CHEMISTRY AND CHEMICAL ENGINEERING

Volume 2020 | Number 3 Article 11

October 2020

WATER-SOLUBLE JERUSALEM ARTICHOKE EXTRACTS AS FAT REPLACER IN DIETARY MARGARINE RECIPE

SALIJANOVA Shahnozaxon
Tashkent Chemical-Technological Institute, avliyoxonova@list.ru

RUZIBAYEV Akbarali
Tashkent Chemical-Technological Institute, akbar216@mail.ru

RAKHIMOV Dilshod
Tashkent Chemical-Technological Institute, rahimov1984@list.ru

XUSANOV Zafar
Tashkent Chemical-Technological Institute, Zafar4848.wz@gmail.com

WATER-SOLUBLE JERUSALEM ARTICHOKE EXTRACTS AS FAT REPLACER IN DIETARY MARGARINE RECIPE

Shahnozaxon SALIJANOVA (avliyoxonova@list.ru), Akbarali RUZIBAYEV (akbar216@mail.ru), Dilshod RAKHIMOV (rahimov1984@list.ru), Zafar XUSANOV (Zafar4848.wz@gmail.com), Shahnoza GAIPOVA (charosgaipova@gmail.com)
Tashkent Chemical-Technological Institute, Tashkent, Uzbekistan

Creating dietary margarines using biologically valuable substances is the purpose of the work. According to the results of the experiments, it was found that the use of soybean oil, edible vegetable phospholipids and a Jerusalem artichoke extract in the margarine, allowed reducing the amount of fat and enriching the margarine with omega-3 and omega-6 fatty acids, dietary fibre, inulin and other water -soluble substances. Based on these studies prepared margarine enriched inulin and essential fatty acids, which provide not only a preventive property of the finished product, but also high flavor indicators, as well as, original and attractive appearance.

Keywords: soybean oil, Jerusalem artichoke extract, margarine, inulin, essential fatty acids

ВОДОРАСТВОРИМЫЕ ЭКСТРАКТЫ ТОПИНАМБУРА КАК ЗАМЕНИТЕЛЬ ЖИРА В РЕЦЕПТЕ ДИЕТИЧЕСКОГО МАРГАРИНА

Шахнозахон САЛИЖАНОВА (avliyoxonova@list.ru), Акбарали РУЗИБАЕВ (akbar216@mail.ru), Дилшод РАХИМОВ (rahimov1984@list.ru), Зафар ХУСАНОВ (Zafar4848.wz@gmail.com), Шахноза ГАЙПОВА (charosgaipova@gmail.com)
Ташкентский химико-технологический институт, Ташкент, Узбекистан

Целью работы является получение диетических маргаринов с использованием биологически ценных веществ. По результатам экспериментов установлено, что использование соевого масла, пищевых растительных фосфолипидов и экстракта топинамбура в маргарине позволило снизить количество твердого жира и обогатить маргарин эссенциальными жирными кислотами омега-3 и омега-6, пищевыми волокнами, инулином и другими водорастворимыми вещества. На основе этих исследований приготовлен маргарин, обогащенный инулином и эссенциальными жирными кислотами, которые обеспечивают не только профилактические свойства готового продукта, но и высокие вкусовые показатели, а также оригинальный и привлекательный внешний вид.

Ключевые слова: соевое масло, экстракт топинамбура, маргарин, инулин, эссенциальные жирные кислоты

TOPINAMBURNING SUVLI EKSTRAKTI PARHEZ MARGARINING YOG'NI BOSUVCHI MODDASI SIFATIDA

Shahnozaxon SALIJANOVA (avliyoxonova@list.ru), Akbarali RUZIBAYEV (akbar216@mail.ru), Dilshod RAKHIMOV (rahimov1984@list.ru), Zafar XUSANOV (Zafar4848.wz@gmail.com), Shahnoza GAIPOVA (charosgaipova@gmail.com)
Toshkent kimyo-texnologiya instituti, Toshkent, O'zbekiston

Biologik qimmatli moddalardan foydalanib parhez margarinlarini olish tadqiqot ishining maqsadi hisoblanadi. Tajribalar natijalariga ko'ra, soya moyi, oziq-ovqat fosfolipidlari va topinamburning suvli ekstraktlarini margaringa qo'llanilishi yog' miqdorini kamaytirish va margarinni omega-3 va omega-6 yog' kislotalari, oziq-ovqat tolasi, inulin va boshqa suvda eruvchan moddalar bilan boyitish imkonini berishi aniqlandi. Ushbu tadqiqot ishi asosida nafaqat tayyor mahsulotning profilaktika xususiyatlarini, balki yuqori ta'm xususiyatlarini, shuningdek o'ziga xos ko'rinishni ta'minlaydigan, inulin va essensial yog 'kislotalari bilan boyitilgan margarin tayyorlandi.

