

COMPARISON OF MICROBIOLOGICAL SAFETY OF PASTA AND PASTA RELATED PRODUCTS DEPENDING ON THE CONDITIONS OF PRODUCTION

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ABSTRACT: Pasta and related products based on wheat grains represent foodstuffs that are characterized by optimal ratio of basic nutrients. Therefore they have an important place in human nutrition. Pasta and related products have almost daily presence in nutrition. Their production can take place in industrial and artisanal conditions. Among many advantages in industrial production, significantly greater microbiological safety of the finished product is one of the most important.

The aim of this paperwork was to investigate the microbiological safety of pasta and related products produced in industrial plants that are fully automated and in handicraft establishments that are not fully automated.

We tested 120 samples of pasta produced in industrial conditions and 90 samples of pasta produced in artisanal shops. From the group of pasta related products the tests were conducted on phyllo and pasta tatters, 80 of those were produced in industrial conditions and 65 in artisanal shops. All samples of pasta and pasta related products manufactured in industrial conditions were correct. Of 90 samples of pasta produced in artisanal shops 18 samples were not correct due to the presence of coagulase positive staphylococci and increased total number of microorganisms. In some samples of phyllo made from Type 850 flour and from buckwheat flour an increased total number of microorganisms and increased total number of moulds were observed.

Key words: *pasta, phyllo, pasta tatters, microbiological safety*

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INTRODUCTION

Wheat and flour based products have a very important role in human nutrition. In the world, as well as in our country, pasta and pasta related products are present in human nutrition on a daily basis. Pasta is easily prepared and has a many advantages for consumers such as: low price, excellent nutritional value, countless ways of preparation, the possibility of storing for long period of time after production, etc. The quality of pasta and pasta related products

is a very important factor in terms of proper nutrition and placement on demanding markets, both domestic and foreign (Bejarović, 2001).

Depending on raw materials that are used, pastas are produced as: plain pasta and pasta with supplements. The pasta related products include: phyllo dough for pies and rolls, pasta tatters with and without eggs (Škrinjar & Tešanović, 2007).

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On the market pasta can be found as: fresh, semi-dry, dry, frozen and instant. By type, pasta can be: ribbon-cut, short and long.

Production of pasta can be industrial and handicraft. The industrial production consists of following technological operations:

- Preparation of raw materials for production,
- Dosing of raw materials and various supplements,
- Mixing the dough under vacuum,
- Pressing and shaping of fresh pasta,
- Cutting and placement of fresh pasta,
- Drying (pre-drying, drying and stabilization – cooling),
- Packaging of finished products,
- Transportation of finished products in storage area.

The advantages of industrial production opposite to artisanal production are:

- Improved features and a wider product range,
- Higher capacity,
- Reduction of manual labour,
- Higher hygienic safety of finished products,
- Packed products,
- The possibility of a longer storing of finished pasta.

Production of pasta related products such as phyllo and pastry tatters with eggs can be done in two ways: industrial and handicraft. Industrial production is automated, while in handicraft production the dough is made by hand. Technological flow of production includes the following stages of production:

- Preparing the flour,
- Mixing the flour with water,
- Extrusion,
- Cutting and pre-drying of phyllo,
- Wrapping, packing and hand weighing of phyllo.

There are different notions of quality of pasta because they are made by using different raw materials, production and quality control methods. Hygienic and sanitary characteristics are certainly one of the criteria for evaluating the quality of pasta.

Quality and safety of the finished product directly depend on quality and safety of raw

materials – mainly quality of wheat and semolina, and compliance with specific technological process of production. Raw materials for pasta and pasta related products are flour, water and various supplements that are used for enrichment of nutrients or improvement of aesthetic appearance of pasta (Bejarović, 2001).

