Development of Manufacturing Technology of Non-Waste Production of the Field Vegetable Processing

To cite this article: A V Kozhemyako et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 224 012058

View the article online for updates and enhancements.

You may also like
- Study on the Solid Waste Properties and Disposal Methods of Island at Home and Abroad
  Ruicheng Dong, Xiao Chen, Zhibin Ding et al.
- The Modelling Of Basing Holes Machining Of Automatically Replaceable Cubical Units For Reconfigurable Manufacturing Systems With Low-Waste Production
  N M Bobrovskij, D G Levashkin, I N Bobrovskij et al.
- Technosphere safety of non-waste production
  A V Gurjanov, A V Shukalov and I O Zharinov
Development of Manufacturing Technology of Non-Waste Production of the Field Vegetable Processing

A V Kozhemyako\textsuperscript{a}, T F Kiselyova\textsuperscript{b}, E A Vechtomova\textsuperscript{c}, E A Monastyrskaya\textsuperscript{d}, O V Mityakina\textsuperscript{e}

Kemerovo State University, 650000, Russia, Kemerovo, Krasnaya str., 6.

E-mail: \textsuperscript{a}asy42@bk.ru, \textsuperscript{b}kisseleva.tf@mail.ru, \textsuperscript{c}vechtomowa.lena@yandex.ru, \textsuperscript{d}dzorochka@yandex.ru, \textsuperscript{e}olgamityakina72@mail.ru

Abstract. The article deals with non-waste production of the field vegetable processing. The food stuff for human beings and livestock was obtained in the course of the work. Developed stuff: lactose fermented beverages, sauces, feed have advantages both in merchandising and economical spheres.

1. Introduction

There is much concern about environmental health, its maintaining and methods creating in different fields. It is aimed at minimizing the industry impact on the nature.

The way of the harmonious exploitation of the natural resources that provides environment protection is the basis of the non-waste methods. It is difficult to organize the non-waste production but it is caused by environmental health as well as resources lack. The multiple resources use produces the complete cycle.

Numerous methods of vegetables processing are suggested but far from every producer can assure environmentally safe production.

2. The purpose of the work

Is to represent the production methods of non-waste field vegetables processing and waste utilization being the complete cycle. During the work the food stuff was developed:

- lactose fermented beverages;
- sauces,
- high protein feed.

3. Objects and methods of the research

The following subjects of the research were used: carrot GOST R 51782-2001, beetroot GOST R 51811-2001, berry raw material GOST R 53956-2010, apple GOST R 54697-2011, walnut, lactic-acid bacteria, bakery yeast GOST R 54731-2011, prune, sugar GOST 21-94, salt GOST R 51574-2000, starch GOST R 53876-2010, dried garlic GOST 16729-71, red pepper GOST 29053-91, sunflower oil GOST 52465-2005.

All the researches were carried out by means of standard methods used in food canning industry. There performed 5-time replication and statistic analysis.

Objectives of the research:
- to estimate vegetable crop potential for production;
- to suggest production methods of vegetables processing and waste utilization being the complete cycle;
- to demonstrate the opportunity of using the field vegetable raw material as to produce lactose fermented vegetable beverages and sauces.

4. Research results and discussion

Rational organization of the operating cycle enables to produce a few products. These are lactose fermented beverages and sauces for adults, and livestock feed. The next food stuff manufacturing is based on the waste using of the previous production. Firstly, non-waste production of field vegetables processing requires that the quality of vegetables from Kemerovo market should be determined. The quality analysis of carrot “Nantskaya” and beetroot “Tsilindr” from sovkhoz “Beregovoi” was done.

Vegetable raw material was investigated according to organoleptic indicators and then the decision about further processing was accepted.