Kalit so'zlar: soya moyi, topinamburning suvli ekstrakti, margarin, inulin, essensial yog' kislotalari

DOI: 10.51348/EHCV5459

Introduction

It has been proven by scientists that excessive consumption of animal and solid fats and a lack of high-quality essential oils of rich essential fatty acids in the diet can lead to increasing atherosclerosis, cardiovascular disease, diabetes, cirrhosis and other diseases. Therefore, using the margarine products with a low fat content is popular in developed countries. Nutrition issues, the creation of optimally balanced food rations for different population groups are given priority in the most developed countries of the world [1-3].

The main objective of the food industry is the development of low-calorie physiological fatty products enriched with biologically valuable substances. In solving this problem the main role is given to creating products which are water-fat emulsions direct (oil-in-water) and inverse (water-in -oil) type, that is caused by wide possibilities of varying the composition and obtaining final products with desired properties.

Margarines of reduced fat content have long been available on the market. Such margarines include in their formulations ingredients such as maltodextrins, modified Starch, Xanthan gum, and other gelling agents that have the function of replacing part of the fat content, thus reducing the calorie contribution per gram of margarine. Some patents give a partial solution to such a problem by including inulin in the formulation [4].

Inulin is used as a technological ingredient in the food industry. Inulin is added to baby foods, pastries, dairy products, chocolate, diet foods, etc. [5, 6]. Interestingly, inulin is used in the manufacture of low-fat foods in order to reduce their calorie content. This turns out because in this way the presence of fat in the product is simulated - when combined inulin, with water, is able to form a creamy substance texture similar to fat [7].

Inulin for 95% consists of natural fructose, which (unlike glucose), firstly, penetrates into cells without any participation of insulin, and secondly, replaces glucose in metabolic processes that occur in the human body. Therefore, Jerusalem artichoke and preparations based on it are indicated for people suffering from diabetes. Inulin, which belongs to the group of prebiotics, contained in large quantities in Jerusalem artichoke, and has positive effects on the body [8-14].

It has been proven that inulin-containing plants, including Jerusalem artichoke, have a hepatoprotective effect, therefore, they are recommend-

Table 1

The fat base of margarines

Fat Margarine Ingredients	Samples in %		
	present-1	present-2	suggested
Partially hydrogenated oil	46.0	0	0
Palm oil	38.0	24.0	0
Sunflower oil	16.0	22.0	0
Palm stearin	0	54.0	44.0
Interesterified fat	0	0	32.0
Cottonseed oil	0	0	10.0
Soybean oil	0	0	12.0
The structure-forming agent (full hydrogenated oil)	0	0	2.0
Total	100	100	100
Melting point of mixture T_{mp},°C	27.7	28.8	29.3

ed for patients with viral hepatitis B and C occurring in the chronic stage. For isolation of inulin from Jerusalem artichoke tubers were used the inulin property as dissolve in hot water.

Materials and methods

As the objects of the research were water-fat emulsions and products based on them (margarine), which are obtained in the laboratories under production conditions. As a raw material were used the standard of the fat products obtained in the Tashkent Oil and Fat Factory. As emulsifiers were used edible vegetable phospholipid concentrates.

The amount of fat in margarine was determined by the extraction method [15].

The amount of proteins in margarine was determined by the Kjeldahl method [16].

The amount of carbohydrates in margarine was determined by the Bertrand method [17].

The melting point of the fatty base of margarine was determined by the capillary method, and the hardness was determined on a Kaminsky device at a temperature of 15 °C [15].

Acid, peroxide and iodine values in margarines were determined according to the methods [15]. Free fatty acid (FFA) was analyzed by a titration method defined in the literature [15].

