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Inter-relationships Between Primary Agriculture Production and Processing Capacities

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Abstract: Aiming at a unique agri-business in food industry, agriculture production must be integrated, but only if based on the economic interests of its integrated members. In this paper, an integral quantitative and qualitative analysis has been made on some clear examples.The trends of primary production and processing capacities have been surveyed and their interdependences analysed.

Pre-requisites and factors determining organizational-economic integration of primary production and processing, have been approached by a case study to define quantitative and qualitative model of economical integrating of primary production and processing into a unique food indystry system.

Key words: agricultural production, food industry, integration, logistics, logistical model.

Introduction

Different tendencies and forms of production integration are noticed on the areas of our country. Although imparted with certain organizational and integration level, these forms further tend to consolidate and shape into a unique food industrial process. Two forms of integration can be distinguished in agriculture production: horizontal and vertical.

The former assumes integration according to production lines, with production factors equally involved in the single and similar lines inside the same production field. Depending on the level of horizontal integrations, the pre-requsites of vertical ones are simultaneously created. The latter is said to depend

on phase character of agricultural production which is also related to intergrated production lines, but among varous production fields. Vertical dependences are considered as the outpts (final products) of one production line, simultaneously being the inputs (raws) of another. Two basic forms of vertical integration can be distinguished. First, both ownership and means of production are common, represeting a closed production cycle (from raws up to final products marketing). Second vertical integration is based on sale contracts between agricultural producers and processors. The analysis of the inter-relationship between agriculture and food industry reveals factors with a profound effect on such an inter-relationship. Therefore, research goals may be defined, as follows:

- modelling of all agri-industrial relationships for higher economic effectiveness and efficiency,
- external assumptions to be defined according to chain-like logistical functioning,
- sustainability of agricultural firms under present market conditions, i.e. transition paths in an overall economcs, with an emphasis on agriculture.

Logistical approaches to agriculture have acquired in importance, since the agricultural firms have proved to be more and more justified when integrated through logistical ties.

Logistics provides as most optimal as cheapest flow of raws, semi and final products, as well as all the information from raws to end users.

Analysing inter-dependences between primary agriculture production and processing capacities, the following hypotheses may be put forth:

- the presence of a closed inter-relationship between primary agriculture production and processing capacities in food industry,
- primary agriculture production may help answer what processing capacities to build and where;
- in some areas, processing capacities can promote primary production to a great extent;
- information flows between primary agriculture production and processing capacities ought to be immediate and permanent;
- modern agri-complexes can be promising provided primary agriculture production and processing capacities are integrated into unique systems,
- integration of primary agriculture production and processing capacities into the logistical chains is presumed a milestone of future agri-business;
- no unique organizational model for integrating into logistical chains exists, so it has to be adjusted to the existing conditions.

Interrelationships of Primary Agriculture Production and Processing Capacities (case study)

The inter-dependence between raspberry production and cold storage intended for processing on the area of Arilje

The highlands of west Serbia are rich in natural conditions favouring production of both highly yielding and high quality raspberry. Unsurprisingly,

such a quality raspberry is highly demanded on the west market. Remarkable yields of over 30 t of raspberries per year have been achieved on the area of Arilje for over two decades, so that by its production volume this area is matchless in Europe, and by frozen raspberries export, in the world.

Raspberry production depends on its processing. In the intensive production, the two phases, primary production and processing represent the inseparable stages of a unique process, for raspberries can be placed on the market only in the processed form. As the fruits are easily perishable, their transportation for further processing must quick. Harvest should be well organized and continuously performed letting recently picked fruits reach processing capacities as quickly as possible without being damaged. Besides, proximity to road transport facilities and that of capacities to newly-picked raspberries ensure an efficient shipping with minimal losses.

Tab.1- Raspberry production in the Republic of Serbia and Arilje commune for the period 1971-1994

