Investments in the Sustainable Development of the Potato Sector in Ukraine based on the Optimal Balance of Production and Consumption

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Abstract: - Growing role of potato farming in food security system of the country needs attracting the new investment in preserving and process restructuring of the sector, at scientifically proven approach to defining the optimal scope of potato production, processing, and storage – to avoid the extra stocks, unnecessary losses, and inefficient investment resources at any stage of agri-food chain. Purpose of the study is to justify the conceptual model of investing in development of Ukrainian potato sector, based on calculated optimal structure of balance between potato production and consumption, as well as the effective combination of fresh and processed products, to ensure competitive parameters of potato market in actual market environment. Object of the study is forming and increasing the added value in agri-food chain, due to optimal parameters of balance between potato production and consumption. The study methodology is based on system analysis laws, which allow justifying the competitive parameters of Ukrainian potato sector in varying economic space, thus reducing the unnecessary loss in "producing-processing-transporting-sale-consumption" chain. Use of developed optimization model for potato production/consumption balance, by minimizing the potato residues at the end of year, revealed the extra stock (2.4 million tons) in early 2020, which was unbalanced with consumer demand. Due to inefficient distribution of gross potato yield in Ukraine, conclusion was made on need to reduce investment in overproduction (17.5%) and direct the major investment flows in potato processing industry, increase the export potential, and expand the foreign market boundaries for Ukrainian potato products, semi-finished and fresh products, at ensuring the relevant quality. In this view, authors proposed a conceptual investment model for potato sector of Ukraine, based on optimal balance of potato production and consumption till 2027, which ensures achieving the strategic result in terms of global competition.

Key-Words: - Investments, potato farming sector, potato production/consumption balance, agri-food added value chains

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1 Introduction

Today, investing in agri-food added value chains is an important factor in developing the modern global economy. At intensive globalization processes, the chains have major impact on individual companies and the entire countries, causing the worldwide movement of investment flows. At that, experience of recent global tendencies affected by pandemia shows the growing role of agri-food chains in food security system and need to attract additional investment in their preservation and process restructuring – given the need to supply the local markets and increase the export potential.

It is known that potato and products of its processing play an important role in agri-food chains. According to actual statistics, potato is the world's fourth consumed food crop – after rice, wheat, and corn. Given the leading position of Ukraine, as the world producer of potato (among the TOP-5 producers), investment strategy for development of Ukrainian potato farming shall be reviewed from the perspective of increasing the added value share in global "potato-potato products" chain. Today, part of Ukraine, as the world potato market player, is very insignificant and export-import operations of Ukrainian businesses do not play a significant role in the world market. At present, potato-growing companies are practically not involved in forming the global added value, as they sell fresh potato, export of which is limited – due to incompliance with phytosanitary regulations, high prime cost of Ukrainian potato growing, and uncompetitively high prices of the final product. At the same time, Ukrainian producers make little use of opportunities to participate in all stages of producing the finished items (starch, frozen potato, chips, semi-finished products, etc.) with chance to cooperate with other economic entities. So, it would be wise to ensure scientific justification of competitive parameters for Ukrainian potato growing in modern market environment and determine on their basis the investment in optimal structure of potato production/consumption balance, as well as the need for additional investment in processing segment, as pre-requisite for further integration of the sector into global agri-food chains.

2 Theoretical Background

Value-added chain concept was first introduced into scientific use by M. Porter in 1985 – in view of studying the competitive advantage (Porter, 1985). Problems of value-added chain formation were studied by Ukrainian and foreign scientists: T. Andreieva, Y. Fang, V. Hubina, V. Ivanenko, R. Johnson, R. Kaplinski, O. Kovalenko, B. Meng, G. Noger, M. Porter, S. Sokolenko, O. Svitovyi, N. Yamano, Zh. Yermakova, I. Zvarych, et al.

Specificity of agri-food chains lies in degree of combining the production and processing of raw materials into finished products. Two main types of agri-food chains are distinguished depending on the minimum and maximum parameters of their dimensions (Krysanov et al., 2017):

a) the simplest (or primary segment) chain includes two links: production and processing of food raw materials, issue and direct sale of food products;
b) full chain – at least 5-6 links: production-transporting-processing-storage-transporting-sale.