The vegetable and fruit raw material should meet the GOST requirements to obtain juices by means of squeezing. The data of juice extraction and waste quantity are presented in table 1.

| Title          | Juice extraction, % | Waste, % |
|----------------|---------------------|----------|
| Carrot         | 45.9                | 54.1     |
| Beetroot       | 49                  | 51       |

Beverages were formulated according to organoleptic perceptions as well as physical and chemical indexes (table 2). Physical and chemical method should be combined with organoleptic one while formulating beverages because of further fermentation by living bacteria.

| Raw material     | Physical and chemical indexes |
|------------------|-----------------------------|
|                  | Dry solids weight ration, % | Titratable acidity, °T | pH       |
| Carrot juice     | 8.0±0.10                    | 11.4±0.04               | 7.36±0.04 |
| Beetroot juice   | 12.0±0.10                   | 10.0±0.04               | 7.38±0.04 |
| Sandthorn juice  | 10.2±0.10                   | 320.0±0.04              | 4.47±0.04 |
| Black current juice | 13.5±0.10               | 270.0±0.04              | 4.33±0.04 |
| Apple juice      | 13.6±0.10                   | 82.0±0.04               | 5.36±0.04 |

Additional amount of water and sugar is required to formulate balanced flavor and fragrance of beverages and create positive environment for fermentation. Quantity of sugar in the beverages does not outnumber 4.2 %. The earthy taste characteristic for vegetables was removed from the beverages formulations. The beverages formulations can compete as a standalone product due to high organoleptic features. The beverages formulations are represented in table 3.

While manufacturing the beverages we used home pressed bakery yeast “Rekord” produced by OOO “SAF-NEVA”. The choice of the yeast was caused by the simplicity of the production method that did not require special equipment for pure yeast cultivation. The yeast was added quantitatively. Application rate was 40 mln c/cm³.

The ferment of bifidus bacteria (acidophilous bacteria) and lactic-acid bacteria (LAB) was used in the course of work. The whey of LAB and bifidus bacteria was added in the following proportion: 5 % from suggested volume of food stuff necessary for fermentation.
Table 3. Vegetable beverages formulation

| Sample | Carrot juice | Beetroot juice | Apple juice | Sandthorn juice | Black current juice | Sugar | Water |
|--------|--------------|----------------|-------------|-----------------|---------------------|-------|-------|
| 1      | 98.0         | -              | -           | -               | -                   | 2.0   | -     |
| 2      | 48.8         | -              | 24.3        | -               | -                   | 2.6   | 4.3   |
| 3      | 88.4         | -              | 9.8         | -               | 1.8                 | -     | -     |
| 4      | -            | 49.7           | -           | -               | 4.2                 | 7.9   | -     |
| 5      | -            | 49.6           | 24.8        | -               | 0.8                 | 4.8   | -     |
| 6      | -            | 48.8           | -           | -               | 9.7                 | 2.5   | 9.0   |

Testing and analyzing the fermentation process depends on change of dry solids weight ration, titratable and active acidity. The materials being fermented to obtain low-alcohol drinks have dry solids from 8 to 14.5 %. That is why we ferment the beverages with initial quantity of dry solids 10±0.25 %. Such materials create positive conditions for yeast growing and have balanced flavor. In dairy industry where lactic-acid and bifidus bacteria are used the fermentation process is tested and analyzed according to increasing titratable acidity. Lactic-acid bacteria stop their growing when acidity becomes 80-85˚T. Therefore initial titratable acidity should be lower 80-85˚T for lactic-acid fermentation processing. Table 4 presents data of physical and chemical indexes of beverages before and after fermentation.

Table 4. Physical and chemical indexes of formulated beverages

| Sample | Dry solids weight ration, % | Physical and chemical indexes |
|--------|-----------------------------|-------------------------------|
|        | Before fermentation | After fermentation | Before fermentation | After fermentation | Before fermentation | After fermentation |
| 1      | 10±0.25                    | 8-8.2                         | 11.2±0.04           | (58-62)±0.04      | 7.26±0.04           | (6.9-6.84)±0.04   |
| 2      | 22±0.04                    | 6.6±0.04                      | (6.48-6.46)±0.04    |
| 3      | 47.0±0.04                  | 6.39±0.04                     | (6.28-6.24)±0.04    |
| 4      | 5.5.0±0.04                 | 7.18±0.04                     | (6.68-6.61)±0.04    |
| 5      | 21.0±0.04                  | 6.59±0.04                     | (6.45-6.44)±0.04    |
| 6      | 45.0±0.04                  | 6.33±0.04                     | (5.94-5.9)±0.04     |

The fermentation processing begins after the ferment addition into the samples. Having analyzed pictures 1 and 2 we can conclude that dry solids declining is shown after 5-5.5 hours of fermentation. The process of fermentation should be stopped when the dry solids content reaches 8.2-8.0 %. The beverage obtained has the ethyl alcohol content about 1.5-2 %.

