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QUALITY MANAGEMENT IN THE FOOD MARKET FOR SUSTAINABLE DEVELOPMENT BASED ON INDUSTRIAL AND MANUFACTURING ENGINEERING IN THE AGE OF DIGITAL ECONOMY

Abstract: *This article is aimed at substantiating the prospects and developing recommendations for quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering in the digital economy. Taking into account the influence of factors and using the capabilities of industrial and manufacturing engineering in the age of digital economy when studying quality management in the food market on the basis of industrial and manufacturing engineering determines the originality and uniqueness of this study. The benefits of digitalization are substantiated in it for the first time, not from the standpoint of enterprises (productivity growth) or the state (growth of transparency and accountability), but from the standpoint of consumers through the lens of quality. The novelty of the research also consists in the development and application of a new scientific and methodological approach to measuring quality in the food market, based on a broad interpretation of quality in the unity of consumer properties, sufficiency and availability of food products. The new approach opens up opportunities for learning and managing the quality in the food market for sustainable development that were not available previously. The authors developed a scientific and methodological approach to the quality management in the food market for sustainable development based on industrial and manufacturing engineering in the digital economy, proposed policy implications for its practical application, and conducted a case study, and tested a new approach on the example of the soybean seed market in Russia.*

Keywords: *Quality; Sustainable Development; Agricultural Management; Food Production; Food Nutrition Improvement; Agricultural Innovation; Food Security.*

1. Introduction

Quality is a universal characteristic, with the help of which the degree of customer orientation of markets and their compliance with the interests of building a social market economy is assessed. In the food market, quality is a specific characteristic, fundamentally distinguishing it from most of others markets. First, food is an essential product. Therefore, if for most markets the quality of products is a subjective assessment and is determined depending on

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the target subject of the market, then for the food market, quality means high satisfaction with products by all (most) consumers. This requires a more conpound and complex interpretation of quality in relation to food products and its consideration in the context of components (in contrast to the indivisible quality applicable to products in most of others markets).

Secondly, food is a perishable product. Therefore, its positive assessment at the production stage does not mean meeting needs in the consumption process. Consequently, the quality of food products changes as they move along the value chain and cannot be measured once, which also implies a complex quality characteristic. Thirdly, in the context of the implementation of sustainable development goals, the food market acquires the strategic importance, since it is intended to ensure food security. This means not only improving the characteristics of food products, but also ensuring their mass quantitative availability. In this regard, from the standpoint of sustainable development, the quality assessment should not be carried out in relation to food (and be limited by its nutritional properties and accordance with food standards), but in relation to the food market, that is, go beyond the usual interpretation of quality and cover others (quantitative, and organizational and managerial) characteristics that determine the ensuring of food security from the standpoint of food deficiency and its benefits for the population.

These features of the food market determine the inapplicability of the traditional approach to monitoring and quality management, limited to the consumer properties of the product itself, and determine the necessity to develop and apply a new approach that defines the quality more widely, from the standpoint of food security in favor of sustainable development. The absence of such an approach is a serious research gap that not only prevents the correct and widespread assessment of quality in the food market, but also does not allow reliable assessments of food security and accurate tracking of progress in the implementation of sustainable development goals.

This article is intended to fill in the indicated gap. The research is based on the hypothesis that the digital economy opens up new opportunities for quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering. The article is aimed at substantiating the prospects and developing recommendations for the quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering in the digital economy. Taking into account the influence of factors and using the capabilities of industrial and manufacturing engineering in the age of digital economy when studying the quality management in the food market on the basis of industrial and manufacturing engineering determines the originality and uniqueness of this study. For the first time, the benefits of digitalization are grounded in it, not from the standpoint of enterprises (productivity growth) or the state (growth of transparency and accountability), but from the standpoint of consumers - through the lens of quality.

The novelty of the research carried out in this article also lies in the development and application of a new scientific and methodological approach to measuring quality in the food market, based on a broad interpretation of quality in the unity of consumer properties, sufficiency and availability of food products. The new approach opens up opportunities for learning and managing quality in the food market for sustainable development that were not available previously.

The chosen goal determined the logic and structure of the article. Further, it provided a literary review, the materials, and the research methods, reflected the obtained results: 1) a scientific and methodological approach to quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering in the age of digital economy is developed; 2) policy implications for applying a new approach to quality management in the food market for sustainable development based on industrial and manufacturing engineering in the age of digital economy are drawn up; 3) a case study of the stage of quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering is carried out and a new approach is tested on the example of the soybean seed market in Russia, and a conclusion is made.

2. Literature Review

The study of the theory and practice of measuring and managing quality in the food market is devoted to the works of Goyal and Sergi (2015), Sergi et al. (2019), Sofina (2019), Zimon et al. (2020).

The strategic importance of the food market for ensuring food security and achieving sustainable development is emphasized in the works of Asitik and Abu (2020), Fan et al. (2020), Kissoly et al. (2020), Satapathy et al. (2020), Guido et al. (2020).

Prospects for improving industrial and manufacturing engineering based on advanced digital technologies in the food market are considered in publications of Cane and Parra (2020), Khoza et al. (2019), Raile et al. (2019), Sagarna Garcia and Pereira Jerez (2019), Tankha et al. (2020), Tran et al. (2019), Trivelli et al. (2019).

The carried out literary review has revealed a plurality of publications on the research topic, which formed its reliable theoretical background. Nevertheless, the methodological issues of taking into account the influence of industrial and manufacturing engineering factors in the age of digital economy in assessing quality and managing quality in the food market remain understudied. In addition to this, the existing scientific and methodological approach assumes a shallow interpretation of the quality, limited to products, which does not allow to full, accurate and reliable determining the quality in the food market from the standpoint of sustainable development.

The identified methodological gaps cause the unsolved problem of quality management in the food market in favor of sustainable development based on industrial and manufacturing engineering in the digital economy. Their filling in requires further research, which is the subject of this article.

3. Materials and methodology

Testing of the developed hypothesis in this article is carried out in two consecutive stages using the methods of correlation and regression analysis. At the first stage, the dependence of the quality characteristics in the food market on state policies aimed at ensuring quality is determined. The source of information and empirical data is the Report "Global Food Security Index 2019", made by The Economist Intelligence Unit Limited (2020).

The following characteristics of quality in the food market were selected: sufficiency of supply (deficit-free), volatility of agricultural production (stability of productivity, yield as a manifestation of quality in crop production), and food loss (risks of quality deterioration), as well as nutrition value determined by dietary diversity, microelements availability, protein quality and food safety.

The measures of state quality management in the food market in the favor of sustainable development are the following: agricultural imports tariffs (y_1, opportunities to overcome the deficit through importing food), presence and quality of food safety net programmes (y_2, standardization), agricultural infrastructure (y_3, logistics), and nutrition monitoring and surveillance (y_4, supervisory activities).

