UDC 664.165

EXPERIMENTAL DESIGN AND DEVELOPMENT OF RECIPES FOR OBTAINING OF FRUCTOSE-FREE JAMS

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Abstract. *Artical present the develop the receipts for jams with low sugar particularly fructose content. The best result was obtained in jams with sugar alcohol erythritol, particularly in product taste (135 while for sugar 140 points) and consistence (120, while for sugar 145 points). It is conceivable that the sugar as well as particularly fructose could be replaced in jams with such sweeteners as erythrol, Nevella, sucrofin, but not with stevia, blackberry leaves and Lou Han Guo.*

Key words: *jams, sweeteners, composition, quality*

The aim of this work was the production of jams with reduced fructose content. These products can be especially used by fructose intolerance. At the same time they should fit the tastes of consumers. For this purpose we have developed an experimental design for production and evaluating of raspberry and currant jams in combination with nine different sweet-testing substances as sugar (control), glucose syrup, lactose, erythritol as well as sweeteners Nevella, Sucofin, Luo Han Guo, Stevia leaves, and sweet blackberry leaves. To achieve the proper volume of the end product, we have used different pectins [1, 2, 9]. The jams were analyzed for pH, color, and Brix content. We also have determined stability, differences in color, and dry matter contents of the products. To evaluate the acceptance of the product for the consumers, we have provided questioning. The best results were achieved by

application of sugar alcohol erythritol, especially by raspberry jam. Therefore conclude that erythriol could be an alternative to sugar. Moreover, it is a natural product without side effects.

Nowadays, consumers tend to obtain proper balanced high-quality nutrition. Statistic shows that more as twenty five present of the world population possess various food intolerances [6, 7]. Especially lactose and fructose can cause allergic reactions. The demand for fructose-reduced food is therefore rather high [8, 19]. It is necessary to take into account also hidden fructose in products. It can be found not only in fruits, fruit juices, and jams, but also in many ready-to-eat fast-food products. Also sugar beet, cane and honey contain fructose. It can be found in small quantities even in vegetables and grains [11]. Fructose is industrially obtained from corn syrup and has many beneficial features for the food technology: it has a high sweetening power and stability, acts as humectants and intensifies food color.

People with fructose intolerance will get abdominal pain, nausea, and bloating after its consuming. Currently, according to statistical studies 2 of 100 people are affected from fructose intolerance. According to the WHO classification system ICD-10, fructose intolerance is a disorder of carbohydrate intake [18]. By this metabolic disorder fructose cannot be absorbed insufficiently. The intake of fructose is slow, its concentration increases in the intestine. Intestinal bacteria convert fructose into carbon dioxide and hydrogen [15]. Fructose intolerance symptoms especially depend on the ratio of fructose to glucose: the higher is the amount of glucose as compared to fructose, the better the product can be tolerated [11] (Table 1).

Especially promising strategy of the production of sweet jams is to replace or reduce sugar, especially fructose and to ensure a good distribution of fructose and glucose in jams.

Therefore, the aim of this work was to substitute fructose in jams through various sweet-testing substances. The important aspect was also to develop the product, acceptable for the consumer in its appearance, taste, and texture.

1. Content and ratio of fructose and glucose, g

Culture	Fructose in g	Glucose in g	Ratio F : G
Apricot	0,86	1,73	1 : 2,01
Kiwi	4,41	4,71	1 : 1,07
Apple	5,74	2,04	1 : 0,35
Prune	6,75	1,67	1 : 0,25
White bread	0,03	0,03	1 : 1,04

Materials and methods. This research work has been provided at the Agricultural Faculty of the University of Applied Sciences Weihenstephan-Triesdorf (Germany) in collaboration with University of Applied Sciences Hof (Germany) and with National University of Life and Environmental Sciences in Kiew (Ukraine).

Raw Materials. In order to produce raspberries and currants jams, we have developed the experiment design with three pectin's and nine sweeteners. The fructose : glucose ratio of raspberries is 1: 0.87 and of currants 1: 0.81.

As the gelling agents we have selected NE pectin "Amid CF 005" and "Amid AF 015-A" [9] (Table 2), used usually only for industrial production of jams.