At that, to save the costs, various optimization types are possible at forming the complete agricultural chain, namely:

- merger, consolidation, separation, division (e.g., forming the agri-food chains in agricultural holdings) (Dankevych, 2011);
- use of outsourcing – can be used to reduce the costs or as strategic partnership. I.e., outsourcing is ability to transfer some functions or business processes to subordinate firms or individual experts, who can perform this work better (Sadchykova et al., 2018);
- use of outstaffing – sending the staff (most often, food-processing entities) for certain period to companies involved in sale of food products, etc. (Krysanov et al., 2017).

The following is most often distinguished among the main reserves for increase of added value in agri-food chains: increase of profit at using the previous amount of capital; increasing the range of finished products with new consumer properties; optimizing the staff number/structure; reducing the amount of capital used at keeping the profit on previous level; reducing the costs for involving the capital; market expansion; increasing the amount of invested capital, etc. (Bryl, 2018; Dankevych, 2011; Seredynska, 2010; Shevchuk et al., 2007; Aliev et al., 2018).

Based on systematizing the actual scientific approach to forming the agri-food chain, we defined the main stages of added value in the field of Ukrainian potato growing, depending on degree of their integration into this process (Fig. 1).

Thus, added value grows at each stage and maximum increase is observed at stage of processing the raw materials (potato) into finished products (potato products).

In developed countries of the world, increase of the total added value in agri-food chain pays much attention to potato storage and processing. In Ukraine, structure of using the produced potato is completely different (Table 1). As shown in Table 1, potato in Ukraine is used for food purposes – 26-32%, livestock feed – 29-33%, and processing for non-food purposes – up to 10% of its gross production.

Significant share is occupied by potato-planting costs – 22-27%, which is 2.5-3.0 times more than in all other countries. Potato losses are unreliable –

7.6-11.0% total. No country has such low losses. At the same time, scientists note that "field-storage-consumer" chain loses 25-40% of potato, including 8-10% during harvesting, 4-5% during transporting, up to 25% of harvest after storage. In this view, it must be noted that increasing the scope of industrial potato processing can minimize these losses (Stoliarov, 2002; Patyka et al., 2021).