The technological process of producing pasta and pasta related products from flour will not destroy the entire population of microorganisms that are present in flour. Some of them survive those processes and continue their development. Additional materials, water and especially employee hygiene and cleanliness of working surfaces, equipment and tools used in production of pasta and pasta related products represent a significant source of contamination (Došenović et al., 2001), (Tešanović, 2010). In micro population isolated from pasta one can often find micrococcus, *Escherichia coli*, pathogenic staphylococcus, enterococcus and other bacterial and fungal species. Pathogenic bacteria that can often be found are *Salmonella* species, especially in pasta with supplements. In that case, the main suspects are microbiologically contaminated eggs, their products or other supplements of animal origin, which are used in the production of pasta (Škrinjar and Tešanović, 2007), (De Lisio, 2000).

Due to its chemical composition, flour represents a very convenient environment for development of various populations of microorganisms. The largest number of microorganisms in the flour comes from wheat itself, while a smaller number contaminates the flour during the process of manipulation. Wheat and wheat products are often subject to infection with various fungi, many of which synthesize mycotoxins (Šarić et al., 2004).

In production of pasta, beside the flour (semolina), the most important component is water. All properties of the water that is used must match the quality of drinking water. It cannot contain mechanical impurities, some types of microorganisms and their metabolites, especially pathogenic microorganisms. The right water for kneading the dough for pasta production is the one that is moderately hard, hygienic and free of salts and heavy metals.

Other ingredients in the production of pasta can be eggs and egg products, milk and milk products, vitamins, emulsifiers, soy products, vegetables and others.

Eggs are one of the main additions in the production of pasta. They are used as fresh or canned eggs, as frozen or fresh mélange and as egg powder. Eggs contain very valuable nutrients. The addition of eggs to the dough deteriorates the microbiological picture because, in addition to the already present microorganisms that can be found in water and semolina, eggs that are used, depending on usage (fresh, frozen wiple egg or powder), are often the cause of possible contamination of pasta or excellent surfaces for reproduction of microorganisms.

The content of the egg is an ideal environment for growth and reproduction for many microorganisms. Particularly significant are species of genus *Salmonella* (Škrinjar & Tešanović, 2007). All salmonellas are pathogenic for humans. They cause intestinal diseases collectively known as salmonellosis.

In the production of pasta, in addition to fresh eggs, egg products like frozen mélange and egg powder are often used. Frozen mélange goes under process of pasteurization before freezing, followed by cooling and freezing at temperatures below -30 °C. Pasteurization of eggs without shells or their products usually takes place at a temperature of 63 °C to 65 °C for 4 minutes, followed by cooling at 4 °C. After pasteurization the products are frozen or dried. In frozen and inadequately pasteurized egg products some pathogenic microorganisms like *Salmonella* and *Staphylococcus aureus* can be found. These products pose a risk both to the health of consumers and for products in which they are added (Škrinjar and Tešanović, 2007).

Regardless of the method of production of pasta and pasta related products (industrial or artisanal) the common problem is subsequent contamination in production when employees do not use protective masks on their faces. The practice shows that problems can be caused by bacteria originating from secretions (saliva, mucus of nasal cavity, etc.). Critical points of possible contamination are mainly in two specific areas:

kneading the dough and packaging of finished products. It is enough that the person working on kneading the dough does not wear the protective mask and sneezes; during the kneading there is always invisible dust that comes from sifting and transportation of flour which irritates and forces sneezing and coughing. It is quite common phenomenon that employees ignore the symptoms of "light" cold caused by sudden temperature changes – plants for the pasta production are usually very warm and humid ($t = 25\text{ °C} - 30\text{ °C}$; $r_w = 75 - 90\%$), so moving from the warm area of the plant to the cold storage (warehouse) creates favourable conditions for development of respiratory problems. As a rule, employees with symptoms of cold should not stay at the facility, but the incubation and development of *Streptococcus* and *Staphylococcus* in the human body takes several days, so it is often discovered when the cold is already in an advanced stage.