At the second stage, the dependence of state quality management measures in the food market on factors of industrial and manufacturing engineering in the age of digital economy is determined, which are the indicators from the World Digital Competitiveness Report 2020 (IMD, 2020): robotization of production and management at the state and corporate level (x_1, world robots distribution), the use of analytical systems using Big data (x_2, use of Big data and analysis), the disposition of the enterprises to adopt digital technologies (x_3, agility of companies), and distance government services provided on the e-government platform (x_4 , E-government).

The formulated hypothesis is recognized if the majority (50% or more) of the coefficients b in the models $y=a+b_1*x_1+b_2*x_2+b_3*x_3+b_4*x_4$ for y_1- y_4 turn out to be negative. This will mean that the improvement of positions in the rating by indexes of industrial and manufacturing engineering in the age of digital economy contributes to the effectiveness growth of the state quality control measures in the food market.

For the study, a sample of countries was formed, including: 3 developed countries with the highest level of food security (Singapore, Ireland and the USA), 3 developing countries with a moderate level of food security (China, Brazil and Russia), as well as 4 (since these countries are the majority in the ranking for 2019) countries with a low level of food security (South Africa, Peru, Indonesia and India).

The sample includes countries with different levels of socio-economic development (both developed and developing), with different geographic locations (from different regions of the world, including America, Africa, Europe and Asia), and with different levels of food security (high, moderate and low). This provided a representative sample and an opportunity to extend the research results to the world economy as a whole (to other countries). The food security of the countries in the sample in 2020 (according to the rating for 2019) is described in Figure 1.

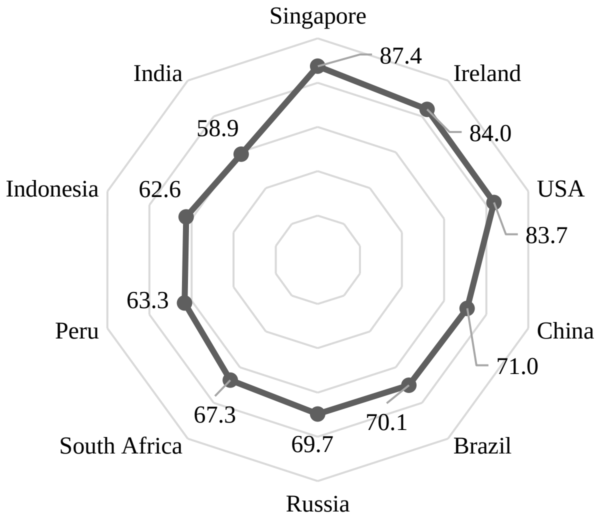

Figure 1. Food security index in sample countries in 2020 (based on the results of 2019), scores 1-100

Source: compiled by the authors based on materials The Economist Intelligence Unit Limited (2020).

The factual basis of the study includes quality characteristics in the food market from the standpoint of sustainable development (in a broad interpretation of quality, Table 1), measures of the state quality control in the food market in the favor of sustainable development (Table 2) and factors of industrial and manufacturing engineering in the age of digital economy (Table 3).

When carrying out a case study, a complex of methods of economic research, general scientific methods of cognition, and modern methods of data analysis are used. The information base was the statistic data of Rosstat and international databases, scientific works of Russian scientists on the topics under the study, materials from ministries and departments, and periodical literature.

Table 1. Quality characteristics in the food market from the standpoint of sustainable development (in a wide interpretation of quality) in 2020, scores 1-100

Country	Sufficiency of supply	Volatility of agricultural production	Food loss	Dietary diversity	Micronutrient availability	Protein quality	Food safety
Singapore	69.0	76.4	100.0	62.9	76.4	70.2	100.0
Ireland	86.6	79.2	94.3	81.0	80.3	86.9	98.2
USA	87.6	91.6	98.5	96.6	73.6	85.8	99.5
China	71.1	99.1	88.0	50.0	66.0	67.3	95.0
Brazil	70.0	88.5	79.3	81.0	72.6	79.3	98.7
Russia	77.3	83.4	95.5	69.0	72.7	71.8	98.0
South Africa	63.8	87.8	90.1	46.6	68.2	44.3	90.6
Peru	55.6	92.4	75.5	43.1	61.4	48.2	92.8
Indonesia	64.9	94.8	84.4	19.0	37.7	18.9	92.0
India	47.3	95.3	86.4	37.9	40.5	18.3	92.8

Source: compiled by the authors based on materials The Economist Intelligence Unit Limited (2020).

Table 2. Government quality management measures in the food market for sustainable development in 2020, scores 1-100

Country	Agricultural import tariffs	Presence and quality of food safety net programmes	Agricultural infrastructure	Nutrition monitoring and surveillance
Singapore	100.0	100.0	77.4	100.0
Ireland	81.1	100.0	64.7	1000
USA	91.8	100.0	74.8	100.0
China	75.4	100.0	75.6	100.0
Brazil	84.2	100.0	35.6	100.0
Russia	82.4	100.0	49.8	100.0
South Africa	86.3	100.0	59.6	100.0
Peru	95.6	75.0	46.5	0
Indonesia	86.4	100.0	46.2	100
India	38.5	100.0	39.8	0

Source: compiled by the authors based on materials The Economist Intelligence Unit Limited (2020).

Table 3. Industrial and manufacturing engineering factors in the age of digital economy in 2020, rank 1-63 (less is better)

Country	World robots distribution	Use of big data and analytics	Agility of companies	E-Government
Singapore	15	10	19	11
Ireland	43	18	5	25
USA	4	9	15	9
China	1	8	29	40
Brazil	17	58	39	47
Russia	32	33	61	33
South Africa	34	44	58	56
Peru	54	54	52	54
Indonesia	25	17	30	57
India	12	32	35	59

Source: compiled by the authors based on materials IMD (2020), The Economist Intelligence Unit Limited (2020).

4. Results

4.1 Scientific and methodological approach to quality management in the food market for sustainable development based on industrial and manufacturing engineering in the age digital economy

To develop a scientific and methodological approach to quality management in the food market in the favor of sustainable development based on industrial and manufacturing engineering in the age of digital economy, it is necessary to determine the relationship between quality characteristics and management measures, for which the correlation coefficients were calculated (Table 4).

Based on the results of the correlation analysis, represented in Table 4, all quality characteristics are amenable to government regulatory measures, except for the instability of agricultural production, which showed a negative correlation with all government regulations. Therefore, further in the study, this quality characteristic is excluded from the consideration, since it does not lend itself to government regulations and goes beyond the studied subject area. Modeling of the regression dependence of the selected quality characteristics on government regulatory measures is carried out in Table5.