The fermentation proceeds at 30˚C during 5-5.5 hours. The dry solids content of the beverage is determined when the fermentation has stopped. The next stage is decantation and pasteurization of the beverage under the temperature 95˚C during a minute. The final stage is filling of the beverage. It is recommended to fill the beverage into glass bottles (0.5 l volume).

All the samples of beverages have balanced flavor characteristic for raw materials they are made from. They taste a little milk-soured. Their colors are bright and typical for raw materials. It is worth mentioning the stability of colors and the deficiency of the earthy taste of fresh squeezed juices.
Figure 1. Dynamics of the dry solids content on the base of carrot juice during the process of fermentation

Figure 2. Dynamics of the dry solids content on the base of beetroot juice during the process of fermentation

The beverages production is followed up by large amount of pulp (up to 50% of raw material), that is necessary to be recovered as waste. The classical approach of recovering such a type of waste is feeding livestock. Besides, the pulp has technological value as the basic raw material in sauce manufacturing. Table 5 presents quality analysis of carrot and beetroot pulp. 1 sample

Table 5. Organoleptic indexes of vegetable pulp

| Indexes   | Carrot pulp                                      | Description                              | Beetroot pulp                                      |
|-----------|--------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Appearance| Length 5-15 mm, width 2-5 mm, spongy texture     | Length - 5-10 mm, width 2-3 mm, spongy texture | Red burgundy                                      |
| Color     | Orange yellow                                    |                                          |                                                    |
| Smell     | Intrinsic to carrot, without foreign smell       | Intrinsic to beetroot, without foreign smell |                                                    |
| Taste     | Intrinsic to carrot, without foreign taste       | Intrinsic to beetroot, without foreign taste |                                                    |
Table 6. Physical and chemical indexes of vegetable pulp

| Indexes                  | Carrot pulp | Quantity | Beetroot pulp | Quantity |
|--------------------------|-------------|----------|---------------|----------|
| Dry solids content, %    | 4.4         | (%)      | 3.60          | (%)      |
| Humidity, %              | 9.0         | (%)      | 8.70          | (%)      |
| Acidity, %               | 0.11        | (%)      | 0.06          | (%)      |
| Fiber, %                 | 5.7         | (%)      | 4.3           | (%)      |
| pH                       | 7.5         |          | 7.0           |          |
| Ash, %                   | 1.0         | (%)      | 1.0           | (%)      |

Tables 5 and 6 show that the vegetable pulp is subject to further processing because of high fiber and minerals content.

The sauce was formulated according to taste matching. The red bell pepper excellently matches carrot in salads. That is why it is a proper ingredient for carrot sauce. It contains a lot of vitamins (C, E, PP, β-Carotene, vitamin B complex), minerals (iron, potassium, calcium, iodine, magnesium, sodium, phosphorus, etc). It is also an oxidant. Generally speaking this sauce has a great food value [1].

Table 7 presents the formulation of spicy carrot sauce “Appetitynyi”.

Table 7. The formulation of spicy carrot sauce “Appetitynyi

| Ingredients        | Quantity, g |
|--------------------|-------------|
| Carrot pulp        | 90          |
| Water              | 360         |
| Red bell pepper    | 450         |
| Sunflower oil      | 68          |
| Salt               | 10.5        |
| Dried garlic       | 5.5         |
| Red pepper         | 1           |
| Starch             | 15          |
| Yield:             | 1000        |

While formulating beetroot sauces we paid attention to taste compatibility of beetroot and other vegetables, fruits and nuts.

