BioMérieux Ltd., Poland). The grown filamentous fungi were identified using the Watanabe identification key (Watanabe, 2002). The results of the study were statistically analyzed using the Statistica software (v 8.0). The average values marked with the same letters (a, b,) differ significantly at $p \leq 0.05$.

RESULTS

The results of microbiological tests of black and green teas are provided in Table 1 to 6. Tea in bags proved to be the most polluted with aerobic mesophilic bacteria - 4.7×10^3 CFU/g (3.67 log CFU/g) for black teas in bags and 2.9×10^4 CFU/g (4.46 log CFU/g) for green teas in bags. Green leaf teas were the least contaminated - 2.0×10^3 (3.31 log CFU/g). As far as the analysis of tea contamination with mesophilic aerobic bacteria is concerned, no statistically significant differences were observed (Table 1).

The level of mycological contamination of the analyzed teas is shown in Table 2. The highest geometric mean value indicating the highest mycological contamination was obtained for green teas in bags - 9.3×10^3 CFU/g (3.97 log CFU/g). The lowest fungi load among green teas were observed for green leaf teas - 1.7×10^2 CFU/g (2.24 log CFU/g). Teas characterized by a minimal number of fungi included black ground teas - 3.5×10^2 CFU/g (2.55 log CFU/g).

Statistical analysis indicated significant differences in mycological contamination between black and green teas and their degree of fragmentation. Green tea in bags manifested the highest fungal contamination, significantly exceeding the other teas. The growth of fungi did not occur in one black granulated tea and green leaf tea. Statistically significant differences in the number of fungi in teas were also recorded between black teas - ground tea and bagged tea and between the group of green leaf tea and black tea in bags (at $p \leq 0.05$), (Table 2).

The level of tea contamination with Gram-negative bacteria is presented in Table 3. The highest contents of Gram-negative rods were recorded for black leaf teas - 1.8×10^3 CFU/g (3.26 log CFU/g) and the lowest for black teas in bags - 4.0×10^2 CFU/g (2.60 log CFU/g). In the remaining groups, the content of bacilli was similar and ranged from 9.5×10^2 CFU/g (2.98 log CFU/g) to 1.1×10^3 CFU/g (3.05 log CFU/g). Two leaf teas, one ground tea, two granulated teas and one bagged tea were found to be free from Gram-negative

bacilli. Among green teas Gram-negative bacilli were found only in one leaf tea and one bagged tea (Table 3).

Table 4 presents the results of the quantitative share of staphylococci in the tested teas. The contamination of black and green tea with staphylococci ranged from 1.5×10^2 to 9.8×10^4 CFU/g. Only four black teas were contaminated with staphylococci. The highest contamination was 8.1×10^2

Table 1: Total number of aerobic mesophilic bacteria in the tested teas (CFU/g)

Type of tea		Country of origin	Sample no.	M	GM	Log	Group GM	Group log
Black teas	Loose leaf	China	1	1.2×10^4	11683.32	4.07	3.4×10^3	3.54
		India	2	7.3×10^3	6923.87	3.84		
		Sri Lanka	3	5.0×10^2	500.00	2.70		
	Ground	NDA	1	1.3×10^3	1249.00	3.10	3.4×10^3	3.53
		NDA	2	5.6×10^3	5484.52	3.74		
		China	3	5.8×10^3	5800.00	3.76		
	Granulated	India	1	1.9×10^3	1897.37	3.28	2.6×10^3	3.41
		India	2	1.4×10^3	1400.00	3.15		
		China	3	6.3×10^3	6296.82	3.80		
	Bagged tea	NDA	1	3.6×10^3	3598.61	3.56	4.7×10^3	3.67
		India	2	2.9×10^3	2846.05	3.45		
		NDA	3	1.0×10^4	10092.08	4.00		
Green teas	Loose leaf	NDA	1	1.3×10^3	1300.00	3.11	2.0×10^3	3.31
		China	2	6.5×10^3	6148.17	3.79		
		China	3	1.1×10^3	1058.30	3.02		
	Bagged tea	China	1	1.5×10^4	15194.74	4.18	2.9×10^4	4.46
		NDA	2	1.1×10^4	10482.84	4.02		
		NDA	3	1.6×10^5	155267.51	5.19		