Year production	Production output in Serbia (t)	Year per (ha)	Production output in Arilje (t)	Year per (ha)	Share of Arilje (%)
1971	18.089	-	68	-	0,4
1975	15.780	-	138	-	0,9
1981	17.047	3,4	971	7,1	5,7
1982	22.047	4,3	1.186	6,8	5,4
1983	23.422	4,4	2.115	7,2	9,0
1984	23.631	4,2	2.005	6,3	8,5
1985	27.092	4,4	3.017	7,8	11,1
1986	26.123	3,8	3.172	8,2	12,1
1987	34.197	4,6	5.419	8,8	15,9
1988	50.432	5,7	6.606	9,3	13,1
1989	57.635	5,4	8.040	10,0	13,9
1990	66.719	6,0	9.060	11,50	13,6
1991	41.117	4,1	5.261	7,5	12,8
1992	43.456	4,5	4.776	8,1	11,0
1993	37.637	4,0	4.860	7,0	12,9
1994	43.487	4,5	5.300	8,0	12,2
Indexi:					
1981/71	94,2		1.427,9		
1990/71	368,8		13.323,5		
1990/81	391,4		933,1		
1994/90	65,2		58,5		

data sources: Fruit and Vegetable Association Beograd, Agricultural Cooperative Arilje and Latvica

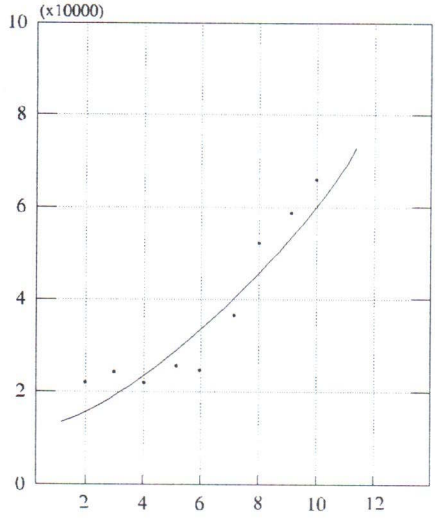
The equation on raspberry production in Serbia for the period 1981-1990 is derived from the data presented above, with the exponential rise given graphically . The model of exponential trend is, as follows:

$$\ln \hat{Y} = 9{,}956211 + 0{,}144928x \qquad F=88{,}91^{**}; \qquad R^2=91{,}75\%$$
$$(9{,}43^{**})$$

Antilogarithm computation gives: $\hat{Y} = 14.215{,}81 \cdot 1{,}156^{x}$ with the average annual rate of production increase of 15,6%.

Suveilance of raspberry production in Serbia points to its exponential increase from 1981-1990, but to its decline from 1991-1994. Thus, the production decrease by 62,27% in 1991 influenced the average annual rate of change to be 1,89% for the period 1991-1994.

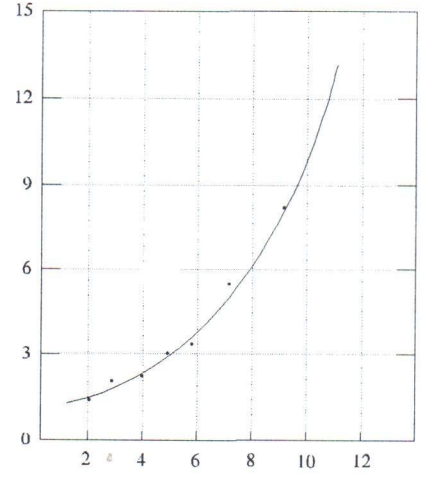
Fig.1. Raspberry production in Serbia for the peroid 1981-1990.



In the raspberry production in the area of Arilje in the period 1981-1990, the production function has the form: $\ln Y = 6{,}67138 + 0{,}255904x$ (F=326,35**; R^2=97,61%) 18,07**

Antilogarithm computation gives: $Y = 789{,}46 \cdot 1{,}2916^x$

Fig. 2. Raspberry production of the Arilje Commune for the period 1981-1990.



Exponential trend is more explicit, average annual increase rate is 29,16%.

After production exponential rise, its decrease in 1990, and a drastic fall even by 72,21%, occurred in 1991. The average annual rate of change for the period 1990-1994, was 8,25%. On the basis of analysed period from 1971, with raspberry production amounting to 68 t, up to 1990 with its output of over 9 000 t, it seems possible to follow raspberry production, as well as to focus on numerous causes and reasons, that led to such a behaviour.

In the period from 1971-1981, raspberry production had a linear trend of increase,index of increase of 1428, and average annual rate of increase of 30,5%. From 1981, the production was on exponential rise, to slightly stagnate in 1984, but continuing to rise in 1985. Year after year, raspberry production boosted to reach an optimum of 9.060 t in 1990.

Based on the index, of increase, one can notice a rapid increase in the total raspberry production of the area of Arilje, compared to that of Serbia.

Two main reasons account for production boost on the area of Arilje:

- new processing capacities initiated by primary production, and
- newly-established processing capacities that are enhancing raspberry production and expansion.

