

PAPER • OPEN ACCESS

## Innovative technologies of modified starch production

To cite this article: D S Ushakov *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **488** 012032

View the [article online](#) for updates and enhancements.

## Innovative technologies of modified starch production

**D S Ushakov<sup>1</sup>, V V Shepelev<sup>2</sup> and O Yu Patlasov<sup>2,3</sup>**

<sup>1</sup>International college Suan Sunandha Rajabhat University, 1-U-Thong Nok road, Dusit, Bangkok, 110300, Thailand

<sup>2</sup>Industrial Technologies department, K.G. Razumovski Moscow State University of Technologies and Management, 63, Pushkina str., Omsk, 644010, Russia

<sup>3</sup>Omsk Humanitarian Academy, 2A, 4th Chelyuskintsev str., Omsk, 644105, Russia

E-mail: denis.us@ssru.ac.th

**Abstract.** Paper analyzes the modern technologies for the modified starches production, as well as their comparative characteristics by production costs, technical and economic indicators of the manufacture process. Study also describes authors' original technologies for the production of magnesia-enriched and iodized wheat starches by creating mineral substances solutions and their later chemical modification. It considers previous studies by Russian and foreign authors on various technologies for the modified starches production, special attention to the quality of modified starches production from various crops was given.

### 1. Introduction

The relevance of the modified starches usage in the modern food industry is based on two circumstances. Firstly, public health status in the countries and regions of the world strongly depends on the folding structure of nutrition, on the amount of consuming vitamins and chemical elements, which deficiency can be compensated by the starches modification widely using in food industry formulations, especially in bakery and confectionery.

Secondly, the results of studies on diseases associated with certain trace elements insufficiency often with magnesium, iodine and selenium, iron, zinc, cobalt, copper, manganese, etc.

According to the Russia Ministry of Health, the problem of diseases related with iodine deficiency occurrence is currently an urgent one in the Russian Federation - annually more than 1.5 million adults and 650 thousand children with thyroid diseases need specialized endocrinological care.

In conditions of iodine deficiency, the risk of thyroid cancer increases, moreover particular cases of iodine deficient cretinism were recorded.

In this regard, the Ministry of Health of the Russian Federation has developed a regulation on total iodization of edible salt and its use in products for the iodine deficient prevention that will be implemented in the country from 2020 [1].

The problems of heart diseases associated with a lack of magnesium is also highly relevant, since heart problems are observed in 40% of the adult population of the Russian Federation [2].

The technologies and organization of the modified starches production have distinctive differences depending on the technological methods of modification, changes in the physicochemical, and (in some cases) the biological properties of starches, which can be used for dozens industries aimed for semi-finished products and materials with specified qualities manufacturing. For example, cationic modified starches are used in the pulp industry [3], and also for drilling wells for hydrocarbon raw



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](#). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

materials [4], biofuels [5, 6] and a number of chemical products, for example, in rubber production [7] and food industry [8].

Hypothesis of the study: due to the relatively high rate of iodine volatilization in the food products during storage, the problem can be solved by including the chemical modification of potassium iodide with starch products in bakery products with a short shelf life, and, therefore, suggesting the rapid consumption with small loss.

## 2. Methodology of the study

To achieve high results of bakery products iodization it is necessary to follow the short terms of their consumption, while in the magnesia starches production such ultra-high efficiency is not required. Even excessive starches consumption can simulate human weight increase, the use of starch products as carriers of vital elements can solve a number of serious problems in terms of nutritional structure optimization.