Arithmetic mean (M), geometric mean (GM), per unit accepting CFU/g (colony forming units per gram of the tested material); NDA: No data available

Table 2: Total number of fungi in the tested teas (CFU/g)

Type of tea		Country of origin	Sample no.	M	GM	Log	Group GM	Group log
Black teas	Loose leaf	China	1	4.5×10^2	424.26	2.63	7.5×10^2 a	2.87
		India	2	4.1×10^3	4012.48	3.60		
		Sri Lanka	3	2.5×10^2	244.95	2.39		
	Ground	NDA	1	6.0×10^2	591.61	2.77	3.5×10^2 bcd	2.55
		NDA	2	5.5×10^2	529.15	2.72		
		China	3	1.5×10^2	141.42	2.15		
	Granulated	India	1	20×10^3	1959.59	3.29	3.5×10^3e	3.54
		India	2	0	0	0		
		China	3	6.1×10^3	6033.24	3.78		
	Bagged tea	NDA	1	2.1×10^3	2090.45	3.32	1.4×10^3 cfg	3.16
		India	2	1.7×10^3	1700	3.23		
		NDA	3	8.5×10^2	836.66	2.92		
Green teas	Loose leaf	NDA	1	1.0×10^2	100	2.00	1.7×10^2 dfh	2.24
		China	2	0	0	0		
		China	3	3.0×10^2	300	2.48		
	Bagged tea	China	1	2.2×10^4	21601.39	4.33	9.3×10^3 abegh	3.97
		NDA	2	3.2×10^3	3146.43	3.55		
		NDA	3	1.2×10^4	11900	4.08		

a, b, c ...: The means marked with the same letters differ significantly at $p\leq0.05$

Table 3: Growth of gram-negative bacilli in the tested teas (CFU/g)

Type of tea		Country of origin	Sample no.	M	GM	Log	Group GM	Group log
Black teas	Loose leaf	China	1	1.9×10^3	1816.59	3.26	1.8×10^3	3.26
		India	2	0	0	0		
		Sri Lanka	3	0	0	0		
	Ground	NDA	1	0	0	0	1.1×10^3	3.05
		NDA	2	4.5×10^2	424.26	2.63		
		China	3	2.9×10^3	2929.16	3.47		
	Granulated	India	1	0	0	0	1.5×10^3	3.16
		India	2	0	0	0		
		China	3	1.5×10^3	1449.14	3.16		
	Bagged tea	NDA	1	8.0×10^2	800	2.90	4.0×10^2	2.60
		India	2	2.0×10^2	200	2.30		
		NDA	3	0	0	0		
Green teas	Loose leaf	NDA	1	0	0	0	1.1×10^3	3.05
		China	2	1.2×10^3	1131.37	3.05		
		China	3	0	0	0		
	Bagged tea	China	1	0	0	0	9.5×10^2	2.98
		NDA	2	0	0	0		
		NDA	3	9.5×10^2	948.68	2.98		

Table 4: Growth of staphylococci in the tested teas (CFU/g)

Type of tea		Country of origin	Sample no.	M	GM	Log	Group GM	Group log
Black teas	Loose leaf	China	1	0	0	0	0	0
		India	2	0	0	0		
		Sri Lanka	3	0	0	0		
	Ground	NDA	1	1.5×10^2	141.42	2.15	1.4×10^2	2.15
		NDA	2	0	0	0		
		China	3	0	0	0		
	Granulated	India	1	0	0	0	1.4×10^2	2.15
		India	2	0	0	0		
		China	3	1.5×10^2	141.42	2.15		
	Bagged tea	NDA	1	4.0×10^2	264.58	2.42	8.1×10^2	2.91
		India	2	0	0	0		
		NDA	3	2.5×10^3	2491.99	3.40		
Green teas	Loose leaf	NDA	1	0	0	0	0	0
		China	2	0	0	0		
		China	3	0	0	0		
	Bagged tea	China	1	4.7×10^3	4589.12	3.66	1.1×10^4	4.02
		NDA	2	2.7×10^3	2626.79	3.42		
		NDA	3	9.8×10^4	97211.11	4.99		

