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MODERNIZATION OF FRUIT JAM PRODUCTION LINE AND THE PRODUCT QUALITY

Summary

This work presents the results of assessment of the quality of fruit jam before and after the modernization of the production line. Research was carried out at the factory of the fruits and vegetables processing. The modernization of the line included: installation of twin-screw pumps, exchange piston batcher on rotary batcher, assembly of the new stationary evaporator, inserting magnetic traps, the purchase of the new labelling machine and the automatic packaging machine. Qualitative parameters of the product, which were analysed based on organoleptic parameters (odour, colour, appearance, taste, consistency) and physico-chemical parameters (net weight, pH, total extract, total acidity). On the basis of gotten data from a production plant the calculations of basic statistics were performed. Than basing on comparative analysis (t-student test, sign test) an information about statistically essential diversity in the quality of the product before and after the modernization with reference to four parameters: consistency, appearance, net mass, total extract was gotten. Moreover the modernization influenced the CCP curtailment. This is very important in improving the system of the production of the safe food.
***Key words**: fruit processing, technological line, product quality*

MODERNIZACJA LINII PRODUKCYJNEJ DŻEMU OWOCOWEGO A JAKOŚĆ PRODUKTU

Streszczenie

W pracy przedstawiono wyniki oceny jakości dżemu owocowego przed i po modernizacji linii produkcyjnej. Badania przeprowadzono w zakładzie przetwórstwa owocowo-warzywnego. Modernizacja linii obejmowała: instalację pomp dwuśrubowych, wymianę dozownicy tłokowej na dozownicę karuzelową, montaż nowej stacji wyparnej, wprowadzenie pułapek magnetycznych, zakup nowej etykieciarki oraz automatu pakującego. Parametry jakościowe produktu, które przeanalizowano odnosiły się do cech sensorycznych (barwa, konsystencja, wygląd, zapach oraz smak) oraz cech fizykochemicznych (masa netto, kwasowość ogólna, pH oraz ekstrakt ogólny). Na podstawie uzyskanych danych z zakładu produkcyjnego dokonano obliczeń podstawowej statystyki i wytypowano parametry do dalszej analizy. W oparciu o analizę porównawczą (test t-studenta, test znaków) uzyskano informacje o statystycznie istotnym zróżnicowaniu jakości produktu przed i po modernizacji w odniesieniu do czterech parametrów: konsystencja, wygląd, masa netto, ekstrakt ogólny. Ponadto wprowadzona modernizacja wpłynęła na zmniejszenie liczby CCP. Ma to duże znaczenie w doskonaleniu systemu produkcji bezpiecznej żywności.
***Słowa kluczowe:** przetwórstwo owoców, linia technologiczna, jakość produktu*

1. Introduction

Production of fruits and vegetables in Poland is an important element of agricultural production. Fruit and vegetables share in the commodity value of plant production is over 36%, 40% of which goes exactly to the processing industry [5, 7]. There was an observed increase in the household consumption of fruits and their products in the years 2011-2014 [4]. On the international market fruit products of the Polish manufacturers cannot withstand the competition from such countries as China or Morocco. Therefore, attempts to improve its position by among others investing in novel technologies shall allow to improve this weak side of fruit and vegetables industry.

Fruit and vegetable processing on an industrial scale is a very difficult branch of agricultural and food industry in terms of organisation. This is due to the following factors [1]:

- possibility of occurrence of so-called curses of abundance affecting yield oscillations.
- short life of raw products,
- high variability of fruit and vegetable species determining their processability,
- changing financial conditions of processing companies,
- moderately developed keeping infrastructure for the raw product.

The control of technological process is a part of the wider system that is to provide quality of the ready product. Quality assurance means all the planned and systematic actions that are necessary to create adequate level of trust. This makes the customer sure that product or service meets the defined qualitative requirements [2, 8].

In the European Union states, the quality of products and services is the main factor determining customer satisfaction level and is essential for the success of manufacturer. Polish food industry companies to become competitive both on domestic and foreign market must provide safe food that meets constantly increasing customer expectations. For food to meet these requirements, it is necessary to apply the state-of-the-art quality assurance systems [3].