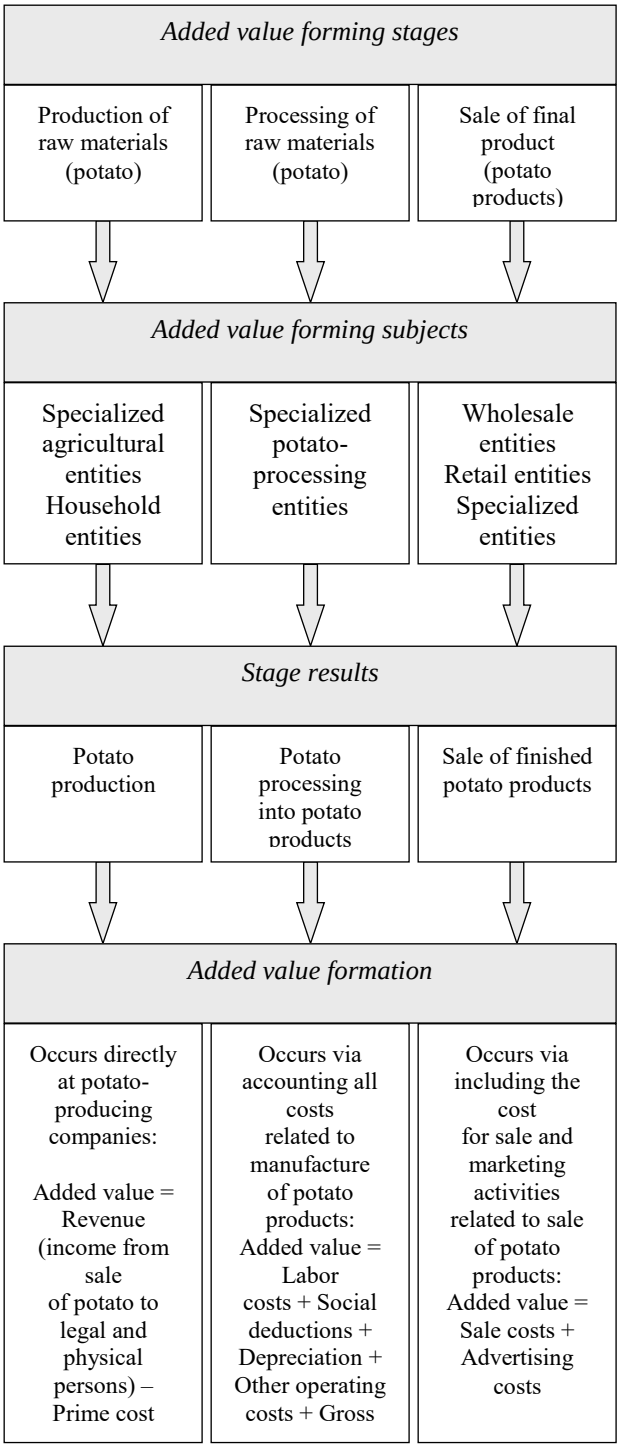

Fig. 1: Process of added value forming by agricultural entities

While share of potato consumption fund in total scope of its production decreased and made 28.1% in 2019, potato consumption for livestock feed was 32.9% (in the US – 2% only) (Food and Agriculture Organization of the United Nations, 2020). In foreign countries, the feed mostly utilizes waste of potato processing into chips, fries, etc., which further increases the profitability of primary production.

Now, global use of potato for feed and technical purposes is constantly dropping – compared to other types of feed and raw materials, potato is more expensive. In general, due to low yield/large loss of potato in "field-consumer" chain (up to 50%), ratio of potato production to consumption by Ukrainian population is 1.5-2.0 times higher than in developed countries.

3 Research Objective

Purpose of the article is scientific justification of conceptual investment model for added value forming in agri-food chain "potato-potato products", based on defined optimal structure of balance between potato production and consumption, effective combination of fresh and processed products – to ensure competitive parameters of potato farming in Ukraine, in modern market environment.

4 Methodology

Methodological basis of the study is using the balance method for assessment of situation in potato market and achieving the equilibrium in "demand-supply" system, methods of mathematical statistics, extrapolation and expert assessment – to outline the promising values of technical and economic indicators for potato sector. Correlation-regression analysis was used to mathematically formalize the statistical dependence of performance indicators on individual factors.

To develop the forecast balance of potato production and consumption in Ukraine, for the period till 2027, we considered the scopes of its use by population, their reduction trends over the past decade, feed consumption scope, possible potato loss, and results of yield forecasting in different categories of farms, based on revealed regularities. While developing the optimal balance of potato production and consumption, we made some assumptions on minimum allowed level of potato stocks, given the need for seed potato, feed consumption, losses, non-food processing, and

scope of consumption fund (population needs for potato till August).

Working hypotheses on defining the optimal scope of potato production/consumption in fresh and processed form were developed on the basis of actual recommendations from Potato Farming Institute at NAAS (National Academy of Agrarian Sciences of Ukraine) of Ukraine – on need to bring the promising scopes of potato processing into various food products (semi-finished or finished) to 20% of the total gross harvest (National Academy of Agrarian Sciences of Ukraine «Potato Farming Institute at NAAS of Ukraine», 2016).

Table 1. Structure of potato consumption in different fields of use, % of its gross production
Source: (State Statistics Service of Ukraine, 2020).

Indicators	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Feed consumption	30.0	28.5	32.0	33.1	29.4	31.4	31.1	30.7	30.7	32.9
Planting consumption	26.2	22.2	25.3	25.4	23.8	26.0	25.2	25.1	24.8	27.3
Losses	8.0	7.6	9.7	8.8	8.9	9.3	8.9	9.5	10.1	11.0
Non-food processing	6.6	6.3	7.2	7.8	7.3	9.5	5.7	5.6	6.8	8.1
Consumption fund	31.6	26.3	27.5	27.7	25.6	28.3	27.4	27.4	26.2	28.1
Stocks at the end of year	68.3	61.9	62.9	62.9	64.2	68.5	67.3	67.6	68.2	68.3

Table 2. Balance of potato production/consumption in Ukraine for 2010-2019, thousand tons
Source: calculated and compiled by the authors under data (State Statistics Service of Ukraine, 2020).

Items	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Stock at the beginning of year	13,183	12,773	15,005	14,635	13,994	15,205	14,268	14,642	15,018	15,355
Production	18,705	24,248	23,250	22,259	23,693	20,839	21,750	22,208	22,504	20,269
Import	30	41	23	23	40	17	27	24	28	32
Resources for use	31,918	37,062	38,278	36,917	37,727	36,061	36,045	36,874	37,550	35,656
Export	8	13	7	16	17	15	5	18	22	20
Feed consumption	5,606	6,906	7,434	7,377	6,970	6,538	6,769	6,821	6,911	6,677
Planting consumption	4,897	5,377	5,873	5,660	5,650	5,416	5,490	5,565	5,570	5,530
Losses	1,493	1,854	2,260	1,967	2,098	1,943	1,938	2,110	2,276	2,234
Non-food processing	1,227	1,539	1,675	1,742	1,726	1,989	1,235	1,251	1,523	1,637
Consumption fund	5,914	6,368	6,394	6,161	6,061	5,892	5,966	6,091	5,893	5,705
Stocks at the end of year	12,773	15,005	14,635	13,994	15,205	14,268	14,642	15,018	15,355	13,853
Sown area, thousand hectares	1408	1439	1440	1388	1348	1291	1312	1323	1319	1309
Yield, dt/ha	132	168	161	160	176	161	166	168	171	155