Preparing fat base of margarine

On the basis of above data, we have developed margarine formulations from local fatty raw materials: soybean, sunflower, cotton seed oils, fully hydrogenated fat, interesterified fat. Also the physicochemical properties of the margarine were investigated.

The main ingredients in the production of margarine are hydrogenated oil, palm oil and interesterified fat. The interesterified fat is obtained by interesterification of vegetable oils and hydrogenated fats. To improve the quality of margarines and increase the thermal stability of the product, it is recommended to use the structure-forming agents – low iodine fully hydrogenated fats [18,19].

Leading manufacturers are developing recipes for margarine products based on market requirements, dietary trends in human nutrition and the desire to reduce the cost of production.

The dietary effect is to reduce the total amount of consumed fats, decrease the cholesterol level (less than 15 mg / kg), increase the consumption of unsaturated fats (not less than 50%) and decrease the level of saturated fats (less than 25%). Depending on the purpose, margarine products must have a certain melting point (fusibility) and ductility. Fusibility is characterized by the temperature of complete melting, which depends on the content and quantitative ratio of solid and liquid fractions: the higher the content of the solid high-melting fraction, the lower the fusibility. Plasticity depends on the ratio of solid and liquid glycerides. Fats have good ductility and spreadability, if the amount of solid glycerides is 15-30%. In dense and non-ductile fat, the content of solid glycerides is more than 30%, and in too soft fats - 10-12%.

Based on the components listed above, we conducted research work in creating a fatty base of diet margarine with optimized properties. The investigation was used edible hydrogenated fat, interesterified fat, palm oil, soybean, sunflower and cotton seed oil (Tashkent Oil and Fat Plant, Uzbekistan). The fat bases of margarines are shown in Table 1.

Table 1 shows that the partially hydrogenated oil were partially replaced with vegetable oils and interesterified. Increasing the amount of liquid oils leads to raising the essential fatty acids in the composition of margarine, decreasing the melting point and hardening of margarine. But by maintaining the structure-forming agents in the fat base of margarine, its melting point and hardness increase.

In the production of dietary margarines and spreads, edible plant phospholipids are used as an emulsifier and dietary supplement [18]. In this work [20] researchers carried out experiments on the degumming of soybean oil and obtained phosphatide concentrate. In the preparation of margarine, we used this phosphatide concentrate.

Preparing Jerusalem artichoke extract

For research we used Jerusalem artichoke tubers mainly of the “Mo’jiza” (“Miracle”) variety, which were washed, cleaned, blanched, thinly slice, dried and crushed to particles about 1 - 2 mm in size. The resulting powder was subjected to extraction with water at a temperature of 75 °C with a water module of 1: 4 for 60 minutes [21, 22]. The extraction of the test samples was carried out on a specially made laboratory setup with constant stirring. The resulting solution was filtered through a cotton pad to get rid of large particles. Then the obtained Jerusalem artichoke extract was evaporated

Figure 1. The sequence of extraction of water-soluble substances from Jerusalem artichoke tubers: A - dried JA slices; B - JA powder; C - JA extract; D - concentrated JA extract.

Table 2

The composition of the water extract in Jerusalem artichoke

Components	Content, %	
	Initial	After evaporation
Proteins	0.8	2.08
Carbohydrates, including:	16.3	50.0
Inulin	11.6	35.6
Alimentary fiber	0.8	2.45
Organic acids	0.1	0.30
Ash	1.2	3.68
Water	80.8	41.49

Table 3

Margarine Recipes[a]

Margarine ingredients, %	Samples		
	M-1	MI-2	MI-3
Fat base	70	67.75	60.47
Dye	0.1	0.1	0.1
Emulsifier	0.2	0.2	0.2
Milk	10	10	10
Salt	0.4	0.4	0.4
Nutritional phosphatide concentrate	2.0	2.0	2.0
Antioxidant	0.05	0.05	0.05
Sugar	0.4	-	-
Water	16.85	-	-
JA water extract (initial)	-	19.5	-
JA water extract (concentrated)	-	-	26.78
Total	100	100	100

[a]Abbreviations used: M, margarine suggested; MI, margarine enriched by inulin.

and concentrated in a vacuum. After evaporation, a concentrated Jerusalem artichoke extract was obtained. Figure 1 shows dried JA slices, JA powder, JA extract and concentrated JA extract after heating -cooling process.