The aim of this research is to analyse effect of technological changes in agricultural and food processing plant on the product quality, as well as on its processing parameters based on the fruit jam production cycle.

2. Modernization of the technological line

The process line for low-sugar jam production of 280 g weight currently consists of the following equipment:

– loading station,
– stationary evaporator (Fig. 1); modernization – installa-

tion of new evaporator station,
– pallet unloader for packaging,
– packaging turntable,
– rotary batcher (Fig. 2); modernization – replacement of piston batcher,
– metal detector,
– automatic tightening machine,
– linear-spraying pasteuriser,
– cooler,
– labelling machine; modernization – new labelling machine procurement.
– automatic packaging machine (Fig. 3); modernization – introduction automatic packaging machine into the production line. This allows automatic jam packaging into bulk containers directly after labelling,
– auxiliary devices:
- scales,
- twin-screw pumps. Installation of new pumps,
- magnetic traps; modernization – introduction of the trap into the production line. This allows to eliminate potential ferromagnetic impurities from the product.
- control valves.

Source: own work / Źródło: opracowanie własne

Fig. 1. Stationary evaporator
Rys. 1. Wyparka stacjonarna

Source: own work / Źródło: opracowanie własne

Fig. 2. Rotary batcher
Rys. 2. Dozownica karuzelowa

Source: own work / Źródło: opracowanie własne

Fig. 3. Automatic packaging machine
Rys. 3. Automat pakujący

3. Material and methods

For the purposes of analysis of fruit jam quality, the data were obtained from fruit and vegetable processing plant in Silesian Voivodeship.

The assessment involved low-sugar strawberry jam of the following composition:
– frozen strawberries,
– glucose-fructose syrup,
– white sugar,
– gelling agent: pectins,
– acidity regulators: citric acid, calcium citrates,
– water.

The assessment was performed based on two property groups:
– organoleptic: odour, colour, appearance, taste, consistency,
– physico-chemical: net weight, pH, total extract, total acidity.

For each parameter, 60 data points were collected before and after the modernization of the process line. The parameters were measured in accordance with the adopted by the plant *Low-sugar jam control and test plan.*

The individual parameters are verified in accordance to the guidelines presented in Table 1 and 2.

Statistical analysis for verification purposes was performed for parameters (consistency, net weight, extract, appearance), for which differences were observed in the preliminary analysis before and after the modernization of the process line. Statistical calculations were performed using Statistica 12.0 [6].

For the purposes of statistics calculations, assumption of normal distribution of population (populations, i.e. results of individual parameters before and after modernization – population 1 and population 2 respectively) using Shapiro-Wilk test. Depending on the results, further verification was performed using tests: t-Student (parametric test used for normal distribution) and sign test (non-parametric test used for non-normal distribution). The calculations were performed for significance level $\alpha = 0.05$.

For calculations of t-Student statistics the following assumptions were made:
The null hypothesis is:
H_0:$\mu_1 = \mu_2$ (1)

The mean of the populations of interest are equal at the value of $r = 2$.
The alternative hypothesis is:
H_0:$\mu_1 \neq \mu_2$ (2)

The mean of the populations of interest are different at the value of $r = 2$.

For calculations of sign statistics the following assumptions were made:
The null hypothesis is:
H_0: $F_1(x) = F_2(x)$ (3)

Two samples come from populations with the same distribution.
The alternative hypothesis is:

H_1: $F_1(x) \neq F_2(x)$ (4)

4. Results and discussion

Results of basic statistics (average μ, standard deviation SD) for analysed parameters before (no. 1) and after (no. 2) process line modernization are presented in Tables 3 and 4.