Table 4. Correlation of government management measures and quality characteristics in the food market from the standpoint of sustainable development, %

Correlation	Sufficiency of supply	Volatility of agricultural production	Food loos	Dietary diversity	Micronutrient availability	Protein quality	Food safety
Agricultural import tariffs	45.83	-42.12	15.24	27.84	53.78	46.70	32.37
Presence and quality of food safety net programmes	38.33	-17.06	59.57	23.20	8.51	15.00	29.69
Agricultural infrastructure (logistics)	55.05	-25.12	72.09	34.38	52.09	49.15	38.31
Nutrition monitoring and surveillance	74.89	-36.04	53.81	40.60	50.42	53.37	44.53

Source: calculated and compiled by the authors.

Table 5. Modeling the regression dependence of the selected quality characteristics from government regulatory measures

Regression factors		Sufficiency of supply	Food loos	Dietary diversity	Micronutrient availability	Protein quality	Food safety
Multiple R		0.8000	0.8825	0.4494	0.6701	0.6527	0.5492
Y-intercept (constant a)		122.48	-62.84	-36.15	98.03	188.61	52.96
Coefficients b in regression equation	Agricultural import tariffs	-0.21	0.32	0.29	0.02	-0.31	0.14
	Presence and quality of food safety net programmes	-0.76	1.25	0.53	-0.70	-1.78	0.33
	Agricultural infrastructure (logistics)	0.22	0.30	0.25	0.30	0.49	0.03
	Nutrition monitoring and surveillance	0.32	-0.17	0.06	0.21	0.52	-0.04

Source: calculated and compiled by the authors.

According to the obtained regression models, the sufficiency of supply with the improvement of agricultural infrastructure by 1 point increases by 0.22 points and with the strengthening of nutrition monitoring and surveillance by 1 point it increases by 0.32 points. The multiple correlations are high (80.00%).

The food loss with an increase in tariffs on import of agricultural products by 1 point increases by 0.32 points, with an increase in the number and quality of food safety programs by 1 point - increases by 1.25 points, with an improvement in agricultural infrastructure by 1 point - increases by 0,30 points. The multiple correlations are high (88.25%).

With an increase on agricultural import tariffs of 1 point, dietary diversity increases by 0.29 points, with an increase in the number and quality of food safety programs by 1 point, it increases by 0.53 points, and with an improvement in agricultural infrastructure by 1 point, it increases by 0,25 points and with increased nutrition monitoring and surveillance by 1 point increases by 0.06 points. The multiple correlations are moderate (44.94%).

The micronutrient availability with an increase on agricultural import tariffs products by 1 point increases by 0.02 points, with an improvement in agricultural infrastructure by 1 point, it increases by 0.30 points, and with increased nutrition monitoring and surveillance by 1 point, it increases by 0.21 points ... The multiple correlation is moderate (67.01%). The protein quality with the improvement of agricultural infrastructure by 1 point increases by 0.49 points and with the strengthening of nutrition monitoring and surveillance by 1 point it increases by 0.52 points. The multiple correlations are moderate (65.27%).

Food safety with an increase on agricultural import tariffs products by 1 point increases by 0.14 points, with an increase in the number and quality of food safety programs by 1 point - it increases by 0.33 points, with an improvement in agricultural infrastructure by 1 point it increases by 0.03 points. The multiple correlations are moderate (54.92%). Nevertheless, modeling revealed not only positive, but also negative relationships of indicators - they are given in Table 5 on a darkened background. This indicates the need for flexible, targeted and high-precision quality management using government regulatory measures.

To determine the prospects for improving government regulatory measures in Table 6, the modeling of their regression dependence on industrial and manufacturing engineering factors in the age of digital economy is carried out.

Table 6. Modeling the regression dependence of government regulatory measures on industrial and manufacturing engineering factors in the age of digital economy

Regression factors		Agricultural import tariffs	Presence and quality of food safety net programmes	Agricultural infrastructure (logistics)	Nutrition monitoring and surveillance
Multiple R		0.6554	0.6482	0.8548	0.5326
Y-intercept (constant a)		90.02	105.62	80.78	123.20
Coefficients b in regression equation	World robots distribution	0.39	-0.24	0.06	-0.27
	Use of Big Data and analysis	0.03	-0.09	-0.52	-0.52
	Agiliy of companies	0.22	0.00	0.16	0.45
	E-Government	-0.65	0.00	-0.41	-0.96

Source: calculated and compiled by the authors.

Table 6 the sought (negative) regression coefficients are shown against a shaded background. The agility of companies has shown positive regression coefficients with all measures of state quality control in the food market. Therefore, this factor is insignificant. The rest of the regression dependencies should be studied in more details. Thus, it was revealed that the efficiency of agricultural import tariff regulation with an increase in the availability of E-government (improved by 1 place) increases by 0.65 points.

The availability for implementation and the quality of implemented food safety net programmes with the growth of the world robots distribution (improvement by 1 place) increases by 0.24 points, and with an increase in the using Big Data and analysis (improvement by 1 place) increases by 0.09 points. Agricultural infrastructure (logistics) with an increase in the activity of using Big Data and analysis (improvement by 1 place) increases by 0.53 points, and with an increase in the availability of E-government (improvement by 1 place) it increases by 0,41 points.

The coverage and effectiveness of nutrition monitoring and surveillance with the world robots distribution (improvement by 1 place) increases by 0.27 points, with an increase in the using Big Data and analysis (improvement by 1 place) increases by 0.52 points, and with an increase in the availability of E-government (improvement by 1 place), it increases by 0.96 points.

4.2 Policy implications for a new approach to quality management in the food market for sustainable development based on industrial and manufacturing engineering in the age of digital economy

For applying a new approach to quality management in the food market in the favor of sustainable development on the basis of industrial and manufacturing engineering in the age of digital economy in accordance with the established regression relationships (Table 5, 6), the following policy implications have been developed (Figure 2).