For forecasting and statistical modeling of indicators it is necessary to investigate patterns of their dynamics, ie to study the general tendencies of development (trend). The construction of the trend on the basis of statistical data for the relevant period (expression of trends in the form of mathematical equations, where the only independent factor is time) allows you to choose an analytical function that most accurately describes the change in time series (until 2027).

5 Results and discussion

Balance of potato production/consumption in Ukraine over the last ten years, given in Table 2, shows excessive process consumption (for seed material), high share of livestock feed consumption, and storage losses of potato. Under provided data, during the study period, despite the growth of potato production, scope of its consumption by Ukrainians decreased by 3.5%. However, it does not indicate the drop of potato consumption, as observed in leading countries of the world. On the contrary, total consumption of potato in Ukraine decreased, but increased per capita – due to reduced number of the residents.

In Ukraine, only about 0.3% of gross potato harvest is sent for industrial processing and making 2 types of products: chips and minor amount of dry mashed potato (developed countries – over 100 types) (Tsarenko, 2002). Increasing the share of industrial processing will not mean the increase of potato need for food purposes. Ukraine needs to develop the export markets for potato products, but product quality requirements (especially, seed material) will restrain manufacture of potato products and export of seed potato for a long time. According to V. Riznyk, absent demand for Ukrainian reproductive material is also caused by

its quality incompliance with modern international requirements – in terms of fierce competition at the world market of potato seeds (Riznyk, 1999).

According to State Statistics Service of Ukraine, food industrial processing of potato in recent years (2015-2019) actually resulted in 65-75 thousand tons of potato products and semi-finished products, while only 190-220 thousand tons of fresh potato was received for processing (State Statistics Service of Ukraine, 2020). Even in the UK, at high income of population, scope of potato used for processing increased over 25 years (1955-1980) from 115 to 1,074 thousand tons, which was 21.2% of the local production (Kalinchik et al., 2010).

The following equation was developed based on dynamics for short-range scope of industrial potato processing in Ukraine (2015-2019):

$$Q=7{,}937.4 \times Ln(t-60{,}325) \quad (1)$$

where Q – scope of manufactured potato products and semi-finished products;

t – years (2015-2019).

Solution of this equation (t = 2027) shows that scope of potato products/semi-finished products manufactured in 2027 will be 112.8 thousand tons only. To do this, about 340 thousand tons of fresh potato or only 9.5% of scope predicted in Sectoral Comprehensive Program "Ukrainian Potato – 2016-2020" will have to be processed (Potato Farming Institute at NAAS of Ukraine, 2016).

According to our calculations, scopes of export by 2027 will not exceed 31 thousand tons, and import – 43 thousand tons. In this situation, hopes for potato sector recovery via export of potato and potato products are not justified (especially, for export of seed potato). Under customs statistics, 95-99% of the total potato scope was exported to Commonwealth of Independent States (CIS) countries every year. At that, every year, the top share was formed by new CIS country. Given that Ukraine imports potato from limited number of permanent countries, and trend of export to other countries is random phenomenon, it is hard to expect the significant increase of export, although potato import rates may grow.

To develop the forecast balance of potato production and consumption in Ukraine, scope of its use by population (P) was calculated. Trends of their decrease by years (2007-2019) are described by the following equation:

$$P=36{,}681-15.203 \times t \quad (2)$$

where t – years (forecast years – t = 2020-2027).

Feed potato consumption (F_k) is calculated as trend of changing the percentage to gross potato harvest:

$$F_k=(0.01 \times (0.1304 \times t-292.27)) \times Y \quad (3)$$

where "Y" – the volume of gross production (harvest) of potatoes for the analyzed period

Potato loss (W) is taken as 0.10114 of gross production, as observed in recent years (2007-2019):

$$W=0.10114 \times Y \quad (4)$$

When developing the perspective potato balance, yield forecast is of particular importance. The whole structure of fresh potato production/consumption balance depends on its absolute value. So, to prepare the potato balance optimizing model (Matviychuk et al., 2014), system of equations/identities shall be developed in Excel environment – first of all, for potato yield dynamics (U).