2: Comparison of pectin usage in terms of their dry matter content (DM), esterification (ES) and grade of amidisation (A), as well as their characteristics and application areas

Pectin Type	DM	ES°	A°	Characteristic Properties	Products
Amid CF 005	>55%	32-40%	10-16%	Amidated Citrus-pektin, low Ca Reactivity	Jams, low-caloric fruit mixtures (pH 3,0-3,5)
Amid AF 005-A	<55%	30-38%	7-14%	Amidated Applepectin, low Ca Reactivity	

To achieve the same level of dry matter content in fructose-reduces jams as in convenient analogue products, we have applied two different amidated low-methoxyl pectin products. These pectin products are relatively stable by the low pH, which is especially important for production of products with high content of organic acids, as raspberries and currant. After selection of suitable alternative sweet-testing

substances, jams were cooked in Thermomix (Overwork) under the same condit... as temperature and cooking time.

As sweet-testing agents we have used some sugar alcohols. They are carbohydrates as well as sugar, but they possess about 40% energy in comparison to sugar. They are less sweet than sugar and cannot or can only partially be digested [16]. For our experiment we have selected erythritol, isomalt, lactitol, mannitol, maltitol, sorbitol, and xylitol.

Since sugar alcohols are absorbed into the small intestine, in comparison with sugar they increased consumption (from 10 to 20 grams) can cause abdominal pain. Therefore it is necessary to find the optimal amount. It has also to be regulated according to the Additive Approval Regulation and EU Directive 94/35.

During our studies we have selected erythriol as the most suitable substitution of sugar. Sweetener erythritol occurs naturally in a small amount in some fruits, mushrooms, and cheese. It can also be produced by genetically modified micro-organisms. Metabolic studies have shown that erythritol is one of the sugar alcohols, which is up to 95% absorbed by the small intestine and excreted unchanged by the kidney. Since only about 5% of the sugar alcohol pass through the large intestine, higher amounts may be eaten without unpleasant side effects such as digestive discomfort.

Sweeteners. This class of low-caloric or calorie-free substances includes chemically different, natural or synthetic substances with very high sweetness as compared to sugar. Because of the sweetness they are used sparingly in food and therefore cannot replace the mass and volume of sugar. Another characteristic of sweeteners are that they are not metabolized or not great role on human organism. Hence, after consuming any insulin secretion is induced [12]. For our experiments we have selected some traditionally used sweeteners as aspartame, but also some novel as Nevella, Sucofin, Luo Han Guo, Stevia leaves, and sweet blackberry leaves.

Aspartame. The sweetener aspartame is a dipeptide, which is obtained from aspartic acid and phenylalanine. It is used by a human organism and provides low

energy. Because aspartame is used not only in very small quantities, there fo[illegible] appreciable contribution to total energy supply guaranteed [14]. Since aspartame enhances fruit flavors, it is often used in confectionery to flavor improvement.

Stevia. Steviosides are a group of natural, non-caloric sweeteners from the plant *Stevia rebaudiana* Bertoni. The main ingredient in the fraction of stevia leaf is stevioside A, which is about 300 times sweeter than sugar. Stevia leaf content in the dry matter reach 20%. Therefore dry leaves of stevia are 15 to 30 times sweeter properties than sucrose [17].

Sweet blackberry leaves. The leaves of Chinese bramble (*Rubus suavissimus* S. Lee) contain up to 8% of the sweet glycoside rubusoside, which chemical structure is similar to the stevioside in Stevia. In traditional Chinese medicine, sweet blackberry has been popular for decadesm, it has a proven antioxidant action and is used to treat high blood pressure and diabetes [5].

Luo Han Guo is a sweet tropical fruit of the plant *Siraitia grosvenorii*, which is grown in China, where it is used for a long time in traditional Chinese medicine for coughs and pharyngitis [14]. The ingredient mogroside, a sugar-like compound, gives sweet taste to it.

Determination of the sweet power. As we have used different substances with individual sweetening power, we had to find out the required amount of the sweeteners. Table 3 provides an overview of the sweet power and the amount of sweeteners that are necessary to achieve the sweetness like sugar. Therefore we compared the sweet power of sugar (as 1) tot he other substances.

