Evaluation of Chemical safety of Food Products

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Abstract. In the diet of the rural population, the main products of consumption were meat and meat products, bakery products, dairy, fruit and vegetable products. The greatest contribution to the population exposure to cadmium, arsenic, mercury when ingested with food products like milk and dairy products, meat and meat products, fish, bread and bread products. The most susceptible to the total nonspecific effects from domestic products are the cardiovascular system, the hormonal system, the central nervous system, the blood of the kidney and the reproductive system, from the imported products - blood, hormonal system, central nervous system and reproductive system. With combined intake of pollutants by alimentary methods, the total index of the risk of development of non-carcinogenic effects was 16.2 (95% per cent) for domestic products, 4.6 (95% per cent) for imports. The non-carcinogenic risk from contamination of domestic food products is formed by cadmium, arsenic and mercury. Systems most susceptible to total nonspecific effects are cardiovascular (HI) = 3.6, hormonal with an index of danger (HI) = 2.7, the central nervous system with an index which is dangerous (HI = 2.4), immune (HI = 1.45), blood (HI = 0.88), kidneys (HI = 0.79), and reproductive (HI = 0.71). The influence of imported products on functional systems was distributed as follows: blood (HI = 0.48), hormones (HI = 0.81), cc HI = 0.52), reproductive system (HI = 0.41). With the combined intake of pollutants by alimentary methods, the total index of the risk of development of non-carcinogenic effects by domestic products was 16.2 for imported - 4.6.

1. Introduction
The WHO report “On the estimates of the global burden of foodborne diseases” on the effect of the polluted food on the human health and well-being, presents the estimates of disease burden caused by 31 foodborne agents (bacteria, viruses, parasites, toxins and chemicals), resulting in the fact that 600 million people, or almost 1 in 10 people in the world, fall ill after eating polluted food and 420 000 die every year, resulting in the loss of 33 million of healthy life years (DALYs) [1].

Nutrients, which are known to be multicomponent systems, contain not only useful substances, but can be the sources of hazardous compounds of natural and anthropogenic origins. Chemicals can get into the food products either due to their intended use in technological process (for example, as food additives), or due to the air, water and soil pollution. The presence of chemical substances in food products is a global scale problem of public health and is one of the major causes of trade barriers arising [2,3].

The establishment and functioning of the Customs Union, the accession of the Russian Federation to the World Trade Organization and the Organization for Economic Cooperation and Development require bringing all applicable domestic sanitary and epidemiological requirements for food safety in
line with international standards developed on the basis of the methodology for assessing and managing the health risk of the population. Therefore, the development and application of the methods of assessing the risk of chemical contaminants of food products in the practical activities of territorial agencies and institutions of the Federal Service in the field of consumer rights protection and human well-being acquire special urgency and will contribute to the training of specialists for effective work in the harmonization of domestic and foreign principles of rationing food safety [4].

2. Materials and Methods
To study the quality of food products, the research data of the laboratory of the Federal State-Funded Health Care Institution (FBHI) “Center for Hygiene and Epidemiology in the Republic of Tatarstan (Tatarstan)” and the data on consumption of the main product groups based on the results of sampling studies of the household budgets on the whole in the Republic of Tatarstan were used [5]. The risk assessment was carried out according to the data of the Regional Information Fund (RIF) of social and hygienic monitoring and results of the research carried out on the basis of an accredited laboratory of the Federal State-Funded Healthcare Institution “The Center of Hygiene and Epidemiology in the Republic of Tatarstan” in keeping with Guidelines P 2.1.10.1920-04 [6].

Exposure calculations, contribution of each of the product groups to total exposure value were carried out according to the formulas (1) and (2)

\[
\text{Exp} = \frac{\sum_{k=1}^{N} C_i M_i}{B W},
\]

where \(\text{Exp}\) is the value of pollutant exposure, mg/kg body weight/day (mg/kg body weight /week, mg/kg body weight); \(C_i\) is the pollutant content in the i-th product, mg/kg; \(M_i\) is the consumption of the i-th product, kg/day (kg/week, kg/year); \(B W\) is the human body weight, kg (standard value is 70 kg); \(N\) is the total amount of products included into the study.

