TRANSNAV
http://www.transnav.eu
the International Journal on Marine Navigation and Safety of Sea Transportation
Volume 15
Number 3
September 2021
DOI: 10.12716/1001.15.03.21

Selected Quality Characteristics of Sea Salt Important During Transport and Storage

M. Śmiechowska, M. Ruszkowska & O. Olender
Gdynia Maritime University, Gdynia, Poland

ABSTRACT: Salt is obtained in various regions of the world and using differing technologies. The origin of the salt and its production methods influence its composition, properties and application possibilities. In recent years, sea salt has attracted a lot of interest, as it is commonly believed that it is richer in minerals than pure evaporated salt. One of the oldest methods of extracting edible salt in the world is the evaporation of seawater. Salinas are found in coastal zones of seas and oceans around the world. The salt obtained in the salin is transported to its destination by various means of transport, including sea transport. Taking into account the classification of sea cargo, salt is classified as solid mass cargo, and due to the physicochemical properties of salt, the transport of this product by sea requires security.

The aim of this study was to present selected quality parameters of sea salt that are important in its transport and storage. Parameters relevant from the point of view of transport, storage, technology and processing, which are important in shaping the quality of sea salts were compared in salts obtained in various European salinas vs. Himalayan salt. These parameters included water activity, degree of granulation and discharge angle and embankment angle. The paper also presents the characteristics of sea salts from microscopic analysis and an assessment of the correct labeling of the product, which is important for the consumer of the packaged product. In land transport, not only sea salt is transported in bulk, but also the product in commercial packaging, most often weighing 1 kg.

1 INTRODUCTION

Edible salt, halite, or sodium chloride is one of the most abundant compounds on Earth. The importance of salt for mankind cannot be overestimated. It is difficult to imagine many areas of the economy without the use of salt. Man has been using salt since ancient times. Called “white gold” in the Middle Ages, in modern times salt has been endowed with the epithet of “white death” due to attributing to it the development of diseases caused by inappropriate nutrition [5].

Edible salt comes in many forms and types, including table salt, evaporated salt, and sea salt. The origin of salt and methods of obtaining it affect its composition, properties and application possibilities. Sea salt, which is obtained by desalinating sea waters, is of great interest.

Salinas are found in coastal zones around the world. In Europe, sea salt is obtained in countries such as Bulgaria, Cyprus, Croatia, France, Greece, Spain, Portugal, Slovenia, and Italy. Sea salt undergoes natural evaporation, and the course and efficiency of this process largely depends on the salt content in seas and oceans, the geographical location of the saline and the ambient temperature. The current system of sea salt harvesting was probably introduced by the Phoenicians in Mediterranean countries such as

Greece, France, Italy, and later transferred to Spain and Portugal thanks to the Roman Empire [11].

Salinas create a special ecosystem, classified as agricultural activity, which, due to the acquisition of food raw materials, should be subject to special protection [3]. They are usually located in sparsely populated places, where no industrial activity is carried out, so that industrial and anthropogenic pollutants do not enter coastal waters, because the quality of sea salt depends on the cleanliness of sea water and reservoirs [20]. The entire cycle from filling the tank with water to obtaining salt takes from several months to several years. Salt production depends mainly on high sunlight intensity and temperature and low relative humidity, thus is favored mainly by summer months with high temperatures [8].

Table salt obtained from mines and sea salt are transported by different means, including sea transport. *Salt is classified as a Group C cargo in the International Maritime Solid Bulk Cargoes (IMSBC) Code. This cargo is highly soluble and, depending on its origin, is characterized by variable humidity (up to 5.5 %).* Sea transport of this type of cargo is defined by IMSBC, which is constantly supplemented and subject to changes inspired among others by the results of the research on transportation. The development of information systems recording the quality of loose cargoes transported in bulk allows to increase the selection and application of correct sea transport technologies and the safety of transport [13]. During sea transport of solid bulk cargoes, a number of dangerous phenomena may occur, which may result from the properties of the ingredients included in the goods, the quantity of goods transported, and the form of their transport [17]. The research carried out by the authors of this publication fits into this topic.