**Table 1.** Types of food modified starches and technologies for their production (source: [9])

Modified food starches	Production technologies	Food industries using these types of modified starches
E 1400 - heat-treated starch	Produced by thermal (up to 200 °C) exposure to corn or potato starch with the addition of hydrochloric (not more than 0.15%) or phosphoric acid (not more than 0.17%).	Food industry (production of yoghurts, cottage cheese, canned fish, pasta, soups and sauces, caramel, baby food). Chemical industry (production of paints, detergents, adhesives). Textile industry (for textile paints and glass fiber manufacturing processes). Foundry (for casting rods), as well as for the production of matches and pyrotechnics.
E 1401 - acid treated starch.	Produced by treatment with inorganic (hydrochloric, sulfuric or phosphoric) acids.	Food industry (production of yogurts, canned vegetables, canned fish, sweets, sauces and bagged soups). <u>Paper industry, glues, medicine and pharmaceuticals.</u>
E 1402 - alkali-treated starch	Produced by treatment with sodium or potassium hydroxides.	Food industry (jam, marmalade, jelly, low-calorie lactic acid products, cream, milk, ice cream, canned and simple soups, instant soups, mayonnaise, cheeses, margarine). Medicines, animal feed, paper, artificial silk.
E 1420 - acetate starch	Produced by heating a mixture of glacial acetic acid and native starch to a boiling point, the mixture is kept for 5–13 hours at a temperature of 100°C.	Food industry (jelly, marmalade, marshmallows, molasses, sweets, butter, margarine, yoghurts, processed cheeses, sauces, hard cheeses). Tissue manufacturing (silk and yarn). Paper of different density, powder, foundation, blush and shadows, pharmaceuticals

There are about two dozen technologies for production of the various modified starches, actively used in the food industry of Russia (SanPiN 2.3.2.560-96) (Table 1).

The described above technologies allow using the modified starches production also in the food industry. There are technologies for modified starches using in the confectionery industry [10] for the production of gelatine [11], biscuits [12], banana flour [8] and other baking and confectionery industries.

### 3. Literature review

Frits van der Haar [16] presented a historical digression of salt iodization strategies. In 2014, based on the results of research, WHO strongly recommended mandatory iodization of all edible salt to prevent iodine deficiency disorders (IDD). Current program management challenges include the increase in salt intake from processed foods that occurs with economic development, and problems in aligning two salt-based strategies for reducing salt intake and salt iodization. Sustainable prevention of iodine deficiency diseases requires a guarantee that the USI has established itself as a common norm in the policy and practice of iodine nutrition worldwide.

Current program management concerns include an increase in the salt intake from processed foods that occurs with economic development and the challenges in aligning the two salt-based strategies of salt intake reduction and salt iodization. The chapter ends with a premonition that the sustained prevention of IDD requires assurance that USI has become established as a habitual norm in iodine nutrition policy and practice worldwide.

The study “Non-salt Food Fortification Programs” suggested that a number of methods are available to adjust iodine content of diet, among them the most important non-salt targets for fortification are bread and dairy products [13].

The bread iodization in Russia was firstly proposed by V. B. Khazan. Later M. G. Kolomeytseva and A. I. Ostroglazov obtained the positive results from the iodized bread use to prevent an endemic goiter. Methods for the preparation of bread with seaweed or potassium iodide have been developed, but the problem of iodine preservation in the process of bread cooking has not been completely solved technologically, and the optimal dosages of fortifiers have not been proved.

The study “The Effect of Iodized Salt on the Organoleptic Properties of Processed Foods: A Systematic Review” proves that there is no evidence that the iodized salt use in the production of processed foods or seasonings causes any adverse organoleptic changes, or affect consumer acceptance of product quality [14].

### 4. Results

Assessing the content of magnesium and iodine in food products produced in the south of Western Siberia doesn't demonstrate their optimal content required for human consumption. An adequate level of magnesium per day is 400 mg, and iodine – 0.15 mg [15].

As for experiment and taking into account the economic conditions in Omsk region, we propose to use “Omskaya-1” mineral water source (which is in the highly mineralized category) with the addition of potassium iodide and sulfate (food) magnesium (Table 2).

**Table 2.** The chemical composition of “Omskaya-1” mineral water (data <https://omskaya1.ru/omskaya-1>)

Indices	Indicators, mg / dm <sup>3</sup>	Standards, mg / dm <sup>3</sup>
Mineralization	4900	4500 - 6500
Potassium + Sodium	1918.2	1700-2200
Calcium	21	<100
Magnesium	2.4	<25
Iodine	3.7	2,75+ 1
Chlorides	2662. 5	2500-3300
Fluoride	0.61	<10
Sulphates	9	<10
Hydrocarbonate	579.5	200-600

Production technology:

-“Omskaya 1” mineral water is heated to a temperature of 100° C;

-mineral water evaporates up to 10% of its original volume and iodine (iodized starches) or magnesium (magnesia starches) are added to it;

-by this solution wheat starches are treated in a ratio of 1:20 (1 part of solution to 20 parts of wheat starches) with the addition of 300 ml. glacial acetic acid per tone of wheat starch;

-resulting mixture is heated to a temperature of 100° C and incubated for 8-10 hours, then the remaining acid remove, mixture is washed with cold water (for iodinated starches with 5% potassium iodide solution) and dried.