The product contribution to the total value of pollutant exposure was calculated according to formula:

\[
\text{Contr} = \frac{C_k M_k}{\sum_{i=1}^{N} (C_i M_i)},
\]

where \(\text{Contr}\) is the contribution of the k-th product to the total exposure value; \(C_i\) is the pollutant content in the i-th product, mg/kg; \(M_i\) is the consumption of the i-th product, kg/day (kg/week, kg/year).

Non-carcinogenic risk (route of ingestion: per os) is assessed by calculating the hazard quotient (HQ):

\[
\text{HQ} = \frac{I}{RfD},
\]

where \(I\) is an average daily dose substances by oral intake, mg/kg, \(RfD\) is a reference (safe) dose.

To assess the total effect of chemical substances, the total hazard index is used: \(HI = HQ1 + HQ2 + \ldots + HQn\), where \(HQq, HQ2, HQn\) are the hazard quotients of the 1st, 2nd … n – th chemical substances. The calculation of \(HI\) is usually performed only for the substances, affecting the same body organs and systems. The non-carcinogenic risk was assessed based on the values of the upper limit of the 95% CI of the results of studies carried out on the basis of an accredited laboratory of the Federal State-Funded Health Care Institution (FBHI) “Center for Hygiene and Epidemiology in the Republic of Tatarstan” according to guidelines regulating the carrying out of the population health risk assessment in the RF [6]. Statistical analysis of the obtained data was implemented operating system Windows 2007 with application of standard application program packages Excel 2007 and “Statistica v.6.0”.

3. Results
Comparative analysis of the obtained data revealed that the Republic of Tatarstan had higher indices in the content of pollutants in the fruit and vegetable products. On the whole, considerable consumption of home-baked products rich in carbohydrates and fats, dairy products with high content of fat is typical for nutrition of the rural population in the region. The results of analysis allowed building a picture of frequency, dietary pattern and peculiarities of the basic food package in the diet of the rural population. Analysis of consumption of the basic food groups showed that irregular consumption of fruits and vegetables was typical for 60.8%, of meat and meat products – for 45.2%, of vegetable oil – for 47.2%, and of fish and fish products – for 68.6% of the rural population. At the same time, 34.6%
of the rural population ate fruit and vegetables every day, 51.8% - meat and meat products, 50.2% - vegetable oil, 25.8% - fish and fish products (Table 1).

Table 1. Prevalence of nutritive factors in the sample rural population in the Republic of Tatarstan.

| Nutritive factor                  | Nutritive factor grades | Relative frequency, % | Average error m | Proportions | Confidence interval 95.0% |
|-----------------------------------|-------------------------|-----------------------|-----------------|-------------|--------------------------|
| Number of meals                   |                         |                       |                 |             |                          |
|                                   | Once a day              | 1.3                   | 0.37            | 0.013       | 0.5 ± 2.04               |
|                                   | Two times a day         | 6.8                   | 0.82            | 0.068       | 5.17 ± 8.43              |
|                                   | Three times a day       | 40.1                  | 1.59            | 0.401       | 36.92 ± 43.28            |
|                                   | Four and more times a day| 51.8                  | 1.62            | 0.518       | 48.56 ± 55.04            |
| Frequency of hot meals            |                         |                       |                 |             |                          |
|                                   | Once a day              | 5.9                   | 0.76            | 0.059       | 4.37 ± 7.43              |
|                                   | Two times a day         | 42.8                  | 1.61            | 0.428       | 39.59 ± 46.01            |
|                                   | Three times a day       | 51.3                  | 1.62            | 0.513       | 48.06 ± 54.54            |
| Dietary pattern                   |                         |                       |                 |             |                          |
|                                   | No                      | 70.1                  | 1.49            | 0.701       | 67.13 ± 73.07            |
|                                   | Yes                     | 29.9                  | 1.49            | 0.299       | 26.93 ± 32.87            |
| Consumption of fruits and vegetables |                         |                       |                 |             |                          |
|                                   | No                      | 4.5                   | 0.67            | 0.045       | 3.15 ± 5.85              |
|                                   | Not regularly           | 60.8                  | 1.58            | 0.608       | 57.63 ± 63.97            |
|                                   | Every day               | 34.6                  | 1.54            | 0.346       | 31.51 ± 37.69            |
| Consumption of meat               |                         |                       |                 |             |                          |
|                                   | No                      | 3.7                   | 0.61            | 0.037       | 2.48 ± 4.92              |
|                                   | Not regularly           | 45.2                  | 1.61            | 0.452       | 41.97 ± 48.43            |
|                                   | Every day               | 51.8                  | 1.62            | 0.518       | 48.56 ± 55.04            |
| Consumption of vegetable oil      |                         |                       |                 |             |                          |
|                                   | No                      | 2.0                   | 0.45            | 0.02        | 1.09 ± 2.91              |
|                                   | Not regularly           | 47.2                  | 1.62            | 0.472       | 43.96 ± 50.44            |
|                                   | Every day               | 50.2                  | 1.62            | 0.502       | 46.96 ± 53.44            |
| Consumption of fish               |                         |                       |                 |             |                          |
|                                   | No                      | 5.6                   | 0.75            | 0.056       | 4.11 ± 7.09              |
|                                   | Not regularly           | 68.6                  | 1.51            | 0.686       | 65.59 ± 71.61            |
|                                   | Every day               | 25.8                  | 1.42            | 0.258       | 22.96 ± 28.64            |