Under conducted analysis of potato yield dynamics for all categories of Ukrainian farms in 1995-2019, in 25 years, the yield decreased till 1999 and then began to increase. Fresh potato yield forecast for 2020-2027 was made via equation describing the established pattern:

$$U=219{,}040-221.65 \times t+0.0561 \times t^2 \quad (5)$$

Consumption rate of seed potato per 1 ha was taken at the level of actual average consumption in 2013-2019 – 4.18 tons per 1 ha or 33.3% more than assumed by Sectoral Comprehensive Program "Ukrainian Potato – 2016-2020" (Potato Farming Institute at NAAS of Ukraine, 2016).

In 2007-2019, potato stocks at the end of year ranged from 12.6 million tons (2007) to 13.9 million tons (2019) or 1.1 times more. First, it does not stabilize the situation in potato market and second – it leads to major potato loss. Thus, optimization task assumes setting the rational scope of stocks at the end of year and scope of consumption for planting (depending on potato planting area, i.e., need for seed potato indirectly depends on predicted gross production), scope of livestock feed consumption and potato loss during storage, parameters of which depend on gross production of fresh potato. All the above functional consumptions or product stocks are unknown (when solving the optimization task, you need to calculate their parameters). Yet, since they are

interdependent, there is every opportunity to find their optimal values.

At that, it is accepted that minimum allowed level of stock is share of gross potato production, which should remain at the end of year and will be able to meet the needs for potato till the mass harvesting (till August). This included $^1/_2$ of feed consumption, all needs for seed potato, $^1/_2$ of losses and scope of non-food processing, $^7/_{12}$ of potato consumption fund (need of population for potato till August).

All formulas related to developing the optimal potato production/consumption balance during 2020-2027 will be summarized in the following diagram (Table 3).

Table 3 shows logical sequence of equations and identities, limitations, unknown values used in development of optimal potato production/consumption balance (to be determined for calculation of all other indicators mathematically related to them). In equations, some values depend on calendar time only (import, export, industrial processing, consumption fund, potato yield), others – on gross potato production (loss) or planted area (seed potato consumption), and others – on calendar time and gross potato production (feed consumption). Stocks at the end of year and need for fresh potato, since January 1 till start of mass harvesting, simultaneously depend on three factors: calendar time, planted area, and gross production of fresh potato.

The problem was solved in Excel environment, using "Solution Search" software. The results of solution are given in Table 4.

Table 3. Algorithm of developing the optimal potato production/consumption balance
Source: calculated and compiled by the authors

Equations and identities	Clarification
$I_t = -2{,}600.9 + 1.3042 \times t$	Scope of import
$R_t = Z_{pt} + Y_t + I_t$	Resources for use
$E_t = -2{,}803.7 + 1.3986 \times t$	Scope of export
$F_{kt} = (0.01 \times (0.1304 \times t - 292.27)) \times Y_t$	Feed consumption
$N_t = 4.18 \times S_t$	Planting consumption
$W_t = 0.10114 \times Y_t$	Losses
$G_t = -62{,}607 + 31.836 \times t$	Non-food processing
$P_t = 36{,}681 - 15.203 \times t$	Scope of consumption by population
$Z_{kt} = R_t - (E_t + F_{kt} + N_t + W_t + G_t + P_t)$	Stocks at the end of year
$D_{zt} = \frac{F_{kt}}{2} + N_t + \frac{W_t}{2} + \frac{G_t}{2} + \frac{7}{12} \times P_t$	Need since January 1 till start of mass harvesting
$S_t = \frac{Y_t}{U_t}$	Planted area
$U_t = 219{,}040 - 221.65 \times t + 0.0561 \times t^2$	Crop capacity
Limitations	**Clarification**
$Y_{st} = \sum_{t=1}^{n} Y_t \geq 138{,}765$	Total scope of production in 2020-2027 shall be equal to or exceed 138,765 thousand tons
$Z_{kt} \geq D_{zt}$	Stocks at the end of year shall be equal to or exceed the needs since January 1 till start of mass harvesting
$Z_{pt+1} = Z_{kt}$	Stocks at the beginning of next year are identical to stocks at the end of previous year
Unknown values	**Clarification**
Y_t	Annual scope of gross potato production
Z_{p1}	Stocks at the beginning of 2020
Optimization criterion	**Clarification**
$\sum_{t=1}^{n} Z_{kt} \rightarrow min$	In 2020-2027, total stocks at the end of year shall be minimal