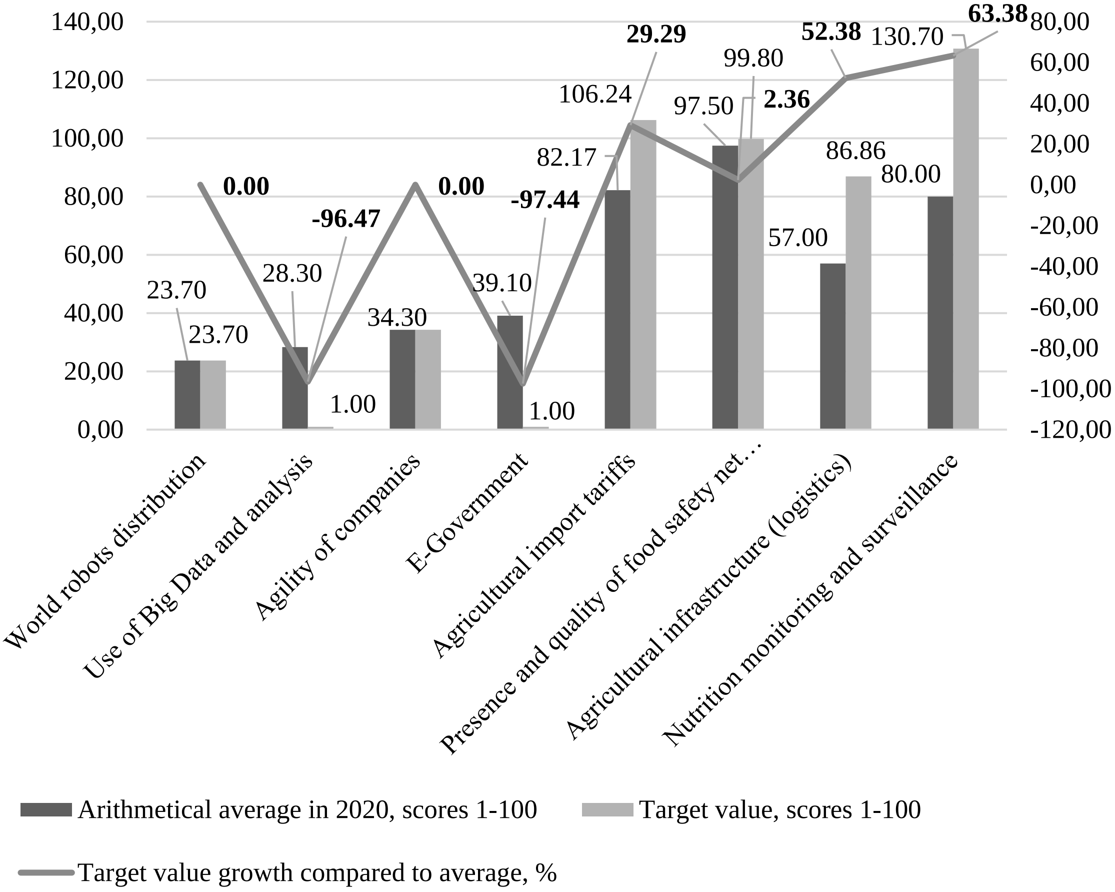

Figure 2. Control values of governance measures and industrial and manufacturing engineering factors in the age of digital economy
Source: calculated and built by the authors

Based on Figure 2, the policy implications are formulated as follows. Initially, it is necessary to stimulate the development of the digital economy and improve industrial and manufacturing engineering in order to provide:

– The activity of using Big Data and analysis should be increased from 28.30th place (on average in 2020) to 1st place, that is, improved by 96.47%;

– The availability of E-government should be increased from 39.10th place to 1st place, that is, improved by 97.44%.

Due to this, increased coverage and increased efficiency of quality governance measures in the food market will be achieved, in particular:

– The efficiency of agricultural import tariffs will increase from 82.17 points to 100 (+ 29.29%);

– Coverage and quality of food safety net programmes will increase from 97.50 points to 99.80 points (+ 2.36%);

– The availability and quality of agricultural infrastructure (and, accordingly, the efficiency of logistics) will increase from 57 points to 86.86 points (+ 52.38%);

– The coverage and effectiveness of nutrition monitoring and surveillance will increase from 80 points to 10 points (+ 63.38%).

The advantages of the developed policy implications for a new approach application to quality management in the food market for sustainable development based on industrial and manufacturing engineering in the age of digital economy are illustrated in Figure 3.

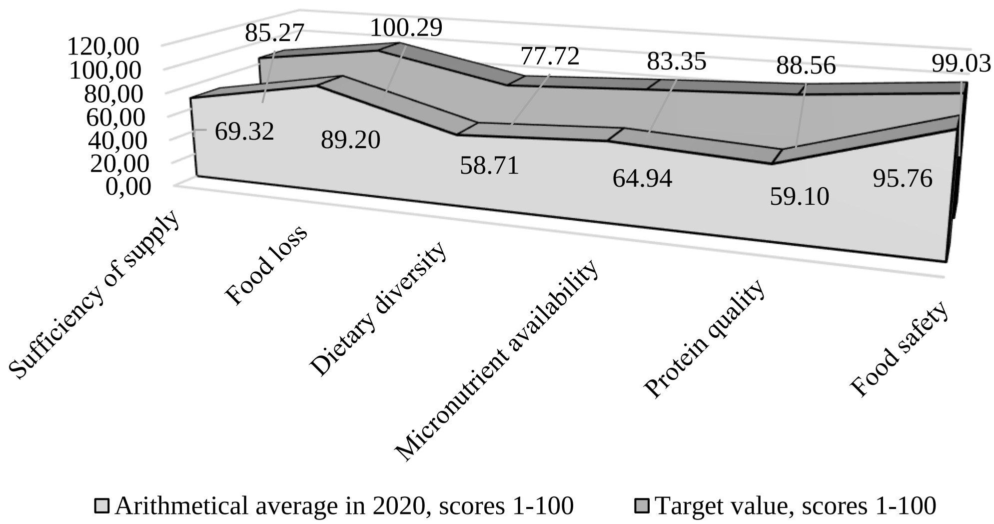

Figure 3. Benefits of developed policy implications to improve quality in the food market for sustainable development based on industrial and manufacturing engineering in the age of digital economy
Source: calculated and constructed by the authors.

As shown in Figure 3, the benefits of developed policy implications to improve quality in the food market for sustainable development based on industrial and manufacturing engineering in the age of digital economy include the following:

– Increasing the sufficiency of supply from 69.32 points to 85.27 points (+ 23.01%);

– Improving the efficiency of food loss risk management from 89.20 points to 100 points (+ 12.43%);

– An increase in dietary diversity from 58.71 points to 77.72 points (+ 32.37%);

– Increasing the micronutrient availability from 69.94 points to 83.35 points (+ 28.35%);

– Increase in protein quality from 59.10 points to 88.56 points (+ 49.85%);
– Improving food safety from 95.76 points to 99.03 points (+ 3.42%).

4.3 Case study of quality management in the food market in the favor of sustainable development based on industrial and manufacturing engineering and testing a new approach on the example of the soybean market in Russia

Soyban is the oldest plant in the Luguminous family, the cultivation of which is mentioned in sources dating back to 3-4 thousand years BC. The East Asian center is considered the homeland of this culture (Vavilov, 1926). The first country in whose history there is a mention of soybeans is China then Korea, and Japan. The spread of soybeans around the world began in the 17th century. In Russia, Russian settlers began to cultivate it in the Far East, and soybean selection began in the middle of the 20th century. Today, soybeans' volume of production in the world ranks fourth after wheat, corn, and rice (Vasilchikov and Akulov, 2019).