Hygienic assessment of the content of lead, mercury, cadmium, arsenic, nitrates and nitrates in 7 food groups for the period from 2004 to 2014 in the Republic of Tatarstan was carried out with the account of methodical approaches recommended by the Federal Service for Surveillance of Consumer Rights Protection and Human Well-being. Milk and dairy products, vegetable oil and other fats, meat and meat products, sugar, fish, vegetables, melons and gourds, bread and baked products were studied according to their priority.
4. Discussion
The analysis, which we carried out, showed that the non-carcinogenic risk from pollution of local food products was formed due to the effect of cadmium, arsenic, and mercury [7-12]. The systems, which were most vulnerable to the total non-specific effect, were the cardiovascular system (HI = 3.6); the hormone system with hazard index (HI) = 2.7; the central nervous system with hazard index (HI) = 2.4; the immune system (HI=1.45); the blood (HI=0.88); the kidneys (HI=0.79) and the reproductive system (HI=0.71) [13]. As far as the effect of the imported food products, the functional systems were arranged in the following way: the blood (HI=0.48), the hormones (HI=0.81), the central nervous system (HI=0.52), the immune system, the reproductive system (HI=0.41). On combined ingestion of pollutants via alimentary tract, the total hazard index of developing non-carcinogenic effects made 16.2 (95% perс) in local products, and 4.6 (95% perс) in imported products (Table 2).

Table 2. Critical organs and systems according to the results of the non-carcinogenic risk assessment on ingestion of chemical substances with local and imported food products.

| Critical organs and systems | Local products           | Imported products       |
|----------------------------|--------------------------|-------------------------|
| Me | 95 Perc | Me | 95 Perc |
| Kidneys | 0.124535 | 0.42927 | 0.074355 | 0.29923 |
| Blood | 0.672021 | 0.280465 | 0.341129 | 0.48854 |
| Hormone system | 0.509034 | 2.703845 | 0.216023 | 0.81812 |
| Liver | 0.003275 | 0.004812 | 0 | 0 |
| Skin | 0.254682 | 1.72692 | 0.029586 | 0.17255 |
| CNS | 0.601261 | 2.479003 | 0.127352 | 0.52203 |
| Ns | 0.421443 | 2.274575 | 0.141668 | 0.52729 |
| CVS | 0.680067 | 3.670502 | 0.258634 | 0.30636 |
| Immune system | 0.250971 | 1.458141 | 0.037003 | 0.22505 |
| Reproductive system | 0.167867 | 0.713672 | 0.119499 | 0.41468 |
| Development | 0.144071 | 0.549648 | 0.112093 | 0.35476 |
| Biochemical indicators | 0 | 0 | 0.112082 | 0.35473 |
| GIT | 0 | 0 | 0.029586 | 0.17255 |
| HI | 3.829 | 16.29 | 1.59901 | 4.65589 |

Our calculations showed that the contribution of arsenic was the largest in local products reaching 23.8% at the median level and 30.5% at the level of the 95-th perc. The proportion of the lead contribution, making 13.5% (Me) and 4% (95-th perc) is considerable. The proportion of cadmium made 10.1% (Me) and 7.6% (95-th perc), correspondingly [14-16]. As far as imported products, the excess of exposure dose of substances entering the body of the adult population was divided up as follows: lead ranked first making 25.4% (Me) and 37.1% (95-th perc), cadmium – 14.9% (Me) and 24.7% (95-th perc), arsenic 6.6% (Me) and 17.9% (95-th perc) [17,18]. Results of calculating the pollution exposure of food products in the Republic of Tatarstan are given in Table 3.