Industrial method of production, as opposed to handicraft, usually has several stages: a heat treatment of dough during production process, the so-called pasteurization of freshly produced pasta, followed by pre-drying, drying on high temperatures and, in the end, conditioning of pasta which improves the microbiological safety of pasta. Regardless of the fact that microbial growth is affected by an exceptional nutritional base, suitable temperature, relative humidity of the air, water activity (a_w) in production of pasta through the use of high temperatures (pasteurization) and a high level of hygiene in production in terms of production and sanitation, industrial production has an advantage in relation to artisanal production.

Fresh pasta is a very favourable environment for development of various biochemical and microbiological processes. In order to prevent these processes raw pasta undergoes the process of preservation by drying. Water activity (a_w) in pasta, at the beginning of drying, is 0.8 to 1.0, while at the end of the process the value of a_w falls below 0.5, which helps in prevention of multiplication of microorganisms. The quality of the final product depends largely on the proper conduct of drying. Drying of pasta can be discontinued, with only one phase, and continuous with multiple pha-

ses. Discontinuous or batch drying is used in artisanal production of pasta. Multi-phase drying is used in industrial production of pasta and consists of pre-drying, drying and stabilization (cooling). The regime of drying imply the overall parameters for the air that is used for drying the pasta (temperature, humidity and air velocity), as well as drying time.

According to the temperatures used for drying the pasta, drying modes can be divided as follows:

- LT (low temperatures for drying the pasta, 40 °C to 60 °C),
- HT (high temperatures for drying the pasta, 60 °C to 84 °C),
- THT (very high temperatures for drying the pasta, 84 °C),
- Turbo-thermal processes.

The quality of finished product – looks and colour, moisture, caloric and nutritional value, microbiological safety and quality of cooked pasta depend on properly guided drying process. Pre-drying is the first phase in the process of drying and it is very delicate. The further course of drying depends on the proper pre-drying. After drying the pasta passes through a phase of stabilization and cooling. Before packing it is necessary to cool the pasta to the temperature of the room where it is packed, otherwise the hot pasta continues to evaporate. The process continues and, if packed, condensation of moisture can occur. It is desirable to use slow cooling of pasta in a period of 1 hour. The air that is blown over and around the product corresponds to the equilibrium moisture of pasta of 13%, temperature from 25 °C to 30 °C and relative humidity of 60% to 65%. For this reason it is necessary to condition the air inside the manufacturing plant (Bejarović, 2001). The production of pasta tatters and phyllo for pies and rolls is quite different from the production of pasta.

Phyllo is made by hand by pulling and stretching the dough on the tables where it is then dried using hot air and cut to the precise dimensions; afterwards phyllo is heat-treated on heated plates, and then cooled, measured and hand packed. Modern production of phyllo is performed by so-called “hot rollers” or by extruding with “extruder presses” and a system for stre-

tching and cutting. Duration of heat treatment of phyllo is different and depends primarily on the type of phyllo and projected operating parameters (temperature and humidity). A certain amount of humidity is removed from the room with the help of an extraction fan.

Pasta tatters, lasagne and other similar products can also be industrial and artisanal; production system can be extrusion or stretching and pulling of the dough using rotating rollers. These products can be dried or sold fresh.

MATERIAL AND METHODS

In this paperwork the microbiological safety of 210 samples of pasta and 145 samples of pasta related products were examined. Samples of pasta and pasta related products made in industry and handicraft were taken for the analysis. Pasta samples were grouped by the shape as long cut, short cut, rolled and lasagne sheets. The following samples of pasta related product for analysis were taken: phyllo (made from wheat flour type 500, type 800 and buckwheat flour) and pasta tatters made with eggs.

Microbiological testing of selected samples was conducted according to the methods of Regulation on the performance of microbiological analysis and super-analysis of foodstuffs (“Službeni glasnik SFRJ”, 25/1980) by the prescribed methods (method 1, method 3, method 4, method 8, method 9, method 10, method 11, method 12) in accordance with the Regulations on microbiological safety of foodstuffs in trade (“Službeni glasnik SRJ”, 26/1993, 53/1995 and 46/2002).