The Figure1 shows the pictures of JA products: dried JA slices (A), JA powder (B), JA extract (C), concentrated JA extract (D). The composition of the water extract of Jerusalem artichoke is shown in Table 2. The water content in the solution was reduced from 80.8 to 41.49%. In turn, the inulin content increased from 11.6% to 35.6%. In the next experiments, this solution of Jerusalem artichoke extract was used instead of pure water.

Results and discussions

In a margarine formulation involving simple blending or interesterifying several oils and fats, temperature is able to show the expected melting profile of the final product. The overall performance of the margarine are packaging and storage, as well as, eating qualities are also predicted from the profile. Thus, the individual SFC (solid fat content) profile of selected oils and fats will contribute significantly to the behavior of the final blend. Combining the individual physical attributes of selected oils and fats will lead to the cumulative physical effects required by different margarines [23-25].

Based on the components obtained in the laboratory, we conducted research to create diet margarine with optimized properties due to the addition of highly unsaturated soybean oil, citric acid which are added to the formulation. Succinic acid is also added to increase dispersion and stability to the oxidation of margarine. The compiled recipe is shown in Table 3.

In the Table 3 it is shown that with an increase in the mass fraction of water or an aqueous extract of Jerusalem artichoke from 11.6 to 35.6, the mass fraction of the fat base decreases from 70.0 to 60.47%. Sugar was added by using water, and it was not added to the water extract of Jerusalem artichoke. This is due to the presence of mono- and

Table 4

The organoleptic and physicochemical indicators of margarine[a]

Name of indicator	Margarine brands				
	M-1	MI-2	MI-3	CP-1	CP-2
Nutritional information (theoretically) – per 100 grams product:					
Total fat content, g	72.2	70.3	62.5	72.1	72.2
Total protein content, g	ND	0.15	0.3	ND	ND
Total carbohydrates, g	ND	3.1	13.3	ND	ND
Inulin, g	ND	2.26	9.53	ND	ND
Dietary fibres, g	ND	0.15	0.3	ND	ND
Chemical information (typical)					
Acid value, mg KOH/g	0.28	0.28	0.29	0.27	0.28
Moisture content, %	26.0	24.6	20.0	26.2	26.3
Peroxide value, meq/kg	2.7	2.4	2.1	3.2	4.0
Sensorial information					
Taste	neutral with buttery taste			absence of off-taste	
Structure:	grainy	grainy	smooth	smooth	smooth
Plasticity:	hard	medium	soft	soft	medium
Colour:	LY	LY	SY	LY	LY

[a]Abbreviations used: M, margarine suggested; MI, margarine enriched by inulin; CP-1, first commercial present margarine; CP-2, second commercial present margarine; ND, not detected; LY, light yellow; SY, slightly yellow.

disaccharides in the water extract of Jerusalem artichoke. Figure 2 shows the changes in the mass fraction of the fat base, as well as, water and inulin in the composition of margarine.

The Figure 2 shows that by reducing the mass fraction of fat to 60.47%, the mass fraction of inulin increases to 9.53%. The water in the margarine is also reduced to 19.98%.

The margarine is prepared in laboratory conditions on the basis of recipe. For this, the mixture of prescription components is mixed until moment when a homogeneous emulsion is obtained and overcooled.

Based on these studies prepared margarine enriched inulin and essential fatty acids, which are provide not only a preventive property of the finished product but also high flavor indicators, as well as, original and attractive appearance.

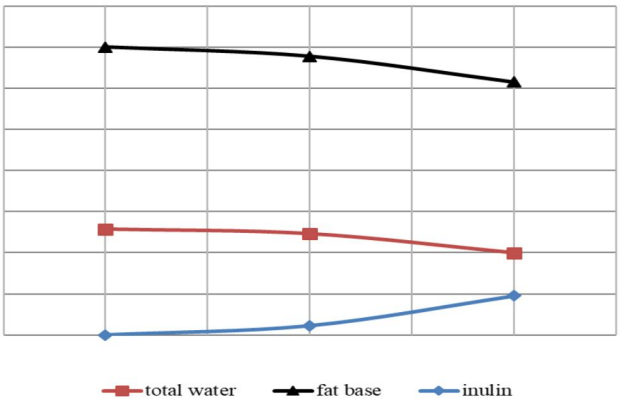

Figure 2. Changes in the mass fraction of the fat base, total water and inulin in the margarine.