Table 5: Bacteria identified in the tested teas

Test	Bacteria strain
API 20 E	*Klebsiella pneumoniae* ssp *pneumoniae 1*
	Shigella sonnei
	Shigella sp.
	Ewingella americana
	Pseudomonas oryzihabitans
API STAPH	*Staphylococcs sciuri*
	Micrococcus sp.
API CORYNE	*Cellulomonas*/*Microbacterium* spp
	Corynebacterium spp

Table 6: Fungi identified in the tested teas (%)

Type of tea		Country of origin	Sample no.	M	Log	Identified fungi	(%)
Black teas	Loose leaf	China	1	4.5×10^2	2.63	*Aspergillus niger*	44.5
						Cryptococcus albidus	22.2
						Rhizopus sp.	22.2
						Rhizopus oryzae	11.1
		India	2	4.1×10^3	3.60	*Aspergillus niger*	97.5
						Aspergillus flavus	2.5
		Sri Lanka	3	2.5×10^2	2.39	*Aspergillus niger*	100
	Ground	NDA	1	6.0×10^2	2.77	*Aspergillus niger*	91.7
						Mucor sp.	8.3
		NDA	2	5.5×10^2	2.72	*Aspergillus niger*	90.9
						Aspergillus flavus	8.1
		China	3	1.5×10^2	2.15	*Aspergillus niger*	66.7
						Aspergillus versicolor	33.3
	Granulated	India	1	2.0×10^3	3.29	*Aspergillus niger*	67.5
						Aspergillus sp.	27.5
						NI	5
		India	2	-	-	NG	-
		China	3	6.1×10^3	3.78	*Aspergillus niger*	86.9
						Aspergillus sp.	11.5
						Mucor sp.	0.8
						Penicillium expansum	0.8
	Bagged tea	NDA	1	2.1×10^3	3.32	*Aspergillus niger*	95.2
						Rhizopus sp.	2.4
						Mucor sp.	2.4
		India	2	1.7×10^3	3.23	*Aspergillus niger*	97.1
						Aspergillus flavus	2.9
		NDA	3	8.5×10^2	2.92	*Aspergillus niger*	52.9
						Aspergillus sp.	35.3
						Aspergillus flavus	5.9
						NI	5.9
Green teas	Loose leaf	NDA	1	1.0×10^2	2.00	*Aspergillus flavus*	50
						Cladosporium sp.	50
		China	2	-	-	NG	-
		China	3	3.0×10^2	2.48	*Aspergillus niger*	100
	Bagged tea	China	1	2.2×10^4	4.33	*Aspergillus niger*	99.8
						Rhizopus sp.	0.2
		NDA	2	3.2×10^3	3.55	*Aspergillus niger*	98.4
						Mucor hiemalis	1.6

Table 6: Continue

Type of tea	Country of origin	Sample no.	M	Log	Identified fungi	(%)
	NDA	3	1.2×10^4	4.08	*Aspergillus niger*	97.9
					Aspergillus sp.	0.8
					Mucor sp.	0.8
					Rhizopus sp.	0.5

NDA: No data available; NI: Not identified; NG: No growth

CFU/g (2.91 log CFU/g) and was noted for black teas in bags. As far as green teas are concerned, an increase on the staphylococcal load was observed exclusively for tea in bags. Green teas in bags was the most contaminated with staphylococci - 1.1×10^4 CFU/g (4.02 log CFU/g).

Among tested teas, the bacteria listed in Table 5 were isolated the most frequently. They were both naturally occurring bacteria in the environment, e.g., *Cellulomonas* spp. or *Corynebacterium* spp., as well as those that may exert a harmful effect upon consumers' health under adverse environmental conditions, i.e., *Shigella* spp.

Fungi present in the analyzed material belonged to species: *Aspergillus*, *Cryptococcus*, *Rhizopus*, *Mucor*, *Penicillium* and *Cladosporium* (Table 6). *Aspergillus niger* constituted the largest share of fungi among black teas - 44.5 to 100%. A significant percentage of isolates contained species of the *Aspergillus* genus, including *A. flavus* and *A. versicolor*. The yeast-like fungi represented by *Cryptococcus albidus* constituted 22.2% of the percentage of leaf tea isolates.