Thanks to its efficient production policy, the firm "Jedinstvo" markedly improved raspberry production from 1971-1990, ranking highest by frozen raspberry export potential as late as '80.

Well-managed raspberry production, and a permanent tendency to partly invest cumulation into cold storage capacities aiming at their expansion and modernization, highly boosted processing capacities.

The processing complex started in 1970 aimed at pome fruit processing (raspberry, strawberry, blackberry) and apple cold storing. Initially, 740 t of storing capacity with regime 0^0C and 1340 t of storing capacity with regime - 25^0C were available. Conventional ducts intendend for deep freezing (-35^0C) of capacity 16 t per 24 hours, were provided, too. At the end of their establishment, these capacities could store 6000 t and freeze 260 t of raspberries per day. Their permanent expansion and modernization can be tabulary presented, with average annual rates of increase and variation indices given in Tab.2.

Tab.2. The Average annual rates of increase in storing and processing capacities per day

Year	Capacities	Procesing capacities per day
1970-1978	0	12,1 %
1978-1980	0	32,2 %
1980-1983	27,2%	12,6 %
1983-1986	8,6%	21,6 %
1986-1988	4,6%	24,7 %
	Indexi:	
1970-1978	100	250
1978-1980	100	175
1980-1983	206	143
1983-1986	128	180
1986-1988	109	156

In the period from 1983-1986, the average annual rate of increase of storing capacities amounted to 8,6%, and that of the processing ones per day to 21,6%. In the same period, 14,4% accounted for the average rate of production increase in the area of Arilje. Characteristically, the more enhanced raspberry production was, the faster improvement of the processing capacities, was. Raspberry production increased to a great extent in the period from 1986-1988, with average annual rate of production increase, amounting to 44,3%. The rate of increase of storing capacities was 4.6%, and that of daily processing ones, 24,7%. These capacities were found to stimulate both production and staff, which is reflected in a highly extension approach to intensive raspberry production.

So created raspberry processing capacaties have shown excellent results, yet at peak harvest, they could have barely admitted all newly-picked raspberries. A question was raised on whether it was profitable at all to invest in new capacities to be used just for a few of days of exploitation, which later proved to be success. The problems arising at peak-harvest were solved by setting up raspberry patches at different altitudes, with an extended time of picking up to 60 days, as well as of that of purchase and processing.

In the course of time, these capacities were improved and allocated a lot of investments to be refunded by 1990.

The inter-relationship of potato production and processing capacities on the area of Cacak Commune

Ever since it was founded in Guca in 1954, the Institute of Potato Production and Selection has marked a steady advancement thanks to modern production technology and highly yelding cultivars. The area of Moravicki District also represents one of the leading potato producers country-wide. Since potato amounts produced on this area have already met the local needs, the problems of storing and placing potato surpluses on the markets being in short supply of this vegetable, are accruing. The issues on potato utilization and processing are none the less significant.

The first factory of industrial potato processing was set up in Cacak and started in May, 1971, with mashed potatoes, chips being the key products. This factory has grown into a recently-modernized comp. "Processing" comp., which is of paramount importance to future potato agri-business.

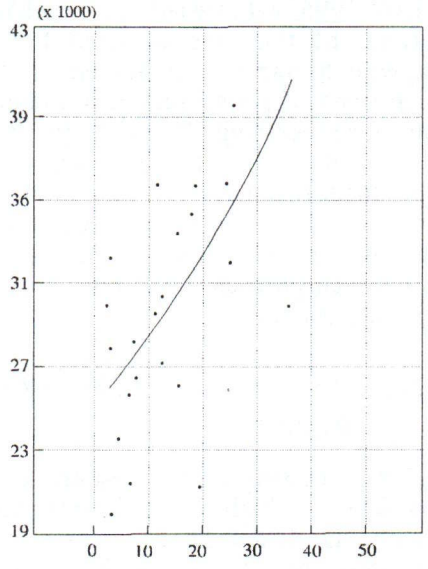
The potato production trend can be presented using square function, as follows:

$$\hat{y} = 25.236{,}2 + 275{,}111t + 5{,}54609t^2 \quad (F=2{,}99 \text{ insignificant}; \quad R^2=23{,}95\%)$$

$$0{,}39^* \qquad 0{,}19^{**}$$

where its production on the area of Cacak averages 29.355,6 t, with variation coefficient of 18,26% for the period 1974-1995.

