

Application of digital marking for confectionery for sustainability life cycle of food products

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Abstract. Currently, one of the priorities of the food industry is to ensure the quality and safety of products. Food industry enterprises produce products that meet the requirements of regulatory and technical documentation and consumer preferences. But often it is at the stages of distribution, storage and sale that quality indicators deteriorate. Failure to comply with the terms and conditions of delivery of products leads to defects, and such products will not be safe for consumption. In this regard, it is necessary to find such methods and means of labeling that would preserve the nutritional value and consumer properties throughout the entire life cycle of products. The work is devoted to the use of modern labeling methods to preserve consumer properties at the stages of product distribution and the economic costs of implementation. It is proposed to use a QR code or radio frequency tags NFC-PASS, which record information about the Internet resource that contains data about this particular product.

1 Introduction

Product quality management throughout the entire life cycle is provided by many components, including control functions in the chain of processes for issuing from the warehouse of the manufacturing plant, transportation, acceptance and storage of the seller enterprise. Particularly relevant is the issue of ensuring the temperature parameters of food products within the specified limits when performing these operations [1]. The introduction of the HACCP system at the enterprise allows you to automatically comply with the specified storage standards [2], but this is not always ensured during the transportation and storage of products in retail outlets.

Chocolate is a confectionery product loved by all of us, it is equally loved by children, adults, men and women. What is the secret of such popularity of this amazing delicacy, what is the composition of chocolate, does it benefit or harm our health, how to store it correctly and what must be indicated on the labeling of each bar? We will try to answer all the questions that interest us and give our recommendations to the manufacturers of these dessert products.

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2 Objective

Rationale for the use of digital marking for confectionery products on the example of chocolate at the stages of distribution, taking into account the peculiarities of storage conditions.

3 Research materials and methods

The most common violation on their part is exceeding the recommended temperature. To solve the problem of possible concealment of a violation, irreversible thermochemical indicators of exceeding the permissible temperature can be used (Figure 1). These indicators not only allow you to fix the temperature increase, but also to estimate the duration of exposure. Unfortunately, the cost of indicators does not allow them to be placed on each chocolate bar, which limits the use of indicators only in small (50-100 bars) and large bulk packaging.

There is also the issue of siled climate data, which makes it difficult to choose the optimal supply chain for both the manufacturer and the retailer.

To reduce the fragmentation of climatic data on storage and transportation conditions, you can use the Internet resource, where, in addition to information from suppliers, you can place information on the date of production, the main quality indicators. Information about the address of the Internet resource can be encrypted using a QR code, which is placed on the boxes, since the supply of bar chocolate to stores is rarely carried out by the piece, and equipment for reading them is ubiquitous.

With the additional placement of a QR code on a thermochemical indicator (Figure 1), the information on the Internet resource can be supplemented with an image of its condition at the time of opening the shipping package.

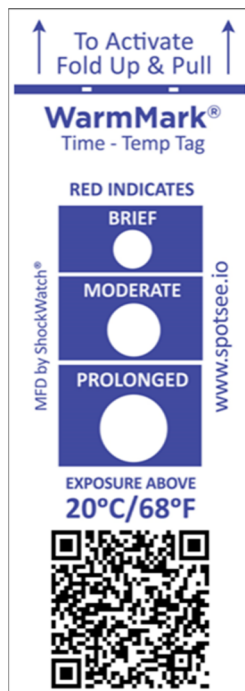


Fig. 1. Thermochemical indicator with a placed QR code.



Fig. 2. Placement of the QR code of the promo site on the package.

In addition to the main task, the Internet resource can be used to increase consumer confidence in products by placing a QR code with the address of the resource on the packaging of a chocolate bar. In this case, the Internet resource can be supplemented with information that allows you to directly find out the necessary information about the product (quality, quantity and location).

Some manufacturers are already placing a QR code next to the information on the expiration date on the promo site of the product (Figure 1).

Looking back at current trends, there may be a proposal to use radio frequency identification using RFID (NFC) tags instead of QR codes, but this will lead, as well as to an increase in implementation costs, since recording and reading equipment is rarely found in manufacturers and retailers, so and to an increase in packaging costs [3, 4].