DISCUSSION

Monitoring the quality of products and raw materials are pursued not only to meet consumers' expectations but also search for safe, high-quality food products comply with applicable regulations. Currently, both the range of tea and its consumption increase. This is especially characteristic for teas in bags, the so-called express tea, to the disadvantage of leaf tea-uncrushed (Dmowski *et al*., 2009; Al-Sohaibani *et al*., 2011; Lindow and Brandl, 2003).

Czerwińska and Piotrowski (2006) analyzed the microbial load of two black and green teas from different manufacturers. The authors mentioned above obtained slightly lower values than in our data. In other studies concerning a greater variety of teas, the bacterial and fungal contamination rates were markedly more diversified than in results of our paper. In the research conducted by Dmowski *et al*. (2009) the number of bacteria in green teas ranged from 1.2 to 5.3 log CFU/g, from 1.5 to 4.0 log CFU/g in granulated teas and from 1.8 to 5.5 log CFU/g in tea dust.

Among the literature data focused on the analysis of the total number of fungi in tea leaves, a significant discrepancy of results is observed. Analogous studies were undertaken by Steinka *et al*. (2011). The total number of fungi in green tea varied from 1.0 to 4.81 log CFU/g, in granulated teas 1.2 - 3.93 log CFU/g, while the concentration of fungi in teas in bags was 1.0 - 2.54 log CFU/g and was smaller than in our research. Lower values were obtained by Dmowski *et al*. (2009), where the contamination amounted to 2.3 log CFU/g in leaf teas and 2.5 log CFU/g in granulated teas. Škrinjar *et al*. (2011) stated that tea is less contaminated with fungi in comparison with other dried plant products. Steinka *et al*. (2011) marked the number of staphylococci for a wide variety of dried plant materials: herbal teas in bags were less contaminated than green tea. We have indicated the presence of *Shigella* among the tested teas. This is a species causing dysentery, which manifests with severe bleeding and inflammation of the colon mucosa (Alwakeel, 2008). Another potentially pathogenic bacteria isolated in our studies was *Klebsiella pneumoniae*, which was also isolated in studies conducted by Idu *et al*. (2011). *Klebsiella* spp. are classified as bacteria from the Coliform group, whose presence in the examined material may be the evidence of fecal contamination (Abba *et al*., 2009). Also, Carraturo *et al*. (2018) detected the presence of bacteria that is an etiological factor of food poisoning - *Clostridium perfrigens*, among commercially available black and green teas. Abba *et al*. (2009), Alwakel (2008) and Idu *et al*. (2011) found the presence of coliform and other pathogenic species in the analyzed plant raw materials. Studies on the microbiological quality of dried herbs by Abba *et al*. (2009) indicate their contamination with *Salmonella typhi*, *Shigella* sp., *Escherichia coli* or *Staphylococcus aureus*. Besides, they also observed that the level of humidity in herbs influences the number of microorganisms. However, not all authors concerning the microbial contamination of dried plant products stated the presence of pathogenic microorganisms. In the studies by Brużewicz and Malicki (2007) and Zweifel and Stephan (2012), *Escherichia coli* or *Salmonella*, as well as coagulase-positive staphylococci were not isolated from dried spices. Many authors have noticed that *Staphylococcus aureus* rarely belongs to the contaminants of plant material (Kosalec *et al*., 2009). We confirmed this observation in the results of this study.

The results of our studies are relatively consistent with the available literature data, especially regarding the contamination of tea leaves with fungi. In the present study the most frequently isolated fungi was *Aspergillus niger*. This species was also the most prevalent one in studies conducted by Carraturo *et al*. (2018) and Tournas and Katsoudas (2008). The latter