Table 3. Data on calculation of the pollution exposure of local and imported food products consumed by the population of the Republic of Tatarstan.

| Pollutants | Local products (Rf) | Imported products (Rf) |
|------------|---------------------|------------------------|
| Me | 95 Perc | Me | 95 Perc |
| Cadmium | 0.10851 | 0.42927 | 0.06694 | 0.23833 |
| Arsenic | 0.25405 | 1.72545 | 0.02959 | 0.17253 |
| Lead | 0.14405 | 0.54911 | 0.11352 | 0.35749 |
| Mercury | 0.02692 | 0.22341 | 0.00742 | 0.0609 |
| DDT | 0.00034 | 0 | 0 | 0 |
According to our calculations, the groups with the largest contribution to pollution in imported products are milk, and fruit and vegetables, meat. Whereas, vegetables, milk, bread and meat rank first in local products. Milk and dairy products (29.8%), fish, non-finfish, and the foods produced from them (8.7%), bread (13.3%) contribute most to exposure of mercury. The maximum amount of arsenic for the period under study was ingested with the following products: fruit and vegetables (27.7%), meat (11%), bread and bread products (11%) [19].

The major contribution to the value of the non-carcinogenic risk from pollution of food products is formed due to nitrates (34%), arsenic (30%) and cadmium (20%) [21-24] (Table 4).

Table 4. Data on calculation of the pollution exposure of local and imported food products consumed by the population of the Republic of Tatarstan.

| Product group name | Local products(Rf) | Imported products (Rf) |
|--------------------|--------------------|------------------------|
|                    | Me | 95 Pers | Me | 95 Pers |
| Meat               | 0.1632 | 0.754022 | 0.03075 | 0.104889 |
| Milk               | 0.2819 | 0.943490 | 0.03174 | 0.125666 |
| Fish               | 0.0185 | 0.063749 | 0.01252 | 0.050183 |
| Cereals            | 0.0698 | 0.354256 | 0.02061 | 0.029369 |
| Sugar              | 0.0416 | 0.217085 | 0.00348 | 0.027171 |
| Fruits             | 0.5995 | 2.836288 | 0.33299 | 0.592896 |
| Oil seeds          | 0.0102 | 0.044832 | 0.00176 | 0.003645 |
| HI                 | 1.1847 | 5.213722 | 0.43385 | 0.933819 |

The systems, which are most vulnerable to the total nonspecific effect, are the central nervous system with hazard index (HI) – 1.03; the immune system (HI=0.98); the blood (HI=0.88); the kidneys (HI=0.79); the cardiovascular system (HI=0.74) and the reproductive system (HI=0.28). On combined ingestion of pollutants via the alimentary tract the total hazard index of developing non-carcinogenic effects made HQ=1.18 (at the Me level and HQ=5.2 (95perc) in local products, and HQ=0.43(Me) and HQ=0.93 (95perc) in imported products, correspondingly.

5. Conclusions
Eating habits of the rural population showed that the priority products were meat and meat products, bread and bread products, dairy products, fruit and vegetable products. Milk and dairy products contribute most to the population exposure to cadmium, arsenic, and mercury on peroral ingestion with food products. The cardiovascular, the hormone, the central nervous and the immune systems, the blood, the kidneys and the reproductive system are most vulnerable to the total nonspecific effect in local products; and the blood, the hormones, the central nervous and the reproductive systems are vulnerable in imported products [20].

On combined ingestion of pollutants via the alimentary tract the total hazard index of developing non-carcinogenic effects made 16.2 (95% perc) in local products, and 4.6 (95% perc) in imported products.
In local products, the total content of the major chemical pollutants is higher than in the imported one. Local producers of food products are also the major suppliers of chemical pollutants to the consumers’ table in the groups of alimentary raw materials and food products.

6. References

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