RESULTS AND DISCUSSION

Obtained results are shown in Tab.1,2,3,4. According to the Regulation on microbiological safety of foodstuffs in trade pasta and pasta related products the presence of pathogenic microorganisms is not allowed. The sample is considered to be microbiologically safe if the total number of microorganisms less than 1.0×10^5 , total number of aerobic sporogenic bacteria is under 1.0×10^4 and the total number of yeasts and molds is under 1.0×10^4 per 1g of the sample total of 120 samples of pasta were analysed.

Table 1.
Microbiological safety of industrially made pasta

Type of pasta	No. of samples	Total number of micro-organisms	Total number of sporogenic bacteria	Total number of yeasts	Total number of molds	Pathogenic micro-organisms
Long cut	30	0-2,0x10 ²	0-50	- ^a	- ^a	- ^a
Short cut	50	0-5,0x10 ²	0-50	- ^a	- ^a	- ^a
Rolled	20	0-1,0x10 ³	0-30	- ^a	- ^a	- ^a
Lasagne sheets	20	0-1,0x10 ²	0-50	- ^a	0-1,0x10 ²	- ^a

Legend: -^a – not found

Table 2.
Microbiological safety of pasta produced in artisanal shops

Type of pasta	No. of samples	Total number of micro-organisms	Total number of sporogenic bacteria	Total number of yeasts	Total number of molds	Pathogenic micro-organisms
Long cut	20	1,0x10 ³ - 5,0x10 ⁴	1,0x10 ² -1,0x10 ³	0-50	0-7,0x10 ²	- ^a
Short cut	30	1,5x10 ³ - 3,5x10 ⁴	1,0x10 ² -8,0x10 ²	0-50	0-5,0x10 ²	+/9
Rolled	20	5,0x10 ² - 4,0x10 ⁴	50-5,0x10 ²	- ^a	0-1,0x10 ²	+/5
Lasagne sheets	20	1,0x10 ³ - 5,5x10 ⁵	0-1,0x10 ²	0-8,0x10 ³	0-5,0x10 ³	+/4

Legend: -^a – not found, + - presence of pathogenic microorganisms/ N₀-number of positive samples

Table 3.
Microbiological safety of industrially produced phyllo

Type of pasta	No. of samples	Total number of micro-organisms	Total number of sporogenic bacteria	Total number of yeasts	Total number of molds	Pathogenic micro-organisms
Phyllo made of T-500 flour	30	50-1,0x10 ³	0-1,0x10 ²	0-1,0x10 ²	0-1,0x10 ²	- ^a
Phyllo made of T-850 flour	15	1,0x10 ² - 2,0x10 ³	20-5,0x10 ²	1,0x10 ² - 3,0x10 ²	1,0x10 ² - 5,0x10 ²	- ^a
Phyllo made of buckwheat flour	15	1,0x10 ³ - 1,0x10 ⁴	50-3,0x10 ²	1,0x10 ² - 1,0x10 ³	1,0x10 ² - 5,5x10 ³	- ^a
Pasta tatters with eggs	20	0-3,0x10 ²	0-60	- ^a	0-50	- ^a

Legend: -^a – not found

According to the Regulation on microbiological safety of foodstuffs in trade all of the samples were in order. No pathogenic microorganisms were isolated. The total number of microorganisms ranged from 0 to 1.0x10³.

Of the total number of analyzed samples of pasta with supplements, which was 90, 18 were contaminated. The reason of microbiological contamination was the presence of coagulase-positive staphylococci and increased total number of microorganisms in samples of lasagne sheets. The industrial production in relation to artisanal is reflected in a number of advantages, such as im-

proving the qualities, less manual work and higher hygienic safety of finished product.