4 Results

World chocolate consumption is about 4 million tons per year, most eaten in Switzerland, Belgium and Germany, consumption per person in these countries is about 10 kg per year. In different countries, chocolate is eaten with different taste preferences. Somewhere chocolate is consumed with tomatoes, somewhere with oranges, with cheese, in Japan with wasabi, in the Czech Republic, of course, with beer. Well, in Russia they consume chocolate mainly for dessert, with hot drinks, and in addition to the main raw materials, nuts, various dried fruits and berries are included in the composition [5]. Annual consumption in our country is about 4 kg per person. In 2015-2019, there was an increase in chocolate consumption (Figure 3), while I would like to note that there is a change in consumer preferences, namely, an increase in demand for products of medium and premium class, and a decrease in consumption of products in the economy segment.

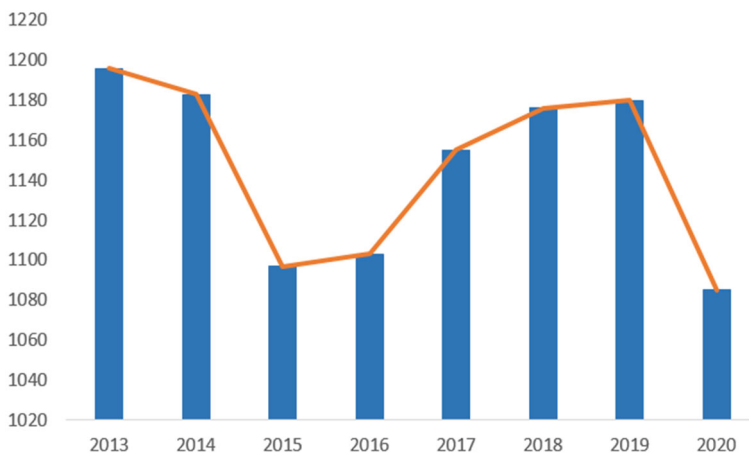


Fig. 3. Distribution of chocolate consumption in Russia by years, thousand tons.

This is due to the fact that the growth of a healthy lifestyle and the popularity of proper nutrition increases the demand for sugar-free chocolate and dark chocolate with a cocoa content of more than 85%. Analyzing the structure of the Russian market of chocolate and chocolate products, it should be noted that it is formed mainly due to Russian-made products - it currently accounts for 91%. Belarus and Kazakhstan stand out among the importing countries, and in the last few years China has taken the lead. According to the Federal Customs Service, Russia exported 233 tons of chocolate in 2018, which corresponds to the 9th place in the world. Currently, Russian manufacturers are expanding their product range and developing new segments, adjusting to the changing interests of consumers.

Chocolate is a product of processing cocoa beans with sugar [6]. The main raw materials for the production of chocolate are cocoa mass, cocoa butter, powdered sugar. It is characterized by special excellent taste properties, fine texture and the ability to melt in the mouth. Such uniqueness is due to the content of cocoa butter, which at normal room temperature is hard, brittle, but quickly melts in the mouth, as it has a melting point of 32-34 °C. Also, chocolate has a high energy value (540-560 kcal per 100 g). Thanks to its special chemical composition, chocolate has beneficial properties that have a positive effect on our body, which makes such a delicacy an ideal dessert. Due to the content of caffeine and theobromine, it has a stimulating effect, quickly relieves fatigue, increases efficiency, improves mood, it is not in vain that chocolate is considered to be a "hormone of joy". Due to the content of cocoa butter, which contains a lot of antioxidants, eating treats slows down the aging process, improves the performance of the cardiovascular system. Of course, the calorie content of the delicacy is quite high, but what a pleasure it is to break off a piece of chocolate from a fragrant bar and feel how it melts on the tongue.

