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Evaluation of Some Food Products Produced in Azerbaijan According to the Species Composition and Ecological-Trophic Relations of Fungal Biota

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ABSTRACT

The life activities of living things (plants and animals) used by human beings for food purposes occur in an open system which makes their contact with microorganisms, including fungi, inevitable. As a result, in all products are found either the microorganisms themselves or their metabolites. This leads to a deterioration in the quality and quantity of products. For this reason, to ensure the microbiological safety of products currently used for food purposes is of great importance, in the present work a number of products used for food purposes in Azerbaijan (beef, mutton and chicken, cow's milk, fruits and vegetables) were studied by their species composition and ecological-trophic relationships. It became clear that, studied food products are also one of the habitats of species belonging to different taxonomic groups of fungi. It also became evident that, foodstuffs are one of the habitats of fungi, and in the course of research identified that in the formation of mycobiota of sampled materials involved 63 species of true fungi. Most of the registered fungi (90.5%) belong to sack fungi (Ascomycota), and a small part (9.5%) to zygomycetes (Zygomycota). Among the fungi met both anamorphs (*Aspergillus, Fusarium, Penicillium* and others. species) and telemorphs (G*loeosporium ampelophagum, Monilia fructigena, M.sitophila, Podosphaera leucotricha* and others). Among the registered fungi were identified allergens, toxigens, conventional pathogens, and fungi of whose biotrophy and saprotrophy have not real character. Therefore, in ensuring food safety should be one of today's topical issues inclusion of indicators reflecting both the ecological- trophic relationships of fungi, as well as their ecological- trophic specialization.

KEY WORDS: FOOD MATERIALS, MYCOBIOTA, ECOLOGICAL-TROPHIC RELATIONS, CONVENTIONAL PATHOGEN, ALLERGEN, TOXIGENIC, FOOD SAFETY

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INTRODUCTION

As known, the basis of human food consists of products prepared separately from plants, animals, fungi, and bacteria, as well as products made by their participation in various combinations. Although their use changes from time to time (Fernando, 2011), these sources are still on the basis of human nutrition. As the world's population continues to grow, their demand for food is also increasing which creates certain problems in food

security. It is no coincidence that today, millions of people in many parts of the world are suffering from problems such as food shortages (FAO, 2017). For this reason, the efficient use of existing food sources, as well as the creation of new sources is one of the most important issues of the modern era.

The importance of resolving this issue is related to another point. Thus, in the composition of plant and animal products, which still have a high share in the meeting of people's food needs, also contains substances necessary for the nourishment of microorganisms (Santos Pereira et al., 2019). Almost all plant and animal foods are produced mainly in an open system. For this reason, their contact with microorganisms is inevitable, and in all the produced products are found either the microorganisms or their metabolites (Misihairabgwi et al., 2019).The impact of both microorganisms themselves and their metabolites on human health, as well as on the quality and quantity of plant and animal products, is not always evaluated positively. Therefore, the microbiological safety of raw materials, semi-finished products, as well as finished products intended for food purposes is of great importance, (Makinde et al., 2020).

The primary task in clarifying these issues is considered to be characteristic of the microbiota of food products in terms of number and species composition, as well as the ecological and trophic relationships of the species involved in the formation of this microbiota. Thus, in order to solve any problem, initially, it is necessary to accurately identify its "participants". Extensive research has been conducted to evaluate microbiological, especially bacterial biota of materials intended for food purposes and some related issues have been clarified (Moradali and Rehm, 2020). Stages of production of plant and animal products for food purposes from production to use usually occurs under non-sterile microbiological conditions and therefore from a taxonomic point of view microorganisms, especially fungi, are considered their natural contaminants (De Borba et al., 2020). However, there is not enough research to evaluate the materials intended for food purposes for fungal biota, and there are still many issues that need to be addressed. Therefore, the purpose of the present work was dedicated to the assessment of the species composition of fungi involved in the formation of mycobiota of some plant and animal materials intended for food purposes and to the manifestations of their ecological-trophic specialization.

MATERIAL AND METHODS

Materials for the study were taken from plant (fruits such as apples, pears, grapes, pomegranates, cherries, etc., and vegetables such as tomatoes, cucumbers, cabbage, eggplant, etc.) and animal origin materials (beef, mutton and chicken, cow's milk) intended for food purposes in Azerbaijan. These materials were taken from products sold to people wholesale and retail, and raw materials imported to process. Sampling, certification, and preparation for laboratory analysis were carried out in accordance with the methods and approaches intended for this purpose (Handbook of Mycological Methods, 2006, Neusely da Silva et al., 2018). To separate the fungi from the samples were used from mediums such as Saburo agar, wort -agar, and agarized Czapek. To obtain pure cultures and determined their species composition were used from known determinants (Kirk et al., 2008, Satton et al., 2001).