Conservation by drying is used in the production technology of pasta in order to prevent a number of biochemical and microbiological processes. Discontinuous (batch) drying is used in artisanal production of pasta. The quality of finished product depends on properly conducted drying. With discontinuous drying the phase of stabilization and cooling is particularly risky phase. This phase takes place at room temperature, and largely depends on environmental conditions and characteristics of air used for cooling the pasta.

The role of eggs in the production of pasta in our country comes down to the fact that they improve the visual appearance of pasta (smoothness and shine of the surface and colour), sensory quality of pasta (hardness and fracture resistance, degree of swelling and overcooking) and nutritional value (increased caloric value due to high content of lipids and proteins).

Supplements, like eggs, which are used in production can be the source of contamination. Sometimes *Salmonella* species can be isolated in completely fresh eggs. They originate from food for laying hens which is made from fish, meat and even bone flour for higher protein content (Plavšić et al., 2010; Čabarkapa et al., 2009). Those microorganisms not only cause eggs to go bad but can also result in mass diseases if such eggs are consumed or used for production. Salmonellas are usually transmitted on humans with contaminated food of animal origin that is not sufficiently cooked (Cantoni et al., 2005; Kormanjoš et al., 2007). The application of hygienic measures in production, trade and germ carriers control is most important for suppression of salmonellosis (Švabić-Vlahović et al., 2005).

Artisanal mode of production involves a lot of manual work. Therefore a significant source of contamination is the hygiene of employees, equipment and accessories used in manufacturing. *Staphylococcus aureus* is one of the most common causes of alimentary toxicoinfections. It belongs to a

group of very resistant bacteria. Most of them die at 60 °C after an hour; some of them can stand even longer exposure to 80 °C. Enterotoxin is thermostable and can withstand 35 minutes at 95 °C (Karakašević et al., 1977; Švabić-Vlahović et al., 2005). Beside enterotoxins they produce some other toxins that cause various diseases. The man is the main source of contamination of food with enteropathogenic *Staphylococcus aureus* (Tešanović, 2010) Improper handling of food largely contributes to the appearance of disease. Risky amounts of toxins appear when the number of present cells exceeds 10^5 per 1g of food.

Number of analysed samples was 80. According to the Regulation on microbiological safety of foodstuffs in trade all of the analysed samples were in order. There were no pathogenic microorganisms isolated. The total number of microorganisms ranged from 50 to 1.0×10^4 . The total number of yeasts and molds ranged from 1.0×10^2 to 5.5×10^3 .

Total number of analysed samples was 65. No pathogenic microorganisms were isolated. Some samples of phyllo made from T-850 flour and buckwheat flour contained increased number of microorganisms and molds per 1g of sample than it is permitted in the Regulation. The results indicate the possible sources of contamination. To obtain microbiologically safe flour which is used for preparing other products proper treatment of grain surface is necessary.

Table 4.
Microbiological safety of phyllo produced in artisanal shops

Type of pasta	No. of samples	Total number of microorganisms	Total number of sporogenic bacteria	Total number of yeasts	Total number of molds	Pathogenic microorganisms
Phyllo made of T-500 flour	20	1.0×10^3 - 5.0×10^3	0 - 1.0×10^2	0 - 5.0×10^2	0 - 3.0×10^2	- ^a
Phyllo made of T-850 flour	15	3.5×10^3 - 5.0×10^4	50 - 7.0×10^2	1.0×10^2 - 7.0×10^2	1.0×10^2 - 4.0×10^4	- ^a
Phyllo made of buckwheat flour	10	3.3×10^3 - 2.0×10^5	1.0×10^2 - 1.0×10^3	1.0×10^3 - 4.5×10^4	1.0×10^2 - 1.0×10^5	- ^a
Pasta tatters with eggs	20	1.0×10^2 - 1.0×10^3	0 - 1.0×10^2	0 -50	0 - 1.0×10^2	- ^a

Legend: -^a – not found

T-850 flour and buckwheat flour contain higher proportion of bran than T-500 flour. Higher number of microorganisms that are present on the surface of the bran can end up in the flour, which is a suitable environment for microbial growth, due to insufficient surface treatment or unprofessional manipulation, especially in artisanal production. Flour is more susceptible to microbial activities than wheat. Wheat grain has an outer layer (bran) that represents an obstacle to the penetration of microorganisms, since many of them don't have the ability to interrupt the continuity of the bran (Žakula, 1980). Damage of the bran can be in the area of the endosperm or in the area of the germ.