Table 1. Control of organoleptic parameters
Tab. 1. Kontrola parametrów organoleptycznych

Sampling	Control	Requirements
Parameter: COLOUR		
At least once a shift in a ready product from each production batch, at least one unit packaging of the product shall be tested.	Employee of physico-chemical laboratory conducts organoleptic test.	Characteristic for used fruits, only slightly changed by the technological process.
Parameter: ODOUR		
At least once a shift in a ready product from each production batch, at least one unit packaging of the product shall be tested.	Employee of physico-chemical laboratory conducts organoleptic test.	Typical for used fruits, without foreign odours.
Parameter: TASTE		
At least once a shift in a ready product from each production batch, at least one unit packaging of the product shall be tested.	Employee of physico-chemical laboratory conducts organoleptic test.	Typical for used fruits, without foreign flavours.
Parameter: CONSISTENCE		
At least once a shift in a ready product from each production batch, at least one unit packaging of the product shall be tested.	Employee of physico-chemical laboratory conducts organoleptic test.	Gelled glassy mass
Parameter: APPEARANCE		
At least once a shift in a ready product from each production batch, at least one unit packaging of the product shall be tested.	Employee of physico-chemical laboratory conducts organoleptic test.	Entire fruits or their fragments in gelled glassy mass – *non-uniform distribution of fruits is not a fault.*

Source: data from the plant / Źródło: dane pozyskane z zakładu

Table 2. Control of physico-chemical parameters
Tab. 2. Kontrola parametrów fizykochemicznych

Sampling	Control	Requirements
Parameter: NET WEIGHT		
3 times per shift from each batcher, after feeding net weight of the product shall be tested. In the ready product, for each production batch, at least one unit packaging is checked.	The test is performed by Quality Control employee and Production Worker using the electronic scales.	Net weight consistent with information of packaging label, allowing for allowable negative error of amount of packaged product.
Parameter: TOTAL ACIDITY		
In the ready product, for each production batch, at least one unit packaging is checked.	Quality Control employee performs one test using titrator.	The result shall be ≥ 0.5 %
Parameter: pH		
In the ready product, for each production batch, at least one unit packaging is checked.	Quality Control employee performs one test using pH-meter.	The result shall be: 3±0.3
Parameter: TOTAL EXTRACT		
Checked at least once per shift and in the ready product, for each production batch, at least one unit packaging is checked.	Quality Control employee performs one test using refractometer.	In this case it should be equal to: 34% ± 3

Source: data from the plant / Źródło: dane pozyskane z zakładu

Table 3. Results of the organoleptic parameters analysis
Tab. 3. Wyniki analizy parametrów organoleptycznych

	Colour		Odour		Taste		Consistence		Appearance	
	No. 1	**No. 2**	**No. 1**	**No. 2**	**No. 1**	**No. 2**	**No. 1**	**No. 2**	**No. 1**	**No. 2**
μ	1.46	1.45	1.55	1.36	1.46	1.5	1.6	1.23	1.6	1.1
SD	0.5031	0.5017	0.5017	0.4860	0.5031	0.5042	0.4940	0.4265	0.4997	0.3025

Source: own work / Źródło: opracowanie własne

Table 4. Results of the physico-chemical parameters analysis
Tab. 4. Wyniki analizy parametrów fizykochemicznych

	Net weight [g]		Total acidity [%]		pH		Total extract [%]	
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
μ	282.1	280.65	0.837	0.851	3.179	3.181	34.203	34.415
SD	2.9556	1.3756	0.0376	0.0339	0.1303	0.1295	0.4464	0.1665

Source: own work / Źródło: opracowanie własne

Table 5. The results of comparative statistical analysis
Tab. 5. Wyniki statystycznej analizy porównaczej

Appearance		Consistence		Net weight [g]		Total extract [%]	
z	p	z	p	t	p	t	p
2.80	0.00510	3.24	0.00119	4.5	0.00001	-3.40	0.00121