Biochemical analysis and statistical data processing was carried out by commonly accepted methods [2, 3].

3. Characteristics of sweet testing substances

Sweetener	Sweet power (Factor 1 is sugar)	Amount (g)
Mono- and Disaccharides		
Sugar	1	100
Glucose syrup	0,6	167
Lactose	0,3	333
Sugar alcohols		
Erythrit	0,6-0,8	167-125
Sweeteners		
Stevioside	300-450	0,3-0,2
Luo Han Guo	300	0,3
Rubusoside	200	0,5
Aspartam	180-200	0,6-0,5
Stevia leaves	30	3

Results and discussion. The sensor evaluations were conducted with 50 test people, including 14 males and 36 females, at the age from 19 to 58 years. It was a blind tasting carried out via answering questions concerning jams with different sweet-tasting substances. Finally, we have evaluated the willingness to buy the product and price expectations.

During the acceptance tests we have investigated such criteria as appearance, consistency, and distribution and taste limits of the respective 9 recipes**.**

The evaluation of the sensor quality of raspberry jam is possible to see in the figure 1.

The comparison of points has shown that sugar was evaluated as the best product with the average score of 149 and Luo Han Guo as the worst one with the average score 81 (Table 4).

Sugar was the sweet-testing substance in the category of carbohydrates with 160 points for spreading and 140 points for taste, however erythrol has shown also relatively good spreading as 130 and taste as 135 point. The lowest scores for spreading the consumers gave to blackberry leaves (90) and the worst taste scores became Luo Han Guo (35). The best results in the category odor reached sweetener Nevella with 140 points, while stevia reached 120 points, and lactose only 80 points.

The sugar reached the best average score with 149. The last place has g Luo Han Guo sweetener with 81 points.