Depending on the recipe and processing method, chocolate is divided into dessert chocolate, which has high taste and aromatic qualities and a fine dispersion of the solid phase. It acquires these properties as a result of the use of noble varieties of cocoa beans, especially careful and lengthy processing in the production process. The sugar content in it is not more than 55%. For dessert varieties, the mass is additionally processed - conched in open conche machines at a temperature of 55 °C to 70 °C for 24-72 hours [7]. In this case, the oxidation of tannins occurs, the volatilization of acetic acid, the development of a subtle strong aroma, and a more uniform distribution of solid particles of chocolate mass in cocoa butter is achieved. Particles of sugar and cocoa beans are further crushed and rounded, resulting in the development of the finest aroma and velvety taste inherent in dessert chocolate. The mass fraction of cocoa products in chocolate must be at least 25%. Black dark chocolate with the maximum content of cocoa (over 70%), cocoa butter and a minimum concentration of sugar is the most beneficial product for health.

Ordinary chocolate is produced from any cocoa beans with a predominance of consumer cocoa beans without conching. Therefore, it has lower taste and aromatic qualities, less fine dispersion. The sugar content should be no more than 63%.

Porous chocolate is obtained mainly from the dessert chocolate mass, poured into molds for 3/4 of the volume, placed in vacuum boilers and kept in a liquid state for 4 hours (at a temperature of 40 °C). When the vacuum is removed due to the expansion of air bubbles, a finely porous structure of the tile is formed.

Depending on the composition, dessert and ordinary chocolate are divided into chocolate without additions, with additions, with filling, diabetic and white.

Chocolate without additives is made from cocoa liquor, powdered sugar and cocoa butter. Such chocolate has specific pronounced properties inherent in cocoa beans. By changing the ratio between powdered sugar and cocoa mass, you can change the taste of the resulting chocolate from bitter to sweet. The more cocoa liquor in chocolate, the more bitter taste and more pronounced aroma it has and the more it is valued.

Chocolate with additives is made from cocoa liquor, cocoa butter, powdered sugar and various nutritional, flavoring and aromatic additives to increase and diversify the nutritional and taste qualities of chocolate.

White chocolate is prepared according to a special recipe from cocoa butter, sugar, milk powder and vanillin, without the addition of cocoa mass, so it has a creamy color (white) and does not contain theobromine.

Chocolate is packed with pre-wrapped tiles. Almost all types of chocolate are produced in a wrapper. As a rule, chocolate is wrapped in two layers: foil and an artistically designed bar label. Wrapped chocolate is packed in corrugated cardboard boxes with further packing in plywood and plank boxes.

Chocolate should be stored in clean, well-ventilated rooms that do not have extraneous odors, not infected with barn pests, at a temperature of $t = 5 \dots 22 \text{ }^\circ\text{C}$ and relative humidity of no more than 70%. The product must not be exposed to direct sunlight. The expiration date is set by the manufacturer in the recipes or technological instructions for products of a particular name. But often when buying a chocolate bar in a store and unpacking it instead of getting joyful emotions, the consumer is often disappointed, as the bar is covered with a whitish or grayish coating, which significantly worsens the appearance of chocolate, although the expiration dates correspond to the labeling. If the production technology, packaging, transportation and storage are not followed, various defects may appear.

The appearance of plaque can occur for two reasons, either a violation of the production technology or storage conditions, which leads to the formation of chocolate defects such as fat or sugar bloom (Figure 4).