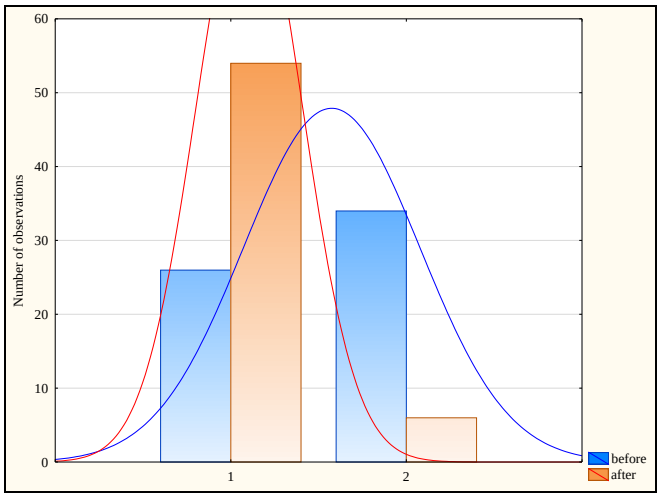
Source: own work / Źródło: opracowanie własne

Results of basic statistics (average μ, standard deviation SD, Table 3 and 4) show differences before and after modernization for four parameters: consistence, appearance, net weight and total extract. Value of standard deviation seems particularly worth noting, which has decreased after implementation of changes in the processing line. This indicates lower diversity of given property, and higher production stabilization in practice. For other qualitative indicators, modernization effect was not observed.

Two samples are different significantly.

The results of statistical comparative analysis were tabulated (Table 5) and presented in graphical form (Fig. 4-7).

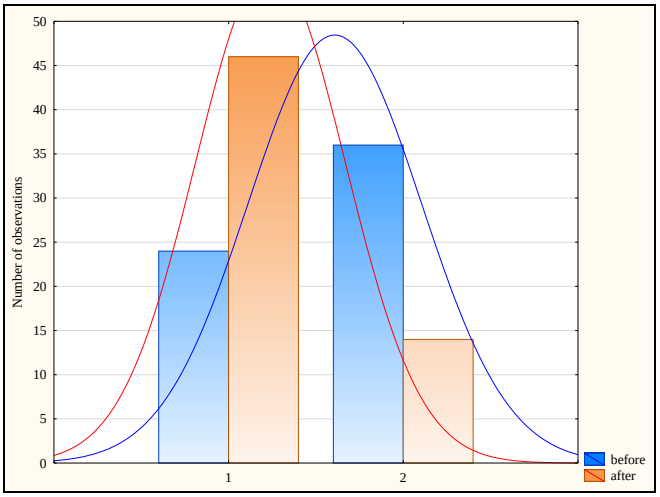
The results of comparative analysis (Table 5) indicate occurrence of statistically significant difference for all the tested parameters before and after modernization of process line for strawberry jam production.



Source: own work / Źródło: opracowanie własne

Fig. 4. Data for appearance parameter before and after modernization of the process line. 1 – visible fruit fragments, 2 – mashed and few visible fruit fragments
Rys. 4. Dane dla parametru wygląd przed i po modernizacji linii technologicznej. 1 – widoczne kawałki owoców, 2 – przetarte oraz nieliczne widoczne kawałki owoców

Fig. 4 shows significant difference before and after of modernization of the process line for appearance parameter. Designation 1 (fruit fragments) is more preferred than 2 (mashed and few visible fruit fragments). One can notice that after that introduced modernization, the desired product appearance was obtained much more often. Data diversity before and after the modernization was confirmed statistically.



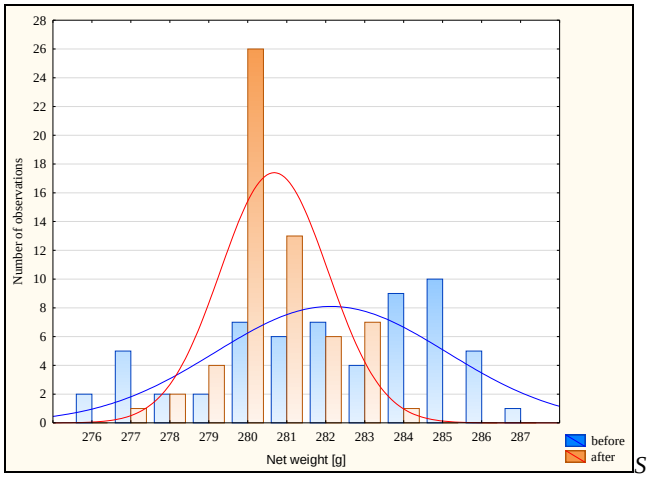
Source: own work / Źródło: opracowanie własne