2 RESEARCH MATERIAL AND METHODS

The research material consisted of 8 sea salts and one Himalayan (white) salt that were purchased on the EU market. Table 1 presents the characteristics of the tested salts. Sea salt samples taken for testing were coded from I to IX and sealed in tight packages protecting against moisture.

The correctness of the labeling was assessed in accordance with the Regulation (EU) [18] No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers.

Samples of the studied salts were also subjected to microscopic analysis for their visual evaluation using the OPTA-TECH SK series stroboscopic microscope, at 100× magnification, using the Optaview 7 software.

The water activity in the samples of the studied salts was determined with the AquaLab 4TE apparatus, version AS4 2.14.0 2017 by Decagon Devices, Inc. at a temperature of 25 ± 1 °C [15].

The color of the samples was determined by measuring the L*a*b* components in the CIELAB color space using a Konica Minolta C-410 apparatus. The apparatus was calibrated with evaporated salt [2].

Physicochemical properties were assessed by determining the granulometric composition of the studied salts, the static angle of repose and the kinetic angle of repose [6, 19].

The Microsoft Office Excel spreadsheet package was used to analyze the obtained results both statistically and mathematically. The position and dispersion measures, arithmetic mean and standard deviation, were used to statistically describe the physicochemical properties of the salt.

Table 1. Characteristics of the research material

Salt code	Salt producer	Country of origin	Granularity	Price kg [€]	Declared composition
I	Radix-bis	Croatia	Coarse-grained	1.54	Sodium chloride (>98%), calcium (<0.20%), magnesium (0.19%), sodium iodide (<5 mg/kg), naturally occurring iodide, E536 (anti-caking agent)
II	O'Sole	Greece	Coarse-grained	0.83	Sodium chloride (99.5%), 3.9±1.3 mg/kg KIO3 – potassium iodate (enriching agent), E536 (anti-caking agent), iodine (23100 μg/kg)
III	Crystalline	Greece, Medditerranean Sea	Coarse-grained	1.91	Unrefined, 100% coarse-grained sea salt; does not contain anti-caking agents
IV	Museo de la sal	Canary Islands, Fuertaventura	Coarse-grained	1.51	Natural, no additives
V	Symbio	Portugal	Coarse-grained	1.51	Natural, may contain sesame seeds or soy, salt 98%
VI	-	Greece, organic product	Coarse-grained	3.71	Edible salt with high iodine contents, no chemical additives, product naturally rich in mineral salts
VII	Kotanyi	Origin not stated	Coarse-grained	1.76	Iodized, potassium iodate (26.0–33.7 mg/kg salt)
VIII	Laeso Salt	Denmark	Coarse-grained	38.51	Sodium chloride (95%), other minerals (5%), naturally occurring iodine
IX	Livity	Pakistan	Coarse-grained	3.13	Himalayan salt, crystal size 1–2 mm, natural

Explanations: (-) – no information on the package
Source: Own elaboration based on information contained on unit packages

Table 2. Assessment of the correctness of the labeling of sea salt

Information on the packaging	I	II	III	IV	V	VI	VII	VIII	IX
Product name	✓	✓	✓	✓	✓	✓	✓	✓	✓
Composition	✓	✓	✓	✗	✓	✓	✓	✓	✗
Name and address of producer	✓	✓	✓	✓	✓	✓	✗	✓	✓
Country of origin	✓	✓	✓	✓	✓	✓	✗	✓	✓
Best before date	✓	✓	✓	✓	✓	✓	✓	✓	✓
Net weight	✓	✓	✓	✓	✓	✓	✓	✓	✓
Production batch number	✓	✓	✓	✓	✓	✓	✗	✓	✓

Abbreviation: (✓) – criterion fulfilled; (✗) – criterion not fulfilled.
Source: Own elaboration.