Table 4 shows the organoleptic and physicochemical indicators of margarine. The obtained margarine has a high plasticity, higher degree of dispersion, processability, durability and oxidation stability. Furthemore, the addition of nutritional vegetable phospholipids and a Jerusalem artichoke extract in water increases the nutritional value of the proposed margarine.

Conclusion

As a result of the experiments, it was found that the use of soybean oil, nutritional vegetable phospholipids and a Jerusalem artichoke extract in the margarine made it possible to reduce fat and enrich margarine with omega-3 and omega-9 fatty acids, dietary fiber, inulin, and other water-soluble substances.

Initially, the use of Jerusalem artichoke extract to replace fat in margarine emulsions was considered an interesting option because of their emulsifying and stabilizing capacities. They enabled some of the texture defects occasioned by the lack of fat to be solved, and, in addition, they enriched the food nutritional value. Some quality parameters such as margarine texture even showed an improvement due to inclusion of prebiotics. The validation of the model has shown that it can be successfully used to produce low fat and sugar margarine with the potential health benefits of prebiotics. The addition of interesterified fat, cottonseed and soybean oils to the proposed margarine recipe improved its SFC properties and allowed to obtain zero *trans*-margarine.

REFERENCES

1. Rios R.V., Pessanha M., Almeida P.F., Viana C.L., Lannes S.C.S. Application of fats in some food products. *Food Sci. Technol (*Campinas), 2014, vol. 34, no. 1, pp. 3-15. doi:10.1590/S0101-20612014000100001
2. Ruzibaev A.T., Salidzhanova SH.D. Issledovaniya processa polucheniya margarina na osnove mestnyh zhirovyh syr'ya [Research of the process of obtaining margarine based on local fatty raw materials]. *Universum: tekhnicheskie nauki*, 2017, no. 10, pp. 9-11.
3. Khodjaev S.F., Abdurakhimov S.A., Akramova R.R., Khamidova M.O. Issledovaniye pokazateley kachestva zhirovo j osnovy margarina pri zamene tradicionnogo khlopkovogo masla saflorovym [Investigation of quality indicators of fatty basis of margarine at replacement of traditional cottonseed oil with safflower]. *Universum: KHimiya i biologiya,* 2018, no. 10, pp. 15-18.
4. Buttini R. Margarine-like food composition with reduced fat content. Patent US, no. 20060051485, 2006.
5. Shoaib M, Shehzad A, Omar M, Rakha A, Raza H, Sharif HR, Shakeel A, Ansari A, Niazi S. Inulin: Properties, health benefits and food applications. *Carbohydr Polymers,* 2016, no. 147, pp. 444-454. doi:10.1016/j.carbpol.2016.04.020
6. Xin Qi, Richard F.Tester. Fructose, galactose and glucose – In health and disease. *Clin. Nutr. ESPEN,* 2019, no. 33, pp. 18-28. DOI: 10.1016/j.clnesp.2019.07.004
7. Pawel Glibowski. Effect of thermal and mechanical factors on rheological properties of high performance inulin gels and spreads. *J. food eng*. 2010, vol. 99, no. 1, pp. 106-113. doi:10.1016/j.jfoodeng.2010.02.007
8. W. Ahmed, S. Rashid. Functional and Therapeutic Potential of Inulin: A comprehensive review**.** *Crit. Rev. Food Sci. Nutr.* 2019, vol. .59, no. 1, pp. 1-13. doi:10.1080/10408398.2017.1355775
9. Akalin A.S., Erişir D. Effects of inulin and oligofructose on the rheological characteristics and probiotic culture survival in low-fat probiotic ice cream. *J. Food Sci.* 2008, vol.73, no. 4, pp. 184-188. doi:10.1111/j.1750-3841.2008.00728.x
10. Coussement P.A. Inulin and oligofructose: Safe intakes and legal status. *The J. Nutr.*, 1999, vol. 129, no. 7, pp. 1412–1417. doi:10.1093/jn/129.7.1412S