author's found that black tea in bags was considered the most mycologically contaminated, which is also confirmed in our research. It is worth notice that many author's results indicate a great diversity of *Aspergillus* sp. Škrinjar *et al*. (2011) found that the most contaminating fungal species are those of the *Aspergillus* genera (*A. awamori*, *A. niger*, *A. versicolor*, *A. lovaniensis*, *A. restrictus*, *A. repens*, *A. sydowii*), but also *Eurotium* spp. (*E. asmtelodamii*, *E. chewalieri*, *E. herbarorium*) and *Penicillium chrysogenum*. However, among the fungi isolated by Al-Sohaibani *et al*. (2011) the most frequently occurring in dried teas were *A. flavus*, *Penicillium* spp., *Pacelomyces* spp. and *Mucor* spp. In the data contained in the paper by Steinka *et al*. (2011), including mycological analysis of black, green, granulated and dusty teas, the predominant species was *Ulocladium chartarum* - it accounted for as much as 89% of the identified fungi. Podgórska and Solarska (2017) report that filamentous fungi from the genera of *Aspergillus* or *Penicillium* are often isolated from dried plants, as shown by the results quoted above. This indicates a significant threat to the safety and quality of these raw materials.

Molds belonging to *Aspergillus* and *Penicillium* species produce secondary metabolites known as mycotoxins, e.g., ochratoxin A and numerous aflatoxins: patulin, citrine, citrerocridine, rubratoxin, penicillin, cyclopiazonic and mycophenolic acid. The main feature of *Aspergillus* fungi is the possibility of growth in an environment with low water content. For this reason, vegetable raw materials of this type should be dried as soon as possible to prevent their multiplication and thus stop the production of toxins (Carraturo *et al*., 2018; Bugno *et al*., 2006). The microbiological quality of dried raw materials for medical purposes (e.g., herbs) is much stricter, although, in terms of quality composition, they are often similar to dried tea (Steinka *et al*., 2011). In the studies conducted by Bugno *et al*. (2006) on the microbiological purity of herbal medicines, the *Aspergillus* genus was also indicated as the most frequent. Among the isolates obtained there were *A. flavus*, *A. niger*, *A. ochraceus*, fewer species of *Rhizopus*, *Mucor*, *Cladosporium*, *Chaetomium*, *Trichoderma* and *Phoma* genera. Similar results were obtained by Toma and Abdulla (2013) and Rawat *et al*. (2014) who also indicated representatives of *Aspergillus*, *Penicillium* or *Mucor* genera as the most numerous in the microflora of medicinal plants. Although herbal medical products and tea leaves serve a different purpose, it can be noted that the results of studies on their microbiological quality are very often similar.

Compared to green teas, the degree of fragmentation of black teas significantly affects their contamination with filamentous fungi, probably due to differences in the production process, resulting in different chemical composition. The technological process of green teas is conducted without the leaf fermentation, which leads to the inhibition of enzymatic activity. The lack of fermentation stage increases the level of biologically active compounds in the raw material, thus can protect the green tea against excessive contamination with fungi (Świderski and Waszkiewicz-Robak, 2012). We observed a statistically significant difference in the contamination of black ground teas and those in bags, which may be related to the quality of the product - the lower the product quality (greater fragmentation), the lower the microbiological quality.

Analyzing the obtained test results, one can point to a high degree of microbial contamination of both black and green teas. There are many potential reasons behind the phenomenon, e.g., contamination of plants at the stage of cultivation and harvesting, insufficient drying, abnormal conditions and excessive storage time (Carraturo *et al*., 2018; Kosalec *et al*., 2009; Quadros Rodrigues *et al*., 2014; Al-Sohaibani *et al*., 2011). Such shortcomings can lead to the multiplication of pathogenic microorganisms producing toxins in the plant material, thus creating a health hazard for consumers. For this reason, it is necessary to introduce monitoring at every stage of processing to improve hygienic conditions during the production, handling, storage and commercialization of these products.

CONCLUSION

In summary, the group of teas with the highest contamination with aerobic mesophilic bacteria were green tea in bags (4.46 log CFU/g) and the purest - green leaf tea (3.31 log CFU/g). The largest number of fungi was observed in green teas in bags (3.97 log CFU/g) and the lowest for green leafy teas (2.24 log CFU/g). Our study demonstrated that there is significant relationship between the degree of tea fragmentation and their microbial contamination. Potentially pathogenic bacteria isolated from black and green tea may pose a threat to consumers' health. Xerophilous filamentous fungi should be considered as a qualitative indicator of microbial contamination of tea.

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