Nowadays soybeans (Glycine max) are the leading industrial crop of great economic importance. The high content of soybeans in almost all essential nutrients (Baranov et al., 2009), as well as fat (18 ... 24%), and protein (38 ... 45%) determine its value as a food crop. Its role as an agrotechnical crop is also high, primarily due to the accumulation of nitrogen in the soil up to 90 kg/ha upon inoculation with rhizotorfin; in addition, soybeans are a good forecrop for non-leguminous crops (Gamzikov al., 2007). Soy is also one of the most important feed crops in the world, since it contains 3.5-4.0 times more digestible protein than the grain-fodder group, and the seeds contain the main essential amino acids that determine the usefulness of feed (Kolomeyenko, 2018).

Soy is also a profitable commercial crop: in terms of profitability, it is close to sunflower and with a yield of 1.5 t/ha, the profitability of its production is 100% (Shirinyan, 2014). According to the Ministry of Agriculture of Russia, soybeans rank first among all field crops in terms of return on production (Akulov and Vasilchikov, 2018).

Soybeans are grown by 23% of the world's countries. However, the main acreages under the crop are concentrated in countries such as the USA, Brazil, Argentina, India, and China in 2018 (of all crops in the world) amounted to 28.6%, 27.8%, 33.0% and 6.4%, respectively (Figure 4). Moreover, in China over the past eighteen years, there has been a decrease in soybean acreage, while in Brazil the value of this indicator has doubled, in India - 1.8 times, in Russia - 9 times.

According to statistics, soybeans in our country are cultivated in all Federal Districts, and the acreage over the past four years has averaged 2864.3 thousand hectares. However, the main production is concentrated in the Far East (1366.6), Central (971.1 thousand hectares), South (215.6 thousand hectares), Siberian (150.5 thousand hectares) and Volga (121.3 thousand hectares) Federal Districts (Table 7).

The main leaders among the regions, in 2020 in terms of soybeans acreage are Amur Oblast - it owns 29.6% of the total area in the Russian Federation (Figure 5). Then Kursk Oblast comes (9.3%), Belgorod Oblast (9.3%) and Primorsky Krai (9.2%). Further in the top ten are Krasnodar Krai (5.9%), Voronezh Oblast (5.5%), Tambov Oblast (4.9%), and Altai Krai (4.6%). And the rating is completed by Oryol Oblast (3.6%), and the Jewish Autonomous Oblast (2.9%). Also in all these regions there are high bulkyield for soybeans. However, this is largely due to the large crop acreage, but not in any way with its yield. Although, this is precisely such an indicator as productivity reflects the ability of zoned soybean varieties to realize their potential.

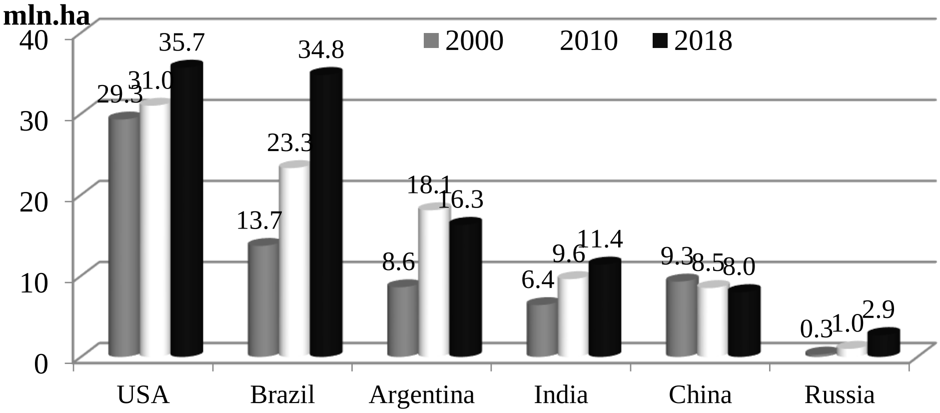

Figure 4. Dynamics of soybean acreage in the world
Source: compiled by the authors based on FAOSTAT (2020).

Table 7. Dynamics of soybean acreage in Russia, thousand hectares

Federal District	2017	2018	2019	2020	average
Central	776.3	909.9	1114.1	1084.2	971.1
Northwestern	1.3	2.4	1.1	1.5	1.6
Southern	200.6	240.6	229.5	191.6	215.6
North Caucasus	31.9	37.3	38.6	23.6	32.9
Volga	113.3	103.2	125.6	143.0	121.3
Urals	4.9	5.5	4.2	3.3	4.5
Siberian	84.5	151.1	166.8	199.8	150.5
Far Eastern	1422.9	1499.0	1218.6	1326.5	1366.6
Total Russia	2635.8	2949.2	3039.4	2832.7	2864.3

Source: calculated by the authors based on data from Rosstat (2020a), Rosstat (2020b).

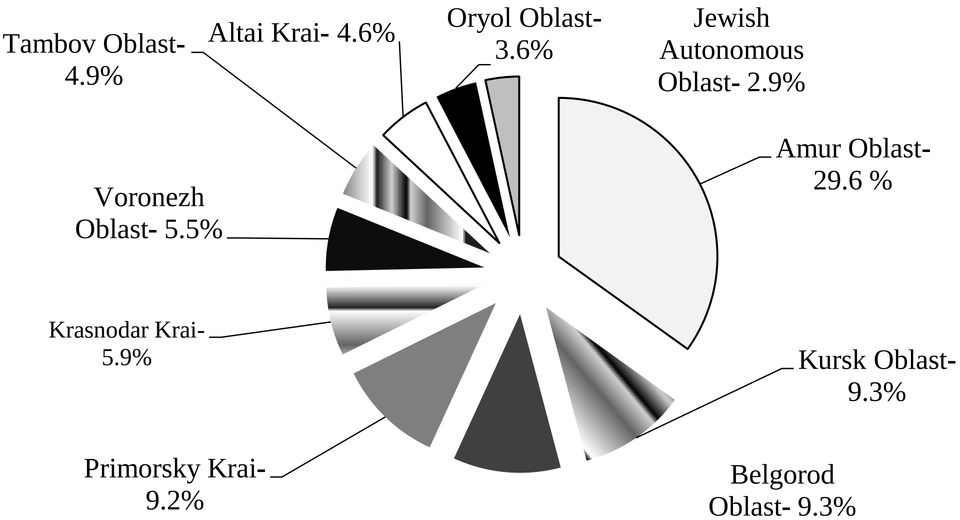

Figure 5. Top 10 regions by share of soybean acreage in 2020
Source: calculated by the authors based on data from Rosstat (2020a), Rosstat (2020b).

Since natural and climatic factors have a significant impact on the realization of the potential of plants, the analysis of indicators for several years makes it possible to largely exclude their influence in assessing the yield of soybeans in the Russian Federation. So the highest crop yield on average for three years was noted in the Kaliningrad Oblast - 21.4 c/ha, Belgorod Oblast - 20.2 c/ha, Kursk Oblast - 19.69 c/ha, and the Kabardino- Balkarian Republic - 18.0 c/ha (Table 8).