11. Cínthia Hoch Batista de Souza, Luiz Antonio Gioielli, Susana Marta Isay Saad. Inulin increases *Bifidobacterium animalis* Bb-12 *in vitro* gastrointestinal resistance in margarine. *LWT-Food Sci. Technol*. 2017, vol. 79, pp. 205-212. doi:10.1016/j.lwt.2017.01.032
12. Guess N.D., Dornhorst A., Oliver N., Bell J.D., Thomas E.L., Frost G.S.. A randomized controlled trial: the effect of inulin on weight management and ectopic fat in subjects with prediabetes. *Nutr Metab*. 2015, no. 12, pp. 36. doi:10.1186/s12986-015-0033-2
13. Parnell J.A., Reimer R.A.. Weight loss during oligofructose supplementation is associated with decreased ghrelin and increased peptide YY in overweight and obese adults. *Am. J. Clin. Nutr.* 2009, vol. 89, no. 6, pp. 1751-1759. doi:10.3945/ajcn.2009.27465
14. Arora T., Loo R.L., Anastasovska J., Gibson G.R., Tuohy K.M., Sharma R.K., Swann J.R., Deaville E.R., Sleeth M.L., Thomas E.L., Holmes E., Bell J.D., Frost G. Differential effects of two fermentable carbohydrates on central appetite regulation and body composition. *PLoS One,* Aug 29, 2012. doi:10.1371/journal.pone.0043263
15. Arutyunyan N.S., Yanova L.I., Arisheva E.A., Kosachev V.S., Kamyshyan M.A. Laboratornyj praktikum po tekhnologii pererabotki zhirov [Laboratory Workshop on Fat Processing Technology]. Moscow, Agropromizdat Publ., 1991. 160 p.
16. GOST 23327-98. Milk and milk products. Determination of mass part of total nitrogen by Kjeldahl method and determination of mass part of protein. Moscow, Standartinform Publ., 2009, 10 p. (In Russian).
17. GOST 54667-2011. Milk and milk products. Methods for determination of sugars mass fraction. Moscow, Standartinform Publ., 2012, 26 p. (In Russian).
18. Paula K. Okuro, Andresa Gomes, Ana Letícia R. Costa, Matheus A. Adame, Rosiane L. Cunha. Formation and stability of W/O-high internal phase emulsions (HIPEs) and derived O/W emulsions stabilized by PGPR and lecithin. *Food res. int*. 2019, vol. 122, pp. 252-262. doi:10.1016/j.foodres.2019.04.028
19. Mandu C.C., Barrera-Arellano D., Santana Mh.A., Fernandes G.D. Waxes used as structuring agents for food organogels: A Review. *Grasas Aceites*, 2020, vol. 71, no. 1, e344. doi:10.3989/gya.1169182
20. Salidjanova Sh.D., Ruzibaev A.T., Botirova M.N., Shavkatov S.J. A study of the processing of soybean oil and its use in the margarine production. *Universum: Tech. sci*., 2018, vol. 57, no. 12, pp. 67-72.
21. Predrag Putnik, Jose M. Lorenzo, Francisco J. Barba, Shahin Roohinejad, Anet Režek Jambrak, Daniel Granato, Domenico Montesano and Danijela Bursa´c Kova˘cevi´c. Novel food processing and extraction technologies of high-added value compounds from plant materials. *Foods*, 2018, no. 7, pp. 106; doi:10.3390/foods7070106
22. Carolina Iraporda, Irene A.Rubel, Guillermo D. Manrique, Analía G.Abraham. Influence of inulin rich carbohydrates from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers on probiotic properties of *Lactobacillus* strains. *LWT-Food Sci. Technol.,* 2019, vol. 101, pp. 738-746. doi:10.1016/j.lwt.2018.11.074
23. Ruzibayev A.T., Salijanova Sh.D., Rakhimov D.P. Cottonseed oil as a valuable raw material to obtain trans-free margarine. *Journal of critical reviews*, 2020, vol 7, Issue 9, pp. 572-577.
24. Rakhimov D.P., Abdullaev U.S., Rakhimov P.H., Ruzibaev A.T. Getting a modified interesterification using the combination of liquid oils and solid fat. *Austrian Journal of Technical and Natural Sciences*, 2020, n.3-4, pp. 3-9.
25. Rahimov D.P., Ruzibaev A., Tashmuratov A., Salijanova Sh. Research of the process of obtaining interesterified fat for margarine production on the basis of sunflower oil and palm stearin. Chemistry and Chemical Engineering, 2020, no. 1, pp. 64-68.