Fig. 5. Data for consistence parameter before and after modernization of the process line. 1 – gelled, 2 – spreadable mass
Rys. 5. Dane dla parametru konsystencja przed i po modernizacji linii technologicznej. 1 – zżelowana, 2 – smarowana masa

The chart (Fig. 5) presents data for consistence parameter before and after modernization of the process line, showing visible differences in populations. After introduced modernization – designation 1 (more preferred) occurs much more often than designation 2 (less preferred). This leads to the conclusion that the modernization has a positive impact on jam consistence. This is moreover confirmed by the results of statistical analysis.

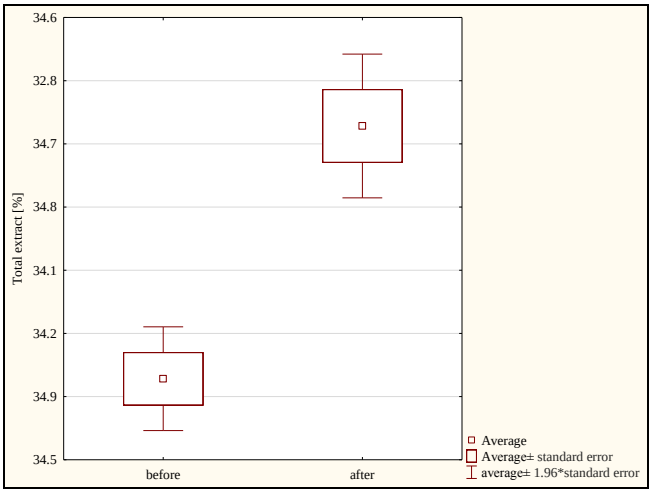
The histogram presents data for parameter net weight before and after modernization of the process line (Fig. 6). Figure shows that after introduced modernization, product weight oscillates around the required value, i.e. 280 g. As a result, the final product becomes more stable in terms of mass. Data diversity before and after the modernization was confirmed statistically.

Fig. 7 shows that after the modernization total extract of the product is more stabilized, which makes sugar content in final product is less varying. While before the modernization this range was greater, which means that it was less uniform in terms of sugar content. Data diversity before and after the modernization was confirmed statistically.



Source: own work / Źródło: opracowanie własne

Fig. 6. Data for net weight parameter before and after modernization of the process line.
Rys. 6. Dane dla parametru masa netto przed i po modernizacji linii technologicznej.



Source: own work / Źródło: opracowanie własne

Fig. 7. Box -plot chart for total extract parameter before and after modernization of the process line
Rys. 7. Wykres typu ramka-wąsy dla parametru ekstrakt ogólny przed i po modernizacji linii technologicznej

5. Summary and conclusions

Based on the analysis of selected parameters obtained during production of low-sugar strawberry jam of 280 g weight, it might be said that the modernization of the production line had positive effect on quality of the final product. Among nine analysed parameters, four have changed significantly: consistence, net weight, extract and appearance. Other parameters: taste, odour, colour, pH, total acidity did not change.

The modernizations responsible for individual parameters are as follows:
– consistence – modernization of the entire line,
– net weight – installation of rotary batcher,
– total extract – installation of refractometer into evaporator station,
– appearance – installation of rotary batcher and twin-screw pump.

Changes in line resulted in decrease in number of Critical Control Points (no CCP at formulatory weighing stage) by introduction of magnetic trap. This means that after modernization there is a lower risk of error, whereas the lower number of CCPs affects also reduction of executing additional procedures and provisions without endangering the safety of production.

Production, in the case of fruit jam, has much better stabilization and repeatability of product qualitative results.

The introduced modernization resulted also in the following changes:
– no need to add a preservative,
– finding potential irregularities related to metal contamination, even before the feeding,
– possibility of using fresh strawberries as a main component, instead of strawberry pomace or frozen strawberries.

The investment in the modernization of production line in the studied fruit and vegetable processing plant will definitely have positive impact on the position of company on the market and increase in its competitiveness.

6. References

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