By results of optimizing calculations for potato production/consumption forecast balance in Ukraine till 2027, which utilize potato stock minimizing at the end of year, the following important conclusions can be made:

1. In early 2020, actual residues of potato made 13,853 thousand tons, which is 2.4 million tons more than optimal values of this indicator (under optimization model in Table 3). It means that this output value had no consumer demand and financial resources for manufacture of extra products were used inefficiently. As a result, business activity in potato forming drops, warehousing costs increase, and financial status of producers gets worse. Under calculations of forecast balance till 2027, to meet the demand of potato consumers since January 1 till end of July, potato stocks at the end of year shall be maintained at 62-63% of gross production or 10.3-11.3 million tons – in contrast to actual 68% in 2019.

2. To meet local potato demand under current consumption structure, much lower gross harvest (than actually formed in Ukraine) is enough. Thus, in 2020, potato production should decrease to 17.9 million tons, in 2021 optimal scopes are at the level of 17.8 million tons, in 2022 – 17.6 million tons, in 2023 – 17.4 million tons, in 2024 – 17.3 million tons, in 2025 – 17.1 million tons, in 2026 – 17.0 million tons, in 2027 – 16.7 million tons.

3. If during 2020-2027 potato yield will increase by another 25% (relative to our forecast indicators), the need for seed material will decrease and in 2027 will be only 2,123 thousand tons or 2.6 times less than in fact in 2019. At the same time, the scope of harvest in 2027 will be reduced to 15.9-16.1 million tons or 4.2-4.4 million tons compared to 2019, and the area of planting potato – up to 508 thousand hectares. The situation is completely different, when the yield will remain at the level reached on average for 1995-2019 – 133 dt/ha. Reducing the cost of seed material and losses in the chain "field-consumer" can significantly increase the level of marketability of potato and revenue from its sale. According to our calculations, potato industry as a whole becomes profitable, if its marketability exceeds 50.6%.

Table 4. Results of optimizing the forecast balance for potato production/consumption in Ukraine till 2027, thousand tons

Source: calculated and compiled by the authors

Indicators	Years							
	2020	2021	2022	2023	2024	2025	2026	2027
Stocks at the beginning of year (Z_p)	11,440	11,279	11,126	10,980	10,840	10,707	10,575	10,464
Yield (Y)	17,942	17,759	17,583	17,415	17,257	17,095	16,984	16,730
Import (I)	34	35	36	37	39	40	41	43
Resources for use (R)	29,416	29,073	28,745	28,432	28,136	27,842	27,600	27,237
Export (E)	21	23	24	26	27	29	30	31
Feed consumption (F_k)	5,179	5,102	5,029	4,958	4,891	4,822	4,769	4,676
Planting consumption (N)	3,449	3,336	3,228	3,125	3,027	2,931	2,846	2,741
Losses (W)	1,815	1,796	1,778	1,761	1,745	1,729	1,718	1,692
Non-food processing (G)	1,702	1,734	1,765	1,797	1,829	1,861	1,893	1,925
Consumption fund (P)	5,971	5,956	5,941	5,925	5,910	5,895	5,880	5,865
Stocks at the end of year (Z_k)	11,279	11,126	10,980	10,840	10,707	10,575	10,464	10,307
Ratio of stocks at the end of year to production, factor (Z_k / Y)	0,63	0,63	0,62	0,62	0,62	0,62	0,62	0,62
Need till start of mass harvesting (D_z)	11,279	11,126	10,980	10,840	10,707	10,575	10,464	10,307
Planted area, thousand hectares (S)	826	799	774	750	725	703	682	656
Yield, dt/ha (U)	217	222	227	232	238	243	249	255

Thus, the analysis shows that in Ukraine there is a significant overproduction of potato. Over the last 10 years, about 1.3-1.5 million hectares have been allocated for potato, and the average annual potato harvest was almost 22 million tons (490 kg per capita). Despite the fact that the consumption of potato in Ukraine reaches a very high level (144 kg per 1 person per year), only 6 million tons are needed to meet the needs of the domestic market and about 5.5 million tons are needed for planting. Then a logical question arises – where does the remaining 10 million tons go? Some of them, unfortunately, are fed to livestock (6.5 million tons), and everything else spoils during storage (annual losses of potato within the state are almost 103 times higher than its exports). That is, in fact, almost 20% of the potato crop is fed to cattle every year or lost in the process of harvesting and storing. This amount is equivalent to half of the harvest in neighboring Poland. At the same time, potato in Ukraine are practically not processed, because industrial processing will

be profitable only at a yield of 30 t/ha, while now the yield of potato in farmers in the best years does not exceed 25-27 t/ha, and in households in general 12 t/ha (average European yield – almost 50-55 t/ha, and reaches 70 t/ha).