Table 8. Top leading regions in terms of soybean yield for 2017-2019, c/ha

Region	2017	2018	2019	Average
Kaliningrad Oblast	18.8	14.0	31.3	21.4
Belgorod Oblast	15.7	23.9	21.1	20.2
Kursk Oblast	17.0	20.9	20.8	19.6
Kabardino-Balkarian Republic	17.8	18.3	18.0	18.0
Krasnodar Krai	19.4	14.0*	18.2	17.2
Tambov Oblast	14.1*	15.8	18.0	16.0
Voronezh Oblast	12.5*	16.5	18.0	15.7
Bryansk Oblast	15.1	16.2	14.6*	15.3

* This year, in terms of productivity, it was not included in the top regions - leaders
Source: calculated by the authors based on data from Rosstat (2020a), Rosstat (2020b).

Moreover, of the leading regions in terms of acreage, only half of the regions entered the yield rating. A region such as the Kabardino-Balkarian Republic, having insignificant acreage, had an average soybean yield of 18.0 c/ha. In turn, the Kaliningrad Oblast in 2019 received the highest soybean yield in Russia - 31.3 c/ha.

Among the Federal Districts, the leaders in terms of soybean yield on average over three years were the North-West (21.4 c/ha), Central (17.6 c/ha) and South (16.8 c/ha) (Figure 6). Thus, we can say that in order to obtain high and stable crop yields, it is necessary, first of all, to ensure the correct selection of varieties and optimize the conditions for its cultivation.

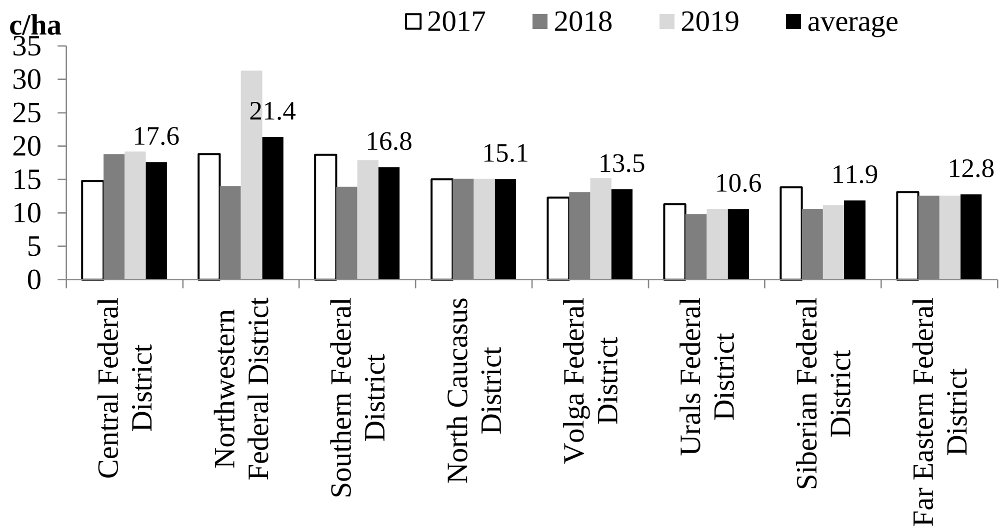

Figure 6. Dynamics of the soybeans yield in Russia by Federal District, c/ha
Source: calculated by the authors based on data from Rosstat (2020a), Rosstat (2020b).

The contribution of selection to increasing the productivity of the most important agricultural crops ranges from 30 to 70%, and its role only increases with the account for climatic changes (Zhuchenko, 2004). The main limiting factor in soybean production in the regions of the Russian Federation is unstable and relatively low grain productivity, the level of which is largely determined by unfavorable weather conditions in the cultivation zone (Kochegura, 2003). An equally important component in obtaining a harvest is the technological equipment of producers with agricultural products (Polukhin et al., 2019).

Analysis of the register of selection achievements showed that at the moment it still numbers 7 varieties of soybeans included in the period from 1984 to 1990 and 28 varieties of crops included in the period from 1991 to 2000, and three of them are Western European breeding (Figure 4). And in the XXI century on the Russian market there are more and more soybean varieties of foreign selection. So far, 12 varieties of soybeans of foreign selection included in the register in the period from 2001 to 2010 have been approved for use. Over the past 10 years, 67 varieties of soybeans of Western European selection and 106 varieties of Russian selection have been included in the register.

Although the number of soybean varieties included in the register of Russian selection currently prevails over foreign ones, Russian farmers prefer to sow seeds of varieties of Canadian and Belarusian selection. So in 2019, 57.8% of the top ten leaders in terms of seeding volume accounted for Western European varieties (Polukhin and Panarina, 2020). Therefore, foreign varieties are more competitive compared to Russian varieties.

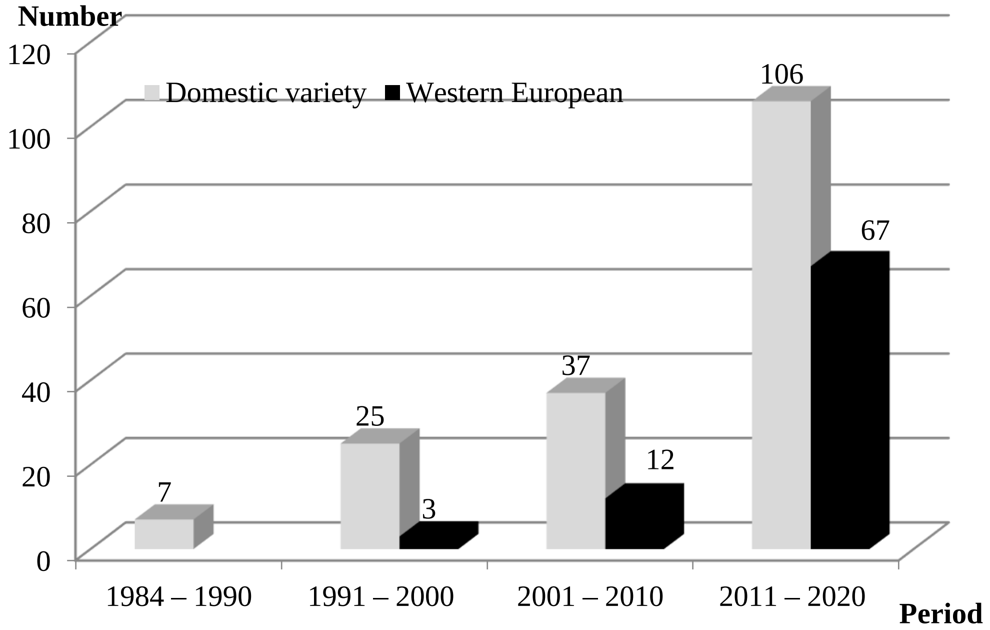

Figure 7 . Dynamics of the inclusion of soybean varieties in the State Register of Selection Achievements Authorizedfor Use for Production Purposes

Source: calculated by the authors based on data from Rosinformagrotech (2020).