Chlorides and sulfates contained in mineral water come in a weak chemical bond with iodine and the formation of this compound contributes to the substantial retention of this element in food baking products, hence to the consumption of almost all contained iodine. The chemical composition of the solutions and chemical compounds developed for the production of magnesia enriched and iodized starches for the production of gray bread are presented in Table 3.

**Table 3.** Recommended chemical composition of the solution for the wheat starch modification in the gray bread production (proposed by the authors)

Chemical element	Recommended doses for the production of magnesia starch, mg / dm <sup>3</sup>	Recommended doses for the production of magnesia starch, mg / dm <sup>3</sup>
Potassium + Sodium	2.1	2.1
Calcium	2.4	2.4
Iodine	2.3	33.4
Magnesium	7.2	3.4
Chlorides	2662.5	2662.5
Fluoride	0.61	0.61
Sulphates	9	9
Hydrocarbonate	579.5	579.5

After the modification of wheat starches with these solutions, they are enriched with chemical elements (in particular iodine and magnesium), and the nutritional value of the bakery and confectionery products increases. Several problems of a balanced diet are solved at once - the problems of its balance, adequacy and prevention of diseases related with heart and thyroid dysfunctions. The indicators of economic efficiency of the food modified starches production are given in Table 4.

**Table 4.** Indicators of economic efficiency in the modified starches production(calculated by the authors using [16])

Name	Annual volume of production, tone	Sale price for 1 tone, Rubles	Commodity production, million rubles	Cost price for 1 tone of marketable products, thousand rubles	Cost of marketable products, million rubles
Acetate Starch	4000	52000	208.0	42000	168.0
Magnesium Starch	4000	32000	128.0	27800	111.2
Iodized Starch	4000	37000	148.8	28200	112.8

The advantages of magnesia enriched and iodized, modified starches are mostly economic, since with the production of 4000 tons of magnesia and iodized starches, the cost price of 1 tone of finished products are lower, respectively, by 33.8% and 32.8% than the production of acetate starch, which can also be used in the food industry (bakery, confectionery, etc.).

## 5. Risks evaluation

Angela M. Leung warns that iodine exposure may also occur as a result of iodine fortifications programs (through salt iodization, fortification of foods, or other routes), medications, dietary supplements, topical iodine antiseptics, radiographic iodinated contrast media, and other sources. Excess iodine exposure, particularly among individuals with underlying thyroid disease, has the potential for inducing hyperthyroidism and hypothyroidism [17].

In the production and consumption of mineral water in its pure form, the side effect of excessive salt consumption can appear. Due to this, evaporation residues are additionally enriched with iodine and magnesium to achieve the set results.

The use of mineral water is necessary for the chlorides and sulfates binding with iodine and magnesium, which we need to modify wheat starches to manufacture bakery products enrich with magnesium and iodine.

The production of magnesia enriched and iodized modified starches are necessary in the volume of the alleged production of the baking industry. While the production of iodized starches must be carried out in such volumes that the baking industry can use (in the production process) for one day (to preserve the iodine content).

In addition, it is necessary:

- to assess the capacity of modified starches in the food products of each region,
- to adjust the technological processes of bakery products,
- to develop specifications for bakery products enriched with these elements in accordance with applicable SanPiNs.

## 6. Conclusion

The analytical data presented in the study allowed concluding that:

1. The task of starches modifying can be linked to a regional source of raw materials (highly mineralized mineral water "Omskaya-1"). The starch iodization unit will be geographically located in the immediate vicinity of large bakeries and confectionery factories (in our example, Fornax OJSC, Sibkhleb OJSC, Khlebodar OJSC, Sadonezh OJSC, KF Sladunitsa LLC, etc.) for operational use in the technological process.
2. Technologies for the modified and iodized starches production are based on a thermal method with using glacial acetic acid.
3. The magnesia enriched and iodized modified starches production is necessary in the volume of the alleged production of the baking industry, and the production of iodized starches must be carried out in such volumes that the baking industry can use them in the production process for a day in order to preserve the iodine content.
4. The proposed technologies for magnesia enriched and iodized starches production have a lower cost per 1 tone of marketable products than the production of acetate starch, by 33.8% (magnesia starch) and 32.8% (iodized starch) respectively.