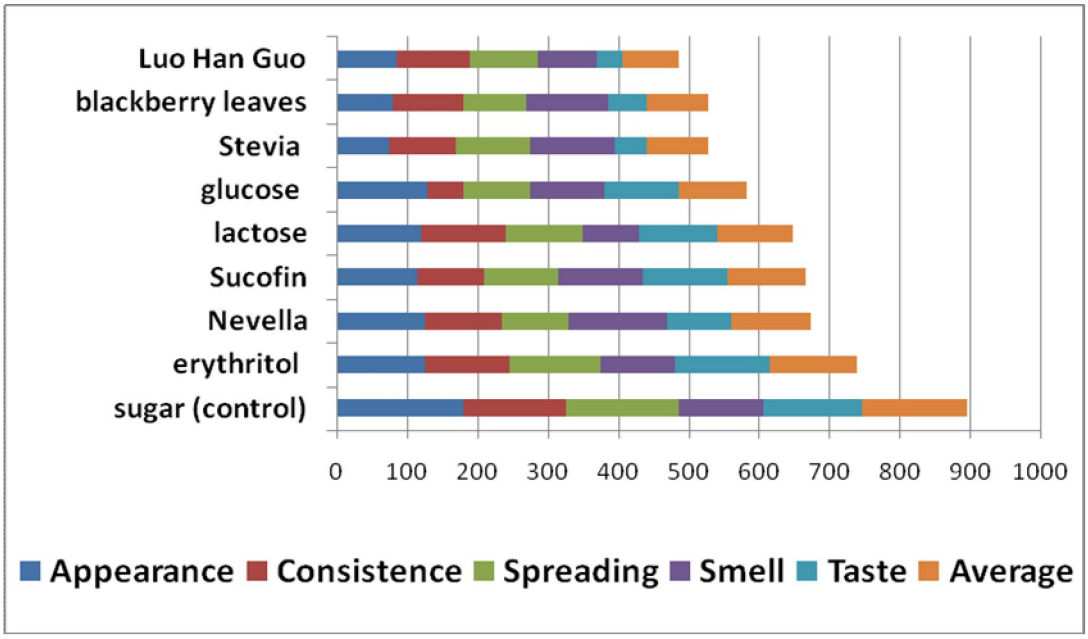

Figure 1. Acceptance test of fructose-reduced raspberry jams

4. Evaluation of Appearance, Consistence, Spreading, Odor, and Tasteof fructose-reduced raspberry jam, points

Components	Appearance	Consistence	Spreading	Odor	Taste	Average
Sugar (control)	180 ± 6	145± 3	160± 5	120± 4	140± 7	149± 5
Erythritol	125± 8	120± 7	130± 2	105± 5	135± 6	123± 3
Nevella	125± 11	110± 7	95± 1	140± 7	90± 2	112± 6
Sucofin	115± 10	95± 3	105± 2	120± 2	120± 4	111± 3
Lactose	120± 7	120± 10	110± 4	80± 5	110± 5	108± 7
Glucose	130±3	50± 3	95± 1	105± 10	105± 10	97± 2
Stevia	75± 5	95± 6	105± 6	120± 2	45± 3	88± 4
Blackberry leaves	80± 4	100± 8	90± 3	115± 4	55± 1	88± 2
Luo Han Guo	85± 2	105± 2	95± 3	85± 2	35± 1	81± 10

Erythritol had good with 123 points, Nevella with 112 points, and Sucrofin with 111 points.

Unextected was the fact, that the estimation of consistency of jams glucose syrup reached only to 50 points. The negative assessment of the consistency of glucose syrup is understandable on the basis of sensory tests. After comparison of other sweet-testing agents, it became noticeable that the jams with glucose syrup were much less viscous than the other products. The addition of a relatively high amount of the syrup which has a weak viscous consistency, the jams was not completely solidified.

The negative assessment of the lactose (80 points) in terms of odor may possibly be due to the fact that during storage lactose can change the odors of the products [17]. In our tests, it was found that lactose jams had slightly "milky" note. This property of jams affects negatively on odor and taste.

The results have shown that 36 persons were ready to buy currant jams with sugar-substitutes and 40 persons were ready to buy raspberry jams. 29 persons agreed to buy currant jams for at least 2 € per 250g and 26 persons were ready to spend this amount of money for raspberry jams.

Conclusions

The best result was obtained in jams with sugar alcohol erythritol, particularly in product taste (135 while for sugar 140 points) and consistence (120, while for sugar 145 points). The average estimation of jams with erythrol has reached 123 point, when for sugar 149 points. Application of Luo Han Guo is not promising, because according to the consumer estimation this product has become only 81 point in comparison to 149 by sugar. Especially negative evaluated was the taste of the products: only 35 point in comparison to 140 by sugar. It is conceivable that the sugar as well as particularly fructose could be replaced in jams with such sweeteners as erythrol, Nevella, sucrofin, but not with stevia, blackberry leaves and Lou Han Guo.

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РОЗРОБКА РЕЦЕПТУРИ ДЖЕМІВ З ВИКОРИСТАННЯМ ЦУКРОЗАМІННИХ КОМПОНЕНТІВ

M. Kilian, Y. Shevchenko, E. Gross, I. Smetanska, V. Voytsekhivskiy

Анотація. *У статті наведено результати досліджень з розробки рецептури джемів з низьким вмісту цукром зокрема фруктози. Найкращий результат було отримано у зразках із застосуванням цукрового спирту еритритол, особливо у смаку продукту. Додавання еритролу, Невела, цукрофін під час виготовлення натуральних фруктових джемів спроможне ефективно замінити цукор і фруктозу, а використання листя стевії, ожини і Лу Хань Го менш менш ефективне.*

Ключові слова: *джем, підсолоджувачі, рецептура, якість*

РАЗРАБОТКА РЕЦЕПТУРЫ ДЖЕМОВ С ИСПОЛЬЗОВАНИЕ САХАРОЗАМЕНИТЕЛЕЙ

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Аннотация. *В статье изложены результаты исследований по разработке рецептуры фруктовых джемов с низким содержанием сахара и фруктозы. Наилучший результат получено в образцах с использование сахарного спирта еритрола, особенно во вкусе продукта. Добавление еритрола, Невела, цукрофина при изготовлении натуральных фруктовых джемов ефективно заменяет сахар и фруктозу, и использование листьев стевии, ежевики и Лу Хань Го менее аффективно.*

Ключевые слова: *джем, подсластители, рецептура, качество*