A large share of the received gross yield in Russia goes for processing, but part of it is exported to other countries and the volume of exports only increases over the years (Table 3). So, until 2011 inclusive, the volume of soybeans exported was 1 ... 16 thousand tons, whereas, starting in 2012, they began to grow and in 2019 already amounted to 901 thousand tons. The main buyers of Russian products in this market segment are: China - 81.9% and Turkey - 6.6%.

Table 3. Export of soybeans from the Russian Federation in 2001 - 2019.

Year	Volume, ths. ton	Year	Volume, ths. ton
2001	12	2011	5
2002	-	2012	120
2003	1	2013	84
2004	4	2014	79
2005	6	2015	383
2006	3	2016	422
2007	16	2017	518
2008	5	2018	967
2009	2	2019	901
2010	1		

Source: compiled by the authors based on materials from Ab-center (2020).

However, due to the lack of raw materials, the Russian Federation also purchases soybeans from other countries. The key suppliers of soybeans to the Russian market in 2018 were Brazil - 1,224.0 thousand tons (54.6% of all soybean imports) and Paraguay - 892.2 thousand tons (39.8%), according to the Ab-center, 2020.

Thus, the case study of quality management in the food market in the favor of sustainable development based on industrial and manufacturing engineering and the testing of the new approach on the example of the soybean market in Russia showed that in Russia the quality of the soybean seed market is moderate. A sufficiently high state control and standardization positively affects the quality, but the deficit and dependence on imports negatively affects the quality of the soybean seed market in Russia.

To improve the quality management practice in the soybean seed market in Russia in the favor of sustainable development based on industrial and manufacturing engineering, it is recommended: digital modernization of analytical systems for monitoring and control of the development of the soybean seed market using Big Data, as well as expanding the list of public services available for both suppliers and consumers on the Russian soybean seed market (Policani Freitas & Candido de Lima, 2020). Taking into account the well-grounded signified interregional differences, framework recommendations are proposed that require clarification in each separate region of Russia.

5. Conclusion

Thus, according to the results of an international empirical study, the hypothesis has been proved that quality management in the food market in the favor of sustainable development should be based on the governance measures of industrial and manufacturing engineering in the age of digital economy. On a global basis, it is recommended to increase the activity of using Big Data and analysis by 96.47% and the availability E-government by 97.44%.

It is substantiated that this will improve the measures of quality governance in the food market, in particular, increase the effectiveness of agricultural import tariffs by 29.29%, the coverage and quality of food safety net programmes by 2.36%, the availability and quality of agricultural infrastructure (and respectively, the effectiveness of logistics) by 52.38%, and the coverage and effectiveness of nutrition monitoring and surveillance by 63.38%.

Thanks to this, a great increase in the quality of food products will be achieved on a global scale, in particular, the sufficiency of supply will increase by 23.01%, the effectiveness of risk loss management by 12.43%, dietary diversity by 32.37%, the micronutrient availability by 28.35 %, protein quality by 49.85% and food safety by 3.42%.

The results of a case study of quality management in the food market in the favor of sustainable development based on industrial and manufacturing engineering and the testing of a new approach on the example of the soybean market in Russia showed that such a crop as soybeans is widespread in many countries of the world. The current situation in the Russian Federation of such a crop as soy is considered. The data on the acreage not only in the world, but also in the context of Federal Districts and regions are presented. In the world, the main producers of soybeans are the USA, Brazil, Argentina, China and India. In the Russian Federation, the main cultivated areas are located in the Far Eastern, Central, Southern, Siberian and Volga Federal Districts. They are also leaders in the gross yield of soybeans.

Data on the yield of soybeans for the leading regions of Russia for several years is also presented, which made it possible to estimate the value of this indicator most accurately. So, the highest yield of soybeans is obtained in the Kaliningrad, Belgorod and Kursk Oblasts, as well as in the Kabardino-Balkarian Republic. The dynamics of the inclusion of soybean varieties in the State Register of Selection Achievements Authorizedfor Use for Production Purposes is analyzed. As before, domestic varieties prevail over foreign ones in terms of the total number in the register, however, producers mostly prefer Western European varieties. Russia is an exporter of soybeans to countries such as China, Turkey and others. The main imports come from countries such as Brazil and Paraguay. The reasons for the low competitiveness of domestic varieties are indicated.

Russia does not have a significant amount of acreage of this crop. The main centers of soybean production are the Far Eastern, Central, Southern, Siberian and Volga Federal Districts. However, high crop yields are observed in the Kaliningrad, Belgorod and Kursk Oblasts, as well as in the Kabardino-Balkarian Republic, which may be associated with the use of an effective agricultural technology and varieties that fully realize their potential.

Despite the predominance in the State Register of soybean varieties of domestic selection, producers in a greater proportion prefer to sow varieties of foreign selection. Although part of the soybean production obtained is exported, Russia is actively buying soybeans from other countries. Nevertheless, the problem of the low competitiveness of domestic varieties and the development of effective agricultural technology for them remains relevant.

References

Ab-centre (2020). *Where we buy, where we sell. Russian trade in soybeans*. Retrieved from: https://ab-centre.ru/news/gde-pokupaem-kuda-prodaem-torgovlya-rossii-soevymi-bobami (03.12.2020).

Akulov, A. S., & Vasil'chikov A.G. (2018). Study of some agricultural methods of cultivation of new varieties of soybeans. *Legumes and cereals, 1*(25), 36-40.

Asitik, A. J., & Abu, B. M. (2020). Women empowerment in agriculture and food security in Savannah Accelerated Development Authority zone of Ghana. *African Journal of Economic and Management Studies*, *11*(2), 253-270. https://doi.org/10.1108/AJEMS-03-2019-0102

Baranov, V. F., Kochegura, A. V., & Lukomets, V. M. (2009). *Soybean in the Kuban territiry*. Krasnodar: All-Russian Research Institute of Oil Crops.

Cane, M., & Parra, C. (2020). Digital platforms: mapping the territory of new technologies to fight food waste. *British Food Journal*, *122*(5), 1647-1669. https://doi.org/10.1108/BFJ-06-2019-0391

Fan, S., Si, W. & Zhang, Y. (2020). How to prevent a global food and nutrition security crisis under COVID-19?. *China Agricultural Economic Review*, *12*(3), 471-480. https://doi.org/10.1108/CAER-04-2020-0065

FAOSTAT (2020). Agricultural crops. Retrieved from: http://www.fao.org/faostat/ru/#data/QC (03.12.2020).