Reproduction of microorganisms on damaged grains can lead to molding and decaying. Therefore, the grain surface treatment is necessary and it is a precondition for obtaining hygienic products (Plavšić et al., 2007). When keeping and storing wheat, due attention is given to the preservation of grain by controlling the temperature and moisture, and by monitoring the presence of rodents and pests as they affect the quality of the milling products (flour and semolina). The presence of insects in stored wheat can cause damage to the outer layer (bran) of the wheat grain (Almaši et al., 2003). Regards on the purpose of flour, the technological quality is very important (Stojanović, Psodorov, 2007).

Artisanal production implies more manual manipulation during the production of phyllo, which is also a possible source of contamination. Drying of formed phyllo is a method of conservation in phyllo production. The drying phase of phyllo on the drying boards is very short, almost insufficient for destroying the present microorganisms or reduction of initial contamination to an acceptable level.

CONCLUSIONS

Based on all the facts that were presented in this paper the following conclusions can be made:

- All samples of pasta and pasta related products produced in industrial conditions were in order.

- Out of 90 samples of pasta produced in artisanal way, 18 were not satisfying due to the presence of coagulase-positive staphylococci and increased total number of microorganisms, which can occur due to increased manual work, discontinuous way of drying and supplements that are used for pasta production.
- In the industrial way of production drying is continuous, while in artisanal way of production it is discontinuous.
- Drying of pasta is done at higher temperatures and over a longer period of time which allows the destruction of microorganisms and reduction of their number.
- Pasta related products are dried a very short period of time, which is not sufficient for destroying the present microorganisms.
- Pasta related products, since they are dried very briefly, have a higher a_w value compared to pasta and thus are more susceptible to proliferation of microorganisms.

Industrial way of production of pasta and pasta related products, unlike artisanal way of production, exclude a lot of manual work and implies a continuous method of drying, thus ensures that the finished product is microbiologically safe

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ПОРЕЂЕЊЕ МИКРОБИОЛОШКЕ ИСПРАВНОСТИ ТЕСТЕНИНЕ И СРОДНИХ ПРОИЗВОДА У ЗАВИСНОСТИ ОД УСЛОВА ПРОИЗВОДЊЕ

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Тестенине и сродни производи на бази жита представљају намирнице које карактерише оптималан однос основних нутријената. Због тога заузимају значајно место у исхрани људи. Тестенина и сродни производи готово су свакодневно присутни у исхрани. Њихова производња може да се одвија у индустријским и занатским условима. Од низа предности индустријског начина производње над занатским, значајно место заузима већа микробиолошка исправност готовог производа.

Циљ рада био је да се испита микробиолошка исправност тестенина и тестенинама сродних производа произведених у индустријским (потпуно аутоматизованим) погонима и занатским (ручним и полуаутоматским) погонима.

Испитано је 120 узорак тестенине произведене у индустријским условима и 90 узорак тестенине произведене у занатским погонима. Из групе тестенинама сродних производа испитане су коре и млинци. Од тога 80 узорак је било произведено у индустријским условима, а 65 у занатским погонима.

Сви узорци тестенина и тестенинама сродних производа, произведени у индустријским условима, били су исправни. Од 90 узорак тестенина произведених на занатски начин, 18 узорак није било исправно због присуства коагулаза позитивних стафилокока и повећаног укупног броја микроорганизама. Код неких узорак кора од брашна Тип-850 и од хељдиног брашна, уочен је повећан укупан број микроорганизама и укупан број плесни.