The balanced compatibility of beetroot and garlic was used as the basis of spicy beetroot sauce. We added prune and walnut into the formulation of beetroot sour-sweet sauce because of compatibility of beetroot with prune, walnut, pine nut, raisins, etc.

Particular usefulness of prune is caused by numerous valuable substances and vitamins – organic acids (oxalic, citric, malic), fiber, pectic substances, calcium, magnesium, phosphorus, iron [2, 3]. For example, prune contains potassium 1.5 times more than banana does. The composition of prune includes wholesome sugars (fructose, sucrose, glucose – no less than 57 %) and a number of vitamins – A, vitamin B complex, C, PP) [4, 1].

Walnut contains lots of wholesome minerals. It is rich in vitamins A, B1, B2, E and F, complete vegetable proteins [5].

Table 8 presents the formulation of spicy beetroot sauce “Pikantnyi”.

The sauces prepacked are sterilized at 120˚C for 20 minutes. The sauces are developed according to technical specification for this kind of product. Their creamy texture with traces of walnut and prune coincides with color and flavor of the raw material.

There exist the following stages of complete and rational use of raw materials. The first one is aimed at processing raw materials to minimize or even exclude waste production. It is important because the greatest part of costs (about 80%) is spent on raw material. The second stage is organization of waste processing as to get foodstuff and technical products. The final stage is formation of waste represented
by yeast cream, lactic acid and bifidus bacteria. At plants such a kind of waste is utilized by sewering. It is dangerous ecologically and non-rational economically. This study presents the waste processing of yeast cream to produce dry high protein feed for livestock.

Table 8. The formulation of spicy beetroot sauce “Pikantnyi”

| Ingredients      | Quantity, g |
|------------------|-------------|
| Beetroot pulp    | 301         |
| Water            | 602         |
| Sunflower oil    | 60          |
| Salt             | 9           |
| Dried garlic     | 16          |
| Starch           | 12          |
| Yield:           | 1000        |

Table 9 presents the formulation of sweet beetroot sauce “Vkusnyi”.

Table 9. The formulation of sweet beetroot sauce “Vkusnyi”

| Ingredients      | Quantity, g |
|------------------|-------------|
| Beetroot pulp    | 164.77      |
| Water            | 638.69      |
| Prune            | 123.62      |
| Walnut           | 49.44       |
| Salt             | 1.24        |
| Sugar            | 11.12       |
| Starch           | 11.12       |
| Yield:           | 1000        |

Table 10 presents physical and chemical indexes of the sauces obtained.

Table 10. Physical and chemical indexes of the sauces

| Indexes, units of measurement | “Appetitnyi” | “Pikantnyi” | “Vkusnyi” |
|-------------------------------|--------------|-------------|-----------|
| Dry solids weight ration, %   | 9.30         | 13.60       | 11.20     |
| Acidity, % in conversion to malic acid | 0.25   | 0.12       | 0.13     |
| Chloride weight ration, %     | 1.34         | 1.57        | 0.24      |
| Fat weight ration, %          | 6            | 7.30        | -         |

The production of lactose fermented vegetable beverages goes with the waste in the form of peels and decanted yeast. There are manufactures that specialize on yeast feed for animals and birds. We suggest to produce livestock feed stuff in the form of vegetable yeast flour made from vegetable and microbiological waste. The yeast bacterial suspension is processed into dry high protein livestock feedstuff. This high protein suspension is rich in amino-acids and vitamin B complex.

Table 11 presents waste output of vegetable peels and decanted yeast/lactic acid bacteria. Unit amount of vegetable peels – a kilogram per ton of fresh vegetables. Unit amount of decanted yeast and lactic acid bacteria (LAB) - a kilogram per ton of beverage obtained.

It is recommended to dry waste at 50-60°C. This temperature keeps the vitamins in raw materials. Dried semi-finished product is crushed into powder. The vegetable yeast flour contains water about 14-16%.