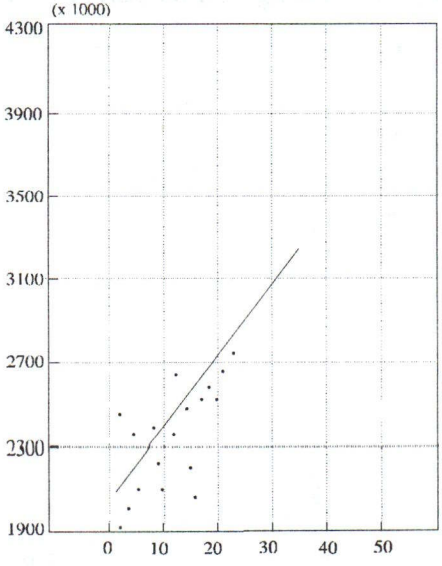
Fig.3. Potato production of the Cacak commune for the period 1974-1995



Potato production had a rising linear trend from 1974-1995. The equation of linear trend can be calculated in the following manner:

$$\hat{y} = 2033{,}47 + 34{,}8961t \quad (F=6^{*};\ R^2=23\%)$$
$$2{,}45^{*}$$

Fig.4. areas under potatoes in Cacak commune from 1974-1995.



According to our estimation, the average production value of this area was 2.434,77 ha from 1974-1995 with variation coefficient of 19,38%.

Potato yields (t/ha) of this area deviated from the average value, amounting to 12.17 t/ha, with the variation coefficient of 15,68%.

Noteworthy, such trend of potato production could provide ample raw sources that are necessary for processing. Thanks to purchase and processing all year round, this factory ensured a stable market for agri-products. In competition with some new food products that have recently become usual foodstuffs at home market, the factory also enhanced potato consumption in human nutrition.

Regression analysis was made on the values given in the table to determine dependences between purchased and processed potato amounts, with the following linear regression model:

$$\hat{y} = -1916{,}021273 + 7{,}68544\,x \quad (F=109{,}204^{**};\ R^2=81{,}9\%)$$
$$10{,}45^{**}$$

Obviously, higher processing by 1 t resulted in a higher purchase by 7,68 t. The regression model seems highly statistically significant (F=109,204**) and, inter-correlation barely significant. Determination coefficient value clearly denotes that purchase variability of 82% resulted from production values. Linear correaltion between purchase and processing is very strong and highly significant, amounting to r=0,90407.

For establishing the dependences between processed and purchased potatoes amounts, the cross-correlation coefficient values were calculated. The cross-correlation values are graphically presented.

Fig.5. Dependence between purchased and processed potatoes in the comp. "Processing" for the period 1971-1995.

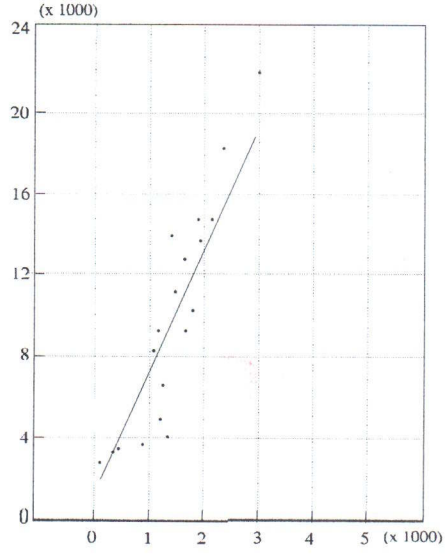
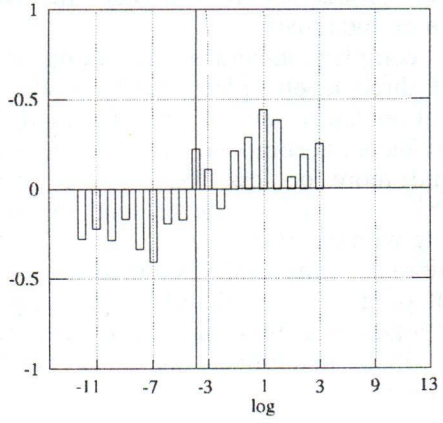


Fig.6. Cross-correlation function of the processed and purchased potatoes



For better understanding of an inhibiting effect between the processed and purchased potatoes, the limiting factors of potato processing should be mentioned, with an emphasis on the possible alleviation of their adverse effects through a stronger integration between potatoes production and processing, as well as through a better production and marketing management at home and world-wide too.