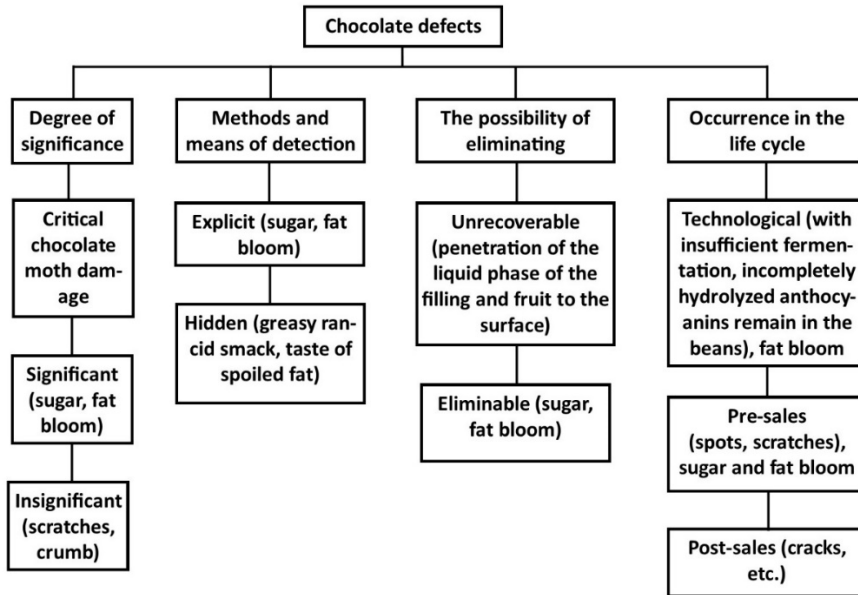


Fig. 4. Classification of chocolate defects.

If the conditions, terms of storage and transportation are not observed, such a defect in chocolate as the deformation of products often occurs (Figure 5a). Fat bloom is the result of non-compliance with the tempering regime during production (Figure 5b). Cocoa butter has 4 polymorphic forms of crystallization, which differ in melting point. With insufficient tempering, unstable forms are formed, which, during storage of chocolate, turn into β -form. The process proceeds with the release of heat, which leads to the melting of cocoa butter and the release of droplets on the surface of the chocolate. When cooled, a fatty coating forms on

the surface, which is called fat bloom. Fat bloom can also occur as a result of storing chocolate. The intensity of the "graying" of the surface of the tiles, due to the processes of migration of fats, depends on the temperature conditions. When the temperature rises, individual fractions of the oil melt and stand out on the surface. When the temperature drops, the melted fat solidifies in the form of large crystals. An increase or cyclic changes in the storage temperature by 5–10°C below the melting temperature underlie the "accelerated aging" of products [8].

Sugar bloom is also the result of non-compliance with storage conditions, that is, with a temperature drop (Figure 5c). As a result, moisture condenses on the surface, in which sugar dissolves. After the moisture has evaporated, a white coating in the form of small sugar crystals remains on the surface of the chocolate.



Fig. 5. External manifestation of chocolate defects.

At the present stage, one of the main tasks of the food industry is to ensure the quality and safety of products, and food industry enterprises are trying to produce products that meet the requirements of consumers, while expanding the range of products, improving consumer characteristics, but often it is at the stages of distribution, storage and sale that deterioration occurs quality indicators. Failure to comply with the terms and conditions for the delivery of products, sale in a retail network, leads to defects, and such products will not be safe for consumption. The reason for the appearance of plaque on a chocolate bar may be due to non-compliance with the conditions of transportation, storage and sale in a retail network.

One of the features of the chocolate market is that the consumer can be several thousand kilometers away from the manufacturer, therefore, in order to preserve the chocolate unchanged, it is necessary to transport it only in containers and vehicles equipped with climate control systems. Large logistics companies carefully monitor the conditions of transportation and storage, but they are not always the only intermediate link between the producer and the consumer. Along with them, delivery of products to the store can be carried out by small carriers in order to reduce transportation costs by saving on the climate system, while the negative consequences of this decision fall on the store and the buyer [9].

Recently, manufacturers and shops increasingly require intermediaries (logistics companies) to register climatic parameters during transportation and storage in order to maintain quality unchanged, but this may not be enough with a large number of intermediaries, which often happens in the transportation of confectionery.

5 Conclusion

In addition, when using this method of unification, access to information will be complicated for the consumer, since, as mentioned earlier, a feature of the market for bar chocolate is its wide distribution among various groups of the population, and radio frequency tags require special readers, while at the same time, a mobile phone equipped with a camera is sufficient for a QR code and able to access the internet.

Despite the rather large amount of data collected, the cost of the system is not high, since with this marking system, the already available data of the entire supply chain is used to the maximum, and given the widespread use of equipment for encoding and reading QR codes, the implementation costs, including the development of an Internet resource for the manufacturer will amount to 600 thousand rubles for one production line, for intermediaries and sellers, the cost of software development and integration will not exceed 180 thousand rubles.

The cost of disposable components (glue-based label with printed QR code for box marking, thermochemical indicator with QR code) will not exceed 210 rubles.

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