The vegetable yeast flour should be mixed with such ingredients as straw and combined feed.
### Table 11. Weight of vegetable yeast flour

| Ingredients                | Quantity, kg/1 t Before drying | After drying |
|----------------------------|--------------------------------|--------------|
| Vegetable peels            | 80 – 110                       | 18 – 25      |
| Decanted yeast and LAB     | 50 – 70                        | 16 – 22      |
| Yield (flour):             | 34 – 47                        |              |

5. Conclusions

The practical significance of our work is in creation of non-waste system of field vegetable processing. The vegetable lactose fermented beverages, sauces and feed stuff are produced by means of the method developed. The manufacturing described goes with the positive ecological effect.

The products obtained have high merchandizing attributes. Our lactose fermented beverage is different from its prototypes significantly. Firstly, raw juices of carrot and beetroot are combined with juices of sandthorn, black current, and apple. Secondly, the completed ferment is used to produce a unique product. It combines the peculiarities of lactic acid products (bifidus beverages, yoghurt, kefir, milk whey) and fermented products (sour cabbage juice and fermented beverages). Therefore, our product includes some acids and vitamins obtained during the processes of lactic acid and alcoholic fermentations. The beverage value is determined by maximum property retention of biologically active components of raw materials, vitamins, amino acids and organic acids. The bacteria contained in these beverages positively affect the gastro-intestinal activity [6].

As for sauces, it is necessary to emphasize the unique property of such a component as carrot. There are more healthy nutrients in boiled carrot than in raw one [7]. After month storage boiled carrot still contains more healthy nutrients than raw one does. So, vitamin composition of the sauces developed keeps stable during the processes of preparing and storing. It can be explained by new chemical substances with high antioxidant properties that appear while storing boiled carrot [8-10]. Sauces are produced from waste. That is why manufacturing new sauces is economically advantageous because of raw material cost reduction. Nowadays Kemerovo market has no sauces based on carrot and beetroot.

So, we can generalize the results of our work as a new method of utilizing plant and microbiological waste by preparing dry feed stuff for livestock.

References

[1] Laaksonen, Oskar; Knaapila, Antti; Niva, Tuija. Sensory properties and consumer characteristics contributing to liking of berries, Food quality and preference Vol. 53, P. 117-126.
[2] Kirke, D. A.; Smyth, T. J.; Rai, D. K. The chemical and antioxidant stability of isolated low molecular weight phlorotannins, Food Chemistry 221, P.1104-1112.
[3] L.A. Dogaeva, Classification and identification features of functional soft drinks. Dogaeva, N.T. Peshtereva // Beer and drinks. 2011. 5. P. 62 - 65.
[4] I.B. Reliable, Use of a pumpkin for obtaining functional drinks / I.B. Relaxed, V.N. Timofeeva, N.I. Titenkova // Beer and drinks. 2008. 3. P. 22-24.
[5] E.P. Terkun, Cryostability of bifidobacteria in dairy and serum media with vegetable additives / M.A. Kozhukhova, O.V. Holoshenko. Proceedings of universities. Food technology. 2012. 1. C.51-53.
[6] Isaeva, V.S. Modern aspects of kvass production (theory, research, practice) / V.S. Isaeva, T.V. Ivanova, N.M. Stepanova, L.M. Dumbrava et al. M.: Food Industry, 2009. 304 p.
[7] N. V. Babii, V. A. Ponomova, T. F. Kiseleva, V. O. Romanenko, Increasing the Adaptive Capacity of the Organism When Exposed to Adverse Environmental Factors Through Phytoadapto gens / Materials Science and Engineering. Vol. 221, conference 1.
[8] MacLeod, Alan; Jones, Glyn D.; Anderson, Helen M. Plant health and food security, linking science, economics, policy and industry: OECD Meeting: 2014 Food security: 1 P. 17-25.
[9] N.N. Kornen, E.P. Viktorova, O.V. Evdokimova, Methodological approaches to the creation of healthy food / Voprosy Pitaniia. 2015. Vol. 84, 1. P. 95-99.
[10] Laaksonen, Oskar; Knaapila, Antti; Niva, Tuija. Sensory properties and consumer characteristics contributing to liking of berries, Food quality and preference Vol. 53, P. 117-126