Table 1. Taxonomic structure of the species involved in the formation of mycobiota of the studied food origin materials

Sample materials	Total number of registered species	Mycota	
		Zygomycota	Ascomycota
Beef	20	2	18
Mutton	17	2	15
chicken meat	23	3	20
Cow's milk (freshly)	12	2	10
Fruit	37	4	33
Vegetables	31	3	28
Total	63	6	57

In the naming of fungi were used from internationally accepted and widely used principles and approaches (Pedro W. Crous et al., 2015). Although the clarification of ecological and trophic specialization of fungi was carried out mainly taking into account the literature, the toxicity of some species has also been identified for both plants (tomatoes, cucumbers, and wheat) and infizor. During carried out this work were used from the methods and approaches used in our previous work (Bakshaliyeva et al., 2020, Yusifova et al., 2020).

RESULTS AND DISCUSSION

During the analysis of fungal biota of plant and animal origin products intended for food purposes determined that in the formation of their mycobiota mainly participants real fungi (Mycota) that the information on their taxonomic structure summarized in the Table 1. As seen, 63 species (*Alternaria alternat, A.mali, A.solani, A.tenuissima, Aspergillus flavus, A.fumigatus, A.niger, A.ochraeus, A.repens, A. terreus,*

A.versicolor, Botrytis cinerea, Candida alpicans, Chaetomium cellulolyticum, Cladosporium cladosporides, C.herbarum, Coniothyrium diplodiella, Debaryomyces hansenii, Endomuces vernalis, Fuzarium moniliforma, F.oxysporum, F.semitechium, F.solani, Geotrichum candidum, Gloeosporium ampelophagum, Gloeosporium fructigenum, Guignardia bidwellii, Monilia fructigena, M.sitophila, Mucor hiemalis, M.mucedo, M.rasemous, Paecilomyces variottii, Penicillium camemberti, P.citrinum, P.chrysogenum, P.cuclopium, P.decumbens, Penicillium digitatum, P.funiculosum, P.expancum, Penicillium glaucum, P.purpurogenium, Phoma rostrupii, Ph.uvicola, Phyllosticta mali, Podosphaera leucotricha, Rhizobus nigricans, Rh.stolonifer, Saccharomyces cerevisia, Saccharomyces vini, Sclerotinia fructigenum, Sclerotinia libertiana, Sporotrichum camis, Stachybotrys chartarum, Thamnidium elegans, Trichoderma lignorum, T.viride, Trichothecium roseum, Torulopsis candida, Venturia inaequalis and *Verticillium dahliae* and *Yarrowia lipolytica*) of fungi takes part in the sample food materials, most of which (90.5%) belongs to the sac fungi(Ascomycota) and a small proportion (9.5%) to the zygomycetes (Zygomycota). Among the fungi met both anamorphs(*Aspergillus, Fusarium, Penicillium* and others. species) and telemorphs (*Gloeosporium ampelophagum, Monilia fructigena, M.sitophila Podosphaera leucotricha*, and others).

It is known that between fungi and other living things, including plants and animals have different relationships. Sometimes, depending on the form of this relationship, the nature of the functions performed by fungi also changes. For this reason, the characterization of fungi from this aspect was of interest both from a scientific and practical point of view. When characterizing the recorded fungi from this aspect, became clear that among the recorded fungi, true biotrophs were not found, saprotrophs made up only 11.1% of the total fungi. The reason why not found real biotrophs was that they are not biologically alive, although all of the sampled materials belonged to living things, (Naranjo-Ortiz and Gabaldon, 2019).

Table 2. Characteristics of fungi species by the manifestations of ecological-trophic specialization recorded in the analyzed materials.

Analyzed products	Total	Number of fungi species, including			
		Conditional pathogens (%)	Allergens (%)	Toxigens (%)	Those whose status is unknown (%)
Beef	20*	25,0	30,0	55,0	20,0
Mutton	17	23,5	29,4	52,9	29,4
chicken meat	23	26,1	30,4	56,5	26,1
Cow's milk (freshly milked)	12	16,7	25,0	41,7	58,3
Fruit	37	16,2	27,0	51,3	18,9
Vegetables	31	25,8	32,3	48,4	22,6

Note: * - some fungi have a dual, some a triple (allergen, toxigen, and conventional pathogen) feature, for this reason, the sum of the data in % in the table is more than 100

Fungi also differ by ecological-trophic specialization - toxigenic, allergenic, conditionally pathogenic. Characterization of fungi from this aspect is also important in terms of biosafety and hygienic requirements for the nutritional value of food materials of both plant and animal origin. When characterizing the registered fungi from this aspect, became clear that among the registered fungi there were species that have been confirmed to be toxigenic, allergenic, and conditionally pathogenic, and their specific gravity was significant (Table 2). As seen, the materials differed from each other in these respects. Thus, the specific gravity of conventional pathogens was found in vegetables, the specific gravity of allergens in chicken meat, and the specific gravity of toxigens in fruits.