3 RESEARCH RESULTS

3.1 *Assessment of the correctness of labeling of sea salt packages*

Prior to conducting the microscopic and physicochemical analyzes of the studied sea salts, the correct labeling of the product introduced on the market was assessed. The results of this assessment are presented in Table 2.

Pursuant to the Regulation (EU) [18] No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, the manufacturer is required to provide the necessary information about the product on the packaging. Not all sea salts assessed for labeling correctness displayed the mandatory information as required by this regulation. Fuertaventura salt and Himalayan salt did not contain information about the composition of the product. Most reservations regarding the availability of information intended for the consumer were found in the Kotanyi brand sea salt, where the country of origin and the name and address of the producer were not indicated on the packaging (Table 2). The regulation imposes an obligation on producers to correctly label their products.

However, do consumers use this information? The research conducted in 2010 in Great Britain shows that only a third of consumers read the information on the labels [9]. However, recent studies have shown that consumers are increasingly knowledgeable about food and nutrition, resulting in increased interest in the content of food labels. Vegans and vegetarians, people on diets restricting or excluding certain food ingredients, e.g., gluten-free diets, diabetics, people suffering from food allergies and intolerances, and avoiding food additives, such as sodium glutamate or table salt, are particularly interested in informative labeling. Ultimately, the results of this study suggest that food producers should develop and implement such strategies to improve food labeling, as well as the nutritional status of consumers [1].

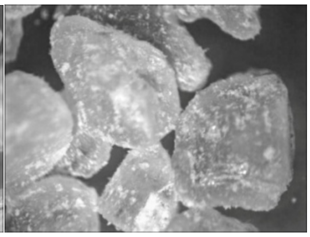
The data in Table 1 shows also that the factor that highly differentiates the studied sea salts is the price per unit package that ranges from 0.83 to 38.51 €/kg. The high price of Laeso Salt compared to others is due to its composition and the difficulty of obtaining, as well as its uniqueness among other products. It is complicated composition, different from other sea salts, is the result of mixing fresh and sea waters and the participation of the halophytes Limonium sp. and Armeria sp. in salt secretion, which takes place via two processes: seawater intrusion and evapotranspiration, as well as the complex geochemistry and hydrochemistry of aquifers on the Danish island of Laeso [10]. Information about the price of a product is very often a decisive factor in the purchase of a food product by the consumer [14].

Another factor differentiating the studied sea salts is the addition of iodine compounds (Table 1). The Regulation of the Minister of Health of September 16, 2010 on food additives specifies the amount of potassium iodide or potassium iodate added to table salt so that 100 g of table salt contains 2.3 (±0.77) mg of iodine, which corresponds to 30 (±10) mg of potassium iodide or 39 (±13) mg of potassium iodate. This supplementation is aimed at protecting the public against iodine deficiency. Sea salt producers often do not add iodine compounds to salt, because sea salt contains iodine in its composition. However, the iodine content of sea salt varies greatly and therefore it is recommended to iodize sea salt as well. The lack of information about the addition of iodine salt does not prove that sea salt contains enough iodine. Salt iodination is used in many countries around the world [4].

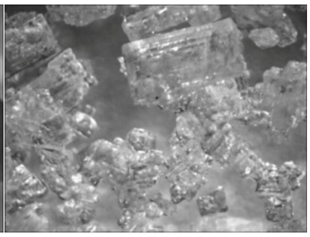
3.2 *Microscopic analysis of sea salts*

The microscopic images of the studied salts showed a large variation in the structure and size of the crystals (Photo 1). Well-formed salt crystals were observed for Radix-bis from Croatia (I), O'Sole from Greece (II), Crystalline from Greece (III), organic salt from Greece (VI), Kotanyi brand sea salt of unknown origin (VII) and Himalayan salt (IX), the crystals of which were the largest and retained an almost perfect cubic structure. The microscopic images of the salts included in this group are confirmed by the sieve analysis, which confirmed that the fraction of particles measuring below 0.8 mm was in the range of 0–1%.

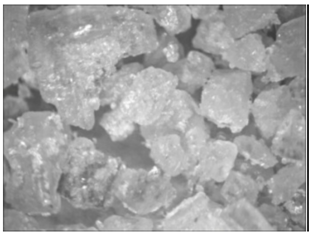
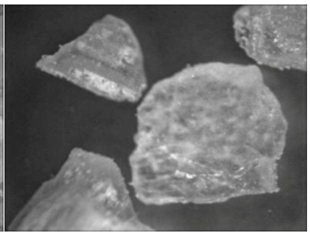
The second group consists of fine-grained salts, including sea salt from Fuerteventura (IV), sea salt from Portugal (V) and Laeso Sal from Denmark (VIII). In this group of salts, the sieving of particles smaller than 0.8 mm ranged from 2–12%. The size and nature of salt crystals affect its physicochemical properties. Studies on the solubility of halite, its crystallization and recrystallization provide valuable results that are important to explain these physicochemical phenomena, but also may play a role in storage, transport and industrial technology [12, 16].

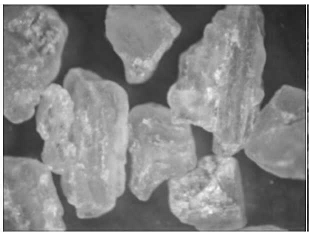
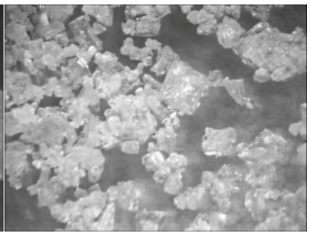
I II

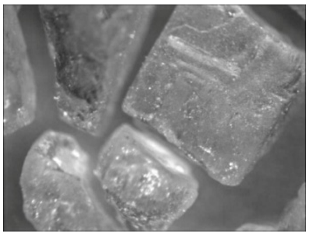
III IV

V VI

VII VIII



IX

Photo 1. Microscopic photos of the studied salts.
Source: Photographed by the authors.

3.3 *Assessment of the water activity of sea salts*

One of the important parameters characterizing food is water activity. Sodium chloride (halite) crystallizes from solutions most often as a dihydrate chemical compound $NaCl \cdot 2H_2O$, known as hydrohalite. Although hydrohalite has been known for over 200 years, its exact structure has been resolved relatively recently. Halite and hydrohalite crystals differ in shape and properties. Knowledge in this field may be of key importance, among others, in the transport and storage of salt and salted food, in its nutritional properties, and affect the shelf life and palatability of the product. Scarcity of publications on this subject may be due to the fact that pure hydrohalite is difficult to obtain. Pure halite crystallizes in a cubic system, but when the crystals grow as a result of evaporation from an aqueous solution, it loses its perfect shape. At high supersaturation, funnel-shaped walls with dendritic branches appear, which is the cause of halite clumping, i.e., agglomeration. Agglomerated halite is not desirable in food production as it makes it difficult to pack and store salt, dissolve it and fit it into food products. Before introducing to the technological process or packaging, the agglomerated salt should be crushed.

Table 3. Water activity of the studied sea salts

Salt code no.	a_w ($\bar{X} \pm S$)
I	0.36 ± 0.010
II	0.37 ± 0.031
III	0.36 ± 0.017
IV	0.51 ± 0.003
V	0.37 ± 0.001
VI	0.34 ± 0.006
VII	0.35 ± 0.012
VIII	0.34 ± 0.004
IX	0.33 ± 0.007

Abbreviation: S – standard deviation
Source: Elaboration based on own data, n = 6

Water activity a_w in the studied samples of sea salts remained mostly at a similar, low level in the range a_w = 0.33 ± 0.007 to a_w = 0.37 ± 0.031 (Table 3). Only the sample from the saline in Fuertaventura (IV) was characterized by water activity a_w = 0.51 ± 0.003. This value was significantly different from the other values of the water activity. We suppose that the cause may be due to its composition and further research on the water activity of this sea salt should be pursued in this direction (Table 3). The packaging of the Fuerteventura sea salt lacks the composition of the product and the proportion of sodium chloride is not stated. With a lower content of sodium chloride and the coexistence of calcium and magnesium salts, the product may become more hygroscopic until reaching the wetting effect. The study by Silva et al. shows that sea salt is rich in various volatile organic compounds. These compounds come from environmental elements such as plants, algae and marine organisms and characterize sea salt, regardless of its geographical origin. On the other hand, while volatile sea salt compounds are minor ingredients, they can be viewed as flavor compounds that can affect the organoleptic and chemical properties of foods to which sea salt is added.

The water molecules contained in the salt are mostly structural water, which is inaccessible to microorganisms and remains in a state of chemical inactivity. The low value of water activity in the salt, including sea salt, explains its use as a food preservative. The development of microorganisms is practically impossible if the water activity drops below 0.6. We note here that a sorption isotherm is in principle a more accurate way of characterizing the water activity of a bulk cargo subjected to varying moisture conditions, however, the determination of sorption isotherms is beyond the scope of this paper.

3.4 *Particle size distribution of sea salts*

The studied sea salts were characterized by different sizes of crystals. The grain size composition of sea salts is shown in Fig. 1. The salt from the saline in Fuertaventura, where as many as 6 fractions were identified in the sieve analysis, turned out to be the salt with very different sizes of crystals. The largest fraction of crystals was 2 mm in size (42%). The most uniform granulometric composition was characteristic for two sea salts from Greece and Kotanyi brand salt of unknown origin. In these salts, the content of the fraction with a crystal size of 2 mm was over 90%.

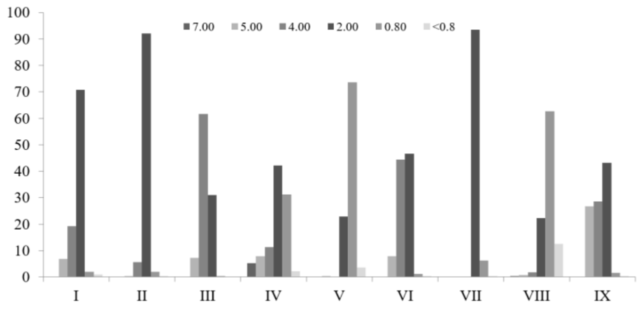


Figure 1. Particle size distribution of sea salts
Source: Own study.

Measurement of the particle size distribution is very important when loading solid bulk cargoes and packing loose products. Different sizes of crystals make it difficult to fill unit packages when using the volumetric method, hence the weight method is recommended in such cases. In addition, the particle size distribution is also influenced by other factors discussed in the section on sea salt crystallization.

3.5 *Measurement of the static and kinetic angle of repose of sea salts*

The parameters defined as the static and kinetic angle of repose are physical properties of great importance in transport, storage, as well as packaging and confectioning of goods. The kinetic angle of repose is used to assess the looseness of products. It is the angle between the generatrix and the base of the cone of a pile of freely poured product. This parameter is extremely important when determining the area needed for the storage of loose products [19]. *Although angle of repose is a characteristic of non-cohesive bulk cargoes and salt is not classified as such, the angle of repose is often used to determine the storage properties of bulk sodium chloride [22].* The values of the kinetic angle of repose of the studied sea salts are presented in Table 4 for two types of surface: rough and smooth.

The kinetic angle of repose, depending on the surface used, ranged from 42.539 to 53.485º (Table 4). The measurement of the angle of repose determines the flow ability of the material. The greater the value of the angle, the lower the flow properties of the product, and the lower the value of the angle, the better the looseness of the powdered product under evaluation. Free flowing powders have an angle lower than 40°, powders with a kinetic angle of repose higher than 50° are characterized by low flow properties. The results of the measurement of the kinetic angle of repose for the rough surface indicate that the studied salts can be assessed as medium-flowable salts, while for the smooth surface most of the tested sea salts should be treated as low-flowable products.

Table 4. Average kinetic angle of repose of the studied sea salts [°]

Salt code no.	Kinetic angle of repose [°]	
	Rough surface	Smooth surface
I	47.813	48.559