Gamzikov, G. P., Shott, P. R., & Litvintsev, P. A. (2007). Soybean productivity depending on nitrogen nutrition sources. Siberian Agricultural Science Bulletin, 7(175), pp. 21-28

Goyal, S. & Sergi, B.S. (2015). Social Entrepreneurship and Sustainability – Understanding the Context and Key Characteristics. *Journal of Security & Sustainability Issues, 4*(3), 269-278.

Guido, R., Mirabelli, G., Palermo, E & Solina, V. (2020). A Framework for Food Traceability: Case Study – Italian Extra-Virgin Olive Oil Supply Chain. *International Journal of Industrial Engineering and Management*, 11(1), 50-60. Doi: 10.24867/IJIEM-2020-1-252

IMD (2020). *World Digital Competitiveness Report 2020.* Retrieved from https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2020/ (02.12.2020).

Khoza, S., Van Niekerk, D., & Nemakonde, L.D. (2019). Understanding gender dimensions of climate-smart agriculture adoption in disaster-prone smallholder farming communities in Malawi and Zambia. *Disaster Prevention and Management*, *28*(5), 530-547. https://doi.org/10.1108/DPM-10-2018-0347

Kissoly, L., Fasse, A., & Grote, U. (2020). Intensity of commercialization and the dimensions of food security: the case of smallholder farmers in rural Tanzania. *Journal of Agribusiness in Developing and Emerging Economies*, *10*(5), 731-750. https://doi.org/10.1108/JADEE-06-2019-0088

Kochegura, A. V. (2003). *Actual problems and results of soybean selection*. Materials of the international conference dedicated to the 90th anniversary of All-Russian Research Institute of Oil Crops (103-109). Krasnodar: Science

Kolomeychenko, V.V. (2018). Field and garden crops in Russia. Legumes and oilseeds: Monograph. 2nd edition, rev. Saint Petersburg: «Lan».

Policani Freitas, A.L. & Candido de Lima, J.D. (2020). What are the Factors that Most Affect Service Quality in Fast-Food Restaurants? *Proceedings on Engineering Sciences, 2*(4), 419-430. Doi: 10.24874/PES02.04.009

Polukhin, A. A., & Panarina, V. I. (2020). The main problems of selection and seed production of agricultural crops and ways to solve them. *Legumes and cereals, 3*(35), 5-11

Polukhin, A. A., Alekseev, K. I., Ryzhkova, S. M., Kruchinina, V. M., Stavtsev, A. N., & Lankin, A.S. (2019). Economic Evaluation of Directions of State Support of Producers of Energy Capacities for Agriculture of Russia. *International Journal of Engineering and Advanced Technology (IJEAT), 9*(1), 5013-5017

Raile, E. D., Young, L. M., Sarr, A., Mbaye, S., Raile, A. N. W., Wooldridge, L., Sanogo, D., & Post, L.A. (2019). Political will and public will for climate-smart agriculture in Senegal: Opportunities for agricultural transformation. *Journal of Agribusiness in Developing and Emerging Economies*, *9*(1), 44-62. https://doi.org/10.1108/JADEE-01-2018-0003

Rosinformagrotekh (2020). *State Register of Selection Achievements Authorized for Use for Production Purposes* Vol. 1*. «Plant varieties» (official Publication)*. Moscow: Federal State Funded Research Institution « Rosinformagrotekh ».

Rosstat (2020a). Acreage of the Russian Federation in 2018, 2019, 2020. Retrieved from: https://rosstat.gov.ru/compendium/document/13277 (03.12.2020).

Rosstat (2020b). Gross harvest and yield of agricultural crops in the Russian Federation in 2018 and 2019. Vol 1. Retrieved from: https://rosstat.gov.ru/compendium/document/13277 (03.12.2020).

Sagarna Garcia, J. M., & Pereira Jerez, D. (2019). Agro-food projects: analysis of procedures within digital revolution. *International Journal of Managing Projects in Business*, *13*(3), 648-664. https://doi.org/10.1108/IJMPB-02-2019-0039

Satapathy, J., Nayak, N. C., & Mahakud, J. (2020). Multidimensional impact of food security on household welfare: evidences from a household survey in three Indian states. *International Journal of Social Economics, 47*(7), 913-932. https://doi.org/10.1108/IJSE-01-2020-0023

Sergi, B. S., Popkova, E. G., Borzenko, K. V., & Przhedetskaya, N. V. (2019). Public-Private Partnerships as a Mechanism of Financing Sustainable Development. In Ziolo, Magdalena and Bruno S. Sergi (Eds.) Financing Sustainable Development: Key Challenges and Prospects (pp. 313-339). Palgrave Macmillan.

Shirinyan, O. M. (2014). Soy. New varieties and technologies. Krasnodar: «Soy enterprise».

Sofina, E. V. (2019). Agricultural land-use optimization by farms based on quality management: Lines of research. *International Journal for Quality Research, 13*(4), 915-929.

Tankha, S., Fernandes, D., & Narayanan, N.C. (2020). Overcoming barriers to climate smart agriculture in India. *International Journal of Climate Change Strategies and Management*, *12*(1), 108-127. https://doi.org/10.1108/IJCCSM-10-2018-0072

The Economist Intelligence Unit Limited (2020). *Global Food Security Index 2019.* Retrieved from: https://foodsecurityindex.eiu.com/Index (02.12.2020).

Tran, N. L. D., Rañola, R. F., Ole Sander, B., Reiner, W., Nguyen, D. T., & Nong, N.K.N. (2019). Determinants of adoption of climate-smart agriculture technologies in rice production in Vietnam. *International Journal of Climate Change Strategies and Management*, *12*(2), 238-256. https://doi.org/10.1108/IJCCSM-01-2019-0003

Trivelli, L., Apicella, A., Chiarello, F., Rana, R., Fantoni, G., & Tarabella, A. (2019). From precision agriculture to Industry 4.0: Unveiling technological connections in the agrifood sector. *British Food Journal*, *121*(8), 1730-1743. https://doi.org/10.1108/BFJ-11-2018-0747

Vasil'chikov, A. G., Akulov A.S. (2019). Search for highly effective inoculants for promising soybean varieties. *Legumes and cereals, 4*(32), 66-71

Vavilov, N. I. (1926). Centers of origin of cultivated plants. Leningrad: Gutenberg.

Zhuchenko, A. A. (2004). *Possibilities of creating varieties and hybrids of plants taking into account climate change.* Collection of articles of the international scientific-practical conference "The strategy of adaptive selection of field crops due to global climate change." Saratov: Science

Zimon, D., Tyan, J., & Sroufe, R. (2020). Drivers of sustainable supply chain management: Practices to alignment with un sustainable development goals. *International Journal for Quality Research*, *14*(1), 219-236.

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