Quantitative model of the primary production and processing capacities integration

Production relations within agriculture production cannot be avoided. High specificity of agriculture production (seasonal activities, phase character etc.) led to a great number of horizontal and vertical dependences in agriculture so that a further course of agriculture production is aimed at a higher level of agri-processing, with preferably synergetic effects on t plants, cattle and processing industry. The process of agriculture production is being implemented at three levels:

- plant production,
- cattle production, and
- agri-processing.

The inter-relationships between primary agriculture production and processing capacities may be presented using mathematical-logistical model, which will clearly show that production flows within the agri-system are based on both horizontal and vertical ties in agriculture production.

The model is to explain an unavoidability of agri-business systems integration, which is of prior importance to future stability and functionality in economics. Mathematical-logistical model will provide optimal utilization of the existing production sources, and production flows will be directed to optimal efficacy, as a criterion of successful business systems. The use of the model will also show how horizontal and vertical structures will be integrated into the

logistical chains of food production, as well as how to structure production as well as how to structure production to be highly effective and to meet all the criteria for competition on food market.

Agri-business complex integrated according to the logistical-chain system, is defined at three levels: plant, cattle production and agri-product processing. Each level includes several organizational units, i.e. production subsystems within agri-business complex. Each organizational unit has its own range of products and more or less fixed costs. Production flows of all organizational units that are at a lower level, tend to catch up with those at a higher one, just as being with external inputs.

Optimal functioning of the model is aimed at economic efficacy, i.e. the feasibility of maximal production profitability, as a key relationship between production values and total costs. Maximal lucrativeness to be accomplished by means of this model will be determined, using "broken" linear programming. The model will be, as follows:

- *The function of optimality criterion:*

$$\sum_{k=1}^{a}\sum_{1}^{n} VP_{k(n)} \cdot X^{e}_{k(n)} + \sum_{k=1}^{l}\sum_{1}^{m} VP_{k(m)} \cdot X^{e}_{k(m)} + \sum_{k=1}^{c}\sum_{1}^{q} VP_{k(q)} \cdot X^{e}_{k(q)} = E_{p(max)}$$

- *The matrix of limitation:*

Sources of plant production: $\sum_{1}^{n} D_{k(n)} \cdot X_{k(n)} - YR_{k(n)} \geq 0, \left(X_{k(n)} = \sum X^{i}_{k(n)} + X^{e}_{k(n)}\right)$

Sources of cattle production: $\sum_{1}^{m} D_{k(m)} \cdot X_{k(m)} - YR_{k(m)} \geq 0, \left(X_{k(m)} = \sum X^{i}_{k(m)} + X^{e}_{k(m)}\right)$

Sources of processing: $\sum_{1}^{q} D_{k(q)} \cdot X_{k(q)} - YR_{k(q)} \geq 0$

Flows of plant production: $\sum_{k=1}^{a} X^{i}_{k(n)} + X^{e}_{k(n)} - \sum_{k=1}^{l} Q_{k(m)} \cdot X_{k(m)} - \sum_{k=1}^{c} Q_{k(q)} \cdot X_{k(q)} = 0$

Flows of cattle production: $\sum_{k=1}^{l} X^{i}_{k(m)} + X^{e}_{k(m)} - \sum_{k=1}^{c} Q_{k(q)} \cdot X_{k(q)} = 0$

- *Limitation of costs:*

$$\sum_{k=1}^{a}\sum_{1}^{n} VT_{k(n)} \cdot X_{k(n)} + \sum_{k=1}^{l}\sum_{1}^{m} VT_{k(m)} \cdot X_{k(m)} + \sum_{k=1}^{c}\sum_{1}^{q} VT_{k(q)} \cdot X_{k(q)} + \sum_{1}^{n} C^{e}_{n} \cdot X^{e}_{n} +$$

$$+\sum_{1}^{m} C^{e}_{m} \cdot X^{e}_{m} + Y \cdot \left(\sum_{k=1}^{a} F^{b}_{k} + \sum_{k=1}^{l} F^{s}_{k} + \sum_{k=1}^{c} F^{p}_{k}\right) = 1$$

where:

$E_{p(max)}$ - is the maximal rationalization to be attained by agri-business complex

VP - production value per product unit

X - independent variables of the model

$X = X_i + X_e$ - total production equal to internal and external production implementation

D - resources required per production unit
$Q_{k(m)}$ - raws "n" required for "m" production in organizational unit "k"
$Q_{k(q)}$ - raws "n" and "m" in production "q" organizational unit "k"
C - unit price of external product
VT - variable costs of product unit
Y - additional variable of the model