As noted, plant and animal foods play an important role in the human diet, and today there is no alternative source that can replace them. Production of almost all food products, transportation and storage of finished products, and other processes carried out under conditions not fully compliant with microbiological sterility (Muradov et al., 2011). The composition of various nutrients rich in various organic and inorganic substances. These nutrients suitable not only for humans, also for other living things. Therefore to develop food safety principles one of the very important issues. From the obtained results became clear that materials that have been researched and widely used for food purposes in the world, including Azerbaijan, are no exception in this regard. All of them characterized by one of the places where fungi were found. On the other side, from the obtained results became clear that animal products characterized by a lack of fungal biota compared to plant-based foods (Table 1).

Thus, the number of species of fungi involved in the formation of mycobiota in beef was 1.85 times less than in fruits, and 1.55 times less than in vegetables. Similar comparisons with other products are always

in favor of plants. This is due to the predominance of polysaccharides among the components of plants and the fact that it is a more suitable food source for fungi. Among the reasons for the widespread spreads of fungi in plant materials the acidity of the environment also plays a role. Thus, the acidity of meat is neutral and high (towards alkalinity), while that of fruits and vegetables is generally neutral and low (towards acidity). An acidic environment is more conducive to the growth of fungi, which was confirmed in our previous studies (Bakshaliyeva et al, 2020).

Based on the interaction of fungi with other living things formed over many years stands their attitude to food, and ecological-trophic features (Naranjo-Ortiz and Gabaldon, 2019). Many studies have confirmed the importance of this approach, both in terms of the functions performed by fungi in their habitat, as well as in terms of assessing the nutritional value of the substrates with which they come into contact (Snyder et al. 2019). From the results carried out of our research became clear that although a wide range of fungi does not participate in the formation of mycobiotas of plant and animal origin food materials, the predominance of polytrophs among them can be assessed as a negative case. Thus, the adaptability of polytrophs especially in terms of meeting their food needs higher than other ecological groups (true saprotrophs and biotrophs), which allows them to more widespread.

The specialization of fungi from the point of view of ecological-trophic relations also different (Richards et al., 2017) and this does not manifest itself in all fungi. Thus, the form of expression of the ecological-trophic specialization of fungi manifests itself in the forms of conditional pathogenicity, allergenity, and toxigenicity. Fungi complying with this characteristic participates in the mycobiota of studied animal and plant food materials and their specific gravity sometimes more than 50% (Bakshaliyeva, 2017). There are enough research materials about the negative impact of fungi that meet this characteristic on the health of other living things, especially humans. However, the sanitary-epidemiological rules and regulations adopted in many countries, including the Republic of Azerbaijan, do not contain indicators regulating the activity of these fungi.

Therefore, the inclusion of indicators aimed at ensuring food safety should be one of today's topical issues. It would be useful to explain our opinion with the information obtained about toxigenic fungi. So that, the number of fungi species that synthesize toxic substances is more than 300, and the number of mycotoxins they produce is more than 500 (Cinar and Onbashı, 2019). Mycotoxins are toxic secondary metabolites produced by various filamentous fungi, of which Fusarium, Aspergillus and Penicillium are the three main genera (Greeff-Laubscher et al., 2020).

With the development of science and technology, the probability that this number will increase is real, and among the mycotoxins synthesized by toxigenic fungi known to science today are those that adversely affect human health in any concentration (Ogunade, 2018). Therefore, the permissible number of fungi in food substances should be specified on the basis of specific groups, but not in generally. Since in similar documents in many countries this does not exist. In this regard, it is necessary to pay special attention to the fact that some fungi carry all of the mentioned features.

For example, in research has been confirmed that A. niger has all the mentioned features.It is impossible to give a definitive opinion about some of the fungi isolated in studies because literature data was not found about on their characterization according to their ecological-trophic specialization in this or that research. On the other side, although some of them have phytotoxic activity against plants, but they do not show such a feature against to infizors. For this reason, it is not possible to give an unequivocal opinion about their status, and in the study was considered expedient recorded their status as groups of unknowns (Table 2) and to clarify this in future studies.

CONCLUSION

Thus, various meats, fruits, and vegetables intended for food purposes in the Republic of Azerbaijan, have been characterized as one of the places for feeding and habitats of fungi. It was determined that in the formation of mycobiota of sampled food materials involves the species of fungi characterized by diversity both in terms of ecological-trophic relations and forms of its specialization. The presence of toxigens, allergens, as well as opportunistic pathogens among the registered fungi, allowed to emphasize the need specification of indicators regulating the activity of this type of fungi for the adoption of the sanitary-epidemiological rules and regulations related to food products.

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