According to Food and Agriculture Organization statistics, Ukraine is among the top ten largest potato producers in the world (ranked 4th in terms of cultivation), but has never been included in the list of leading "potato" players in the global market (less than 0.1% is exported to foreign markets). At the same time, potato have significant potential for diversification of Ukrainian agricultural exports. During 2011-2019, total potato exports almost doubled, which is not the limit, given its significant domestic production and growing demand in the global agri-food market. At the same time, it should be borne in mind that in most European countries the vast majority of potato are sent for processing, and the share of products for the fresh market is relatively small (Food and Agriculture Organization of the United Nations, 2020).

With the right target orientation and sufficient investment in the development of processing infrastructure, the agricultural sector of Ukraine (Kozlovskyi et al., 2010) can additionally receive from the export of one tenth of the output of the industry about 1.1 billion dollars USA export earnings, and with the increase in the average yield of potato growing twice and the further sustainable development (Kozlovskyi et al., 2018) of production capacity for its processing, the export potential of Ukrainian potato industry is quite real to increase to 3-5 billion dollars USA (Cabinet of Ministers of Ukraine, 2020).

At the same time, Ukraine's participation in global value chains is constrained by a number of objective investment factors that prevent the possibility of exporting potato in larger quantities and at a much higher price. In particular, the EU market is unfortunately closed to Ukraine now, as the EU has a Council Directive № 2000/29/EC, which prohibits the supply of potato from countries where soil quality does not meet the phytosanitary standards of the EU, and Ukraine is just part of this list (Council of the European Union, 2000).

Thus, we are convinced that the problems of forming a rational structure for the use of products for technological and food purposes by developing industrial potato processing, finding new sales channels and ensuring their stability, expanding export-import operations remain relevant for Ukraine. From these positions, we have developed and substantiated a conceptual model of investment taking into account the optimal structure of the balance of production and consumption of potato in Ukraine.

Conceptual model is based on the mechanisms of investment cooperation between the business sector and the state and coordination of their economic interests and intentions, as well as stimulating sustainable development (Koziuk et al., 2020) of domestic and foreign consumer market of potato processing sector of Ukraine based on strengthening its competitiveness, which will ultimately accelerate integration into global agri-food added value chains.

It must be noted that even in developed market economy, the mechanism of state regulation of investment processes plays a crucial role in creating a favorable investment climate and investment attractiveness of certain industries. That is, there is an objective need to identify strategic areas of state support and investment in the structure of the chain "potato-potato products", in particular:

- improvement of credit and tax policy of Ukraine, formation of reliable incentives for investment in potato business;
- harmonization of European and Ukrainian legislation, introduction of new standards in the field of potato growing;
- state financial support of breeding centers and basic farms that grow certified potato seeds;
- strengthening and updating the material and technical base of Ukrainian potato growers by investing in technical equipment with modern agricultural machinery and equipment;
- partial compensation to producers of potato suitable for processing into potato products, the cost of officially purchased certified seed (≈ 60 thousand UAH per 1 farm);
- restoration and modernization of artificial irrigation systems (drip irrigation system ≈ 3.0 thousand USD per 1 ha, sprinkler system ≈ 3.0-3.5 thousand USD per 1 ha), subsidies for water and electricity, etc.;
- reconstruction and construction of the latest technologies of potato storages with a total capacity of 450 thousand tons, as well as other infrastructure facilities of the potato market (≈ UAH 3.1 billion);
- investments in equipment for post-harvest processing and pre-sale preparation of potato, in particular lines for washing, sorting, packing, etc. (line with a capacity of 200 tons per day ≈ 200 thousand euros);
- construction and commissioning of enterprises with primary (washing, removal of defective products), secondary (cleaning, slicing, vacuum packaging) and deep (cooking, freezing,

drying, canning) processing of potato (≈ 15 million euros);

- attraction of financial resources (Kozlovskyi & Fonitska, 2013) for creation of integration complexes on production, storage and processing of production;
- contracting in the domestic market with supermarkets and HoReCa system;
- development of the institute of profile traders for the organization of export of potato and potato products.

Based on the analysis of strengths and weaknesses of increasing the level of integration of the Ukrainian potato market into global value chains, as well as an assessment of existing opportunities to optimize the balance of potato production and consumption by 2027, it can be argued that potato growers in Ukraine have significant potential for foreign economic activity and entering the EU market. The following vectors of development can be outlined as time guidelines for the future formation of rational economic behavior of Ukrainian processors and the revival of the potato processing segment as a whole:

- prospects up to 5 years: further development of the value chain by investing in in-depth processing and storage of potato, focusing on domestic consumers, increasing competitiveness and preparing to enter world markets;
- prospects for 5-10 years: expansion of exports of processed products, focus on regional markets, search for markets with strategic advantages;
- prospects in the time horizon of more than 10 years: the development of large-scale production, investment in strategic cooperation between farmers and processors.

An important point is the optimization parameters. These parameters are calculated taking into account the conditions of storage of products according to the standards of the European Union. Also, it should be noted that there are variations of product varieties. In this case, the authors made the calculation in weighted average.

In our opinion, a promising direction for solving problems in potato growing in Ukraine, as well as harmonizing the interests of market participants on a cost-effective basis is to change approaches to investing in the potato industry in order to transfer it to modern technologies, revive industrial potato processing and create a network of specialized food production enterprises (in particular, chips, French fries, semi-finished potato, etc.). Intensification of investment activity in accordance with the identified optimal parameters of the balance of production and consumption of potato will increase the competitiveness of the industry, achieve better economic results and strengthen financial stability in a constantly changing market environment.

6 Conclusion

The optimization of the structure of the balance of production and consumption of potato by minimizing its stocks revealed unnecessary losses in the chain "production-processing-transportation-sale-consumption", as well as reserves to increase the level of marketability and profitability of the potato industry in Ukraine. According to the results of modeling the forecast balance of potato production and consumption in Ukraine until 2027, it was found that the actual potato balances at the beginning of 2020 were 2.4 million tons more than the optimal values of this indicator according to the proposed optimization model.

Determining the optimal size of stocks at the beginning of 2020 (11,440 thousand tons) made it possible to calculate the rational parameters of other functional costs and forecast indicators of gross potato harvest until 2027. In particular, it was found that by increasing potato yield to 255 dt/ha and achieving marketability of products over 50.6% reduced planting costs (2,741 thousand tons in 2027) and total losses in the chain "field-consumer" (1,692 thousand tons in 2027). All this, in turn, will ensure the profitability of potato production at the level of 30-35% and will help improve investment and innovation (Heyets et al., 2021) attractiveness and increase investment activity in the potato sector of Ukraine. In this case, innovative development of the sector should be not only on the basis of increasing scope of investment per unit of sown area, but also with use of scientifically grounded, economically feasible, resource-saving, and environmentally safe modern production technologies.

In the course of solving the optimization problem, the rational size of potato stocks at the end of each forecast year and other functional costs is calculated. As a result of studying the relationship between individual components of the balance (imports, exports, processing, consumption fund, feed costs, planting costs, etc.) and the amount of losses in the chain "field-consumer" we concluded that the reduction of gross potato production to 16.7 million tons in 2027. At the same time, the low level of potato yield and its instability over the years necessitates the cultivation of potato on large areas (up to 1.5 million hectares), which significantly increases

the unbearable for the optimal economy stocks and increases the unpredictability of price tendency in the market.

Therefore, depending on the causes of excessive potato residues, it is necessary to develop effective measures to reduce them, in particular, by finding new markets for potato, which, accordingly, requires a significant reduction in production costs, expanding product range, improving quality, increasing storage capacity and in-depth processing. It is quite possible to do this if we pursue a balanced and consistent financial and investment policy (Kozlovskyi, 2010) in potato processing sector of Ukrainian economy.

Based on conclusion about the inefficient distribution of the gross harvest of potato grown in Ukraine, it is logically necessary to reduce investment in overproduction by 17.5% (according to our optimal balance, potato production by 2027 should be reduced to 16,730 thousand tons) and the direction of major investment flows for the development of the potato processing industry, increasing the export potential and expanding the boundaries of foreign markets for Ukrainian potato products and semi-finished products, and subsequently fresh products, provided that its appropriate quality. Global consumption trends suggest that, despite the higher price, buyers prefer peeled, vacuumed, frozen and canned potato, rather than the usual unprocessed product (Moskovchuk, 2019). In addition, given the fact that implementation of processed potato income in monetary equivalent is 2 times higher than indicators for fresh products, Ukrainian potato shall seriously calculate all possibilities of investment in deep crop processing, period of their payback, and scope of investment costs.

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