Solving such a designed mathematical model, maximal production lucrativeness to be accomplished by agri-business complexes, can be calculated. The quantity of products per organizational units, as well as their external and internal production implementation, are also calculated. The solutions to model are of the following form:

$$B^{i}_{k(n)} = \frac{X^{i}_{k(n)}}{Y}; \qquad B^{e}_{k(n)} = \frac{X^{e}_{k(n)}}{Y};$$

$$S^{i}_{k(m)} = \frac{X^{i}_{k(m)}}{Y}; \qquad S^{e}_{k(n)} = \frac{X^{e}_{k(m)}}{Y};$$

$$P_{k(q)} = \frac{X_{k(q)}}{Y};$$

$$B^{e}_{n} = \frac{X^{e}_{n}}{Y}; \qquad S^{e}_{m} = \frac{X^{e}_{m}}{Y};$$

The solutions obtained in this way, are to define the optimal structure of production per production unit and inside productional levels, as well as to provide an optimal relationship between internal and external production.

Conclusion

Studying of numerous inter-relationships existing between primary agriculture production and processing capacities, it may be concluded that only if integrated, the two segments of production may function far efficiently and successfully. Integral linkages are primarily based on the firm economic relations, heading for profit accumulation by integrated members and a higher efficacy of invested capital.

The need for integration in agriculture and food industry is based on objective existence of the horizontal and vertical structures in agriculture. Integration is economically justified only if it promotes economic interests of all integrated elements. The effects to come true by production and processing integration are, as follows:

- lower costs,
- long-term raw supplies,
- higher competitiveness on the market,
- higher overall efficiency (lower costs of product)
- higher profit and,
- overall means to be integrated and invested in the bottlenecks of logistical chains.

On analysed examples of a case study, the existence of close and firm inter-relationship between primary agriculture production and processing capacities of food industry, has been confirmed.

The expansion of raspberry production of the areas surrounding Arilje largely promoted cold storages for processing, and a highly-extension staff known out of the country.

In addition to agroecological conditions highly suiting potato production in the region of Cacak, the economic ones (market and stable purchase) have also been improved thanks to efficient processing, contributing to optimal potato yields per hectare.

Modern agri-business complexes may be promising only if primary production and processing capacities are integrated into the unique integral systems which will, in turn, function toward higher economic effectiveness and efficiency so that agriculture will be oriented toward developed farming countries in the world. External conditions of business policy that are largely enhancing integration process, cannot be avoided. These are, as follows:

- the government complying with juridical system,
- protected farming,
- interest of capital, and
- social functions at the country's level.

Food-production process ought to be as unique as integral, with all chain-like ties integrated in the logistical manner. Only in this way will a holistic food production policy be feasable along with following up the customer's needs, maintaining high quality products to be marketable, cutting production costs, which will, in turn, lower the product ones.

Logistical integration of agriculture calls for modern information systems with a continuous information flow provided among all sub-systems inside a unique agri-complex one.

Lastly, some undesirable effects hampering agricultural boost are expected to be alleviated through integration linkages, too. The most crucial ones are related to heavily depopulated villages. This problem may be somewhat overcome laying out small-scale primary production units with one requirement co-related to another, leading to an integrated production. This will help generate rural employment and therefore its revival.

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MEĐUZAVISNOSTI PRIMARNE POLJOPRIVREDNE PROIZVODNJE I PRERAĐIVAČKIH KAPACITETA

-skraćena verzija magistarske teze-

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Rezime

Proces proizvodnje hrane mora biti jedinstven i integralan, a sve karike u lancu proizvodnje hrane moraju biti logistički povezane. Jedino bi se tako objedinio proces proizvodnje hrane i ujedno pratili ukusi potrošača, održavao kvalitet i bio u skladu sa postavljenim kriterijumima na svetskom tržištu, snizili bi se troškovi proizvodnje, što bi opet snizilo i samu cenu prehrambenih proizvoda.

Neophodnost integracije u poljoprivredi i prehrambenoj industriji bazira se na objektivnom postojanju horizontalne i vertikalne strukture u poljoprivredi. Integracija je ekonomski opravdana jedino ukoliko su njome ostvareni ekonomski interesi svih elemenata integracije. Za logističko povezivanje u poljoprivredi neophodni su i razvijeni informacioni sistemi. U integraciono povezanim celinama mora crikulisati kontinuirani protok informacija između svih podsistema u jedinstvenom agroindustrijskom sistemu.