## References

- [1] Troshina E A, Platonova N M, Panfilova E A and Panfilov K O 2018 An analytical review of the results of monitoring the main epidemiological characteristics of iodine deficiency diseases in the population of the Russian Federation for the period of 2009–2015 *Problems of endocrinology* [in Russian – Problemy endokrinologii] **64**(1) 21–37
- [2] Baryshnikova G A, Stepanova I I, Chorbinskaya S A and Blokhina O E 2019 Potassium and magnesium deficiency and their role in the development of cardiovascular diseases and the possibility of correction *Medicine and healthcare* **21**(1) 67–73 (in Russian)
- [3] Niegelhell K, Chemel A, Hobich J and Spirk S 2017 Interaction of industrially relevant cationic starches with cellulose *Carbohydrate Polymers* **39** 179

- [4] Monceaux D A 2018 Bioethanol from Starch: The US Experience In: *Encyclopedia of Sustainability Science and Technology* ed R Meyers (New York: Springer)
- [5] Marques S, Moreno A D, Ballesteros M and Gírio F 2018 Starch biomass for biofuels, biomaterials, and chemicals In: *Biomass and Green Chemistry* ed Jr. S. Vaz (Springer, Cham)
- [6] Vanier N L, Pozzada dos Santos J, PinheiroBruni G and Zavareze E R 2019 Starches in foods and beverages In: *Handbook of Eating and Drinking* ed H Meiselman (Springer, Cham)
- [7] Li M C and Cho U R 2017 Starch in rubber based blends and micro composites In: *Rubber based bionanocomposites. Advanced structured materials* ed P M Visakh (Springer, Cham) p 56
- [8] 2008 MP 2.3.1.2432-08 Norms of physiological requirements for energy and nutrients for various groups of the population of the Russian Federation
- [9] Juansang J, Puttanlek C, Rungsardthong V, Puncha-arnon S and Uttapap 2012 Defects of gelatinisation on slowly digestible starch and resistant starch of heat-moisture treated and chemically modified canna starches *Food Chemistry* **131**(2) 500–507
- [10] Nissar J, Ahad T, Naik H R and Hussain S Z 2017 Resistant starch – chemistry and nutritional properties *Int. J. of Food Science and Nutrition* **2**(6) 95–108
- [11] Nasrin T A A and Anal A K 2014 Resistant starch: Properties, preparations and applications in foods In *Functional foods and dietary supplements* pp 227–253
- [12] Sarawong C, Schoenlechner R, Sekiguchi K, Berghofer E and Ng P K W 2013 Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour *Food Chemistry* **143** 33–39
- [13] Laurberg P and Rasmussen L B 2017 Non-salt food fortification programs In: *Iodine deficiency disorders and their elimination* ed E Pearce (Springer, Cham)
- [14] Blankenship J L, Garrett G S, Khan N A et al 2018 The effect of iodized salt on the organoleptic properties of processed foods: A systematic review *J. Food Sci. Technol.* **55** 3341
- [15] Lukin N D 2019 Evaluation of the cost-effectiveness of modified starches *II-nd Int. Conf. Starch and Starch Products* (Moscow: All-Russian Research Institute of Starch Products) pp 40–43
- [16] Van der Haar F 2017 Salt iodization into the modern era and beyond In: *Iodine deficiency disorders and their elimination* ed E Pearce (Springer, Cham)
- [17] Leung A M 2017 The effects of iodine excess In: *Iodine deficiency disorders and their elimination* ed E Pearce (Springer, Cham)
- [18] 2016 *Modified starches production: The main directions of application of modified starches*, available at: [http://chemanalytica.com/book/novyy\\_spravochnik\\_khimika\\_i\\_tekhnologa/06\\_syre\\_i\\_produkty\\_promyshlennosti](http://chemanalytica.com/book/novyy_spravochnik_khimika_i_tekhnologa/06_syre_i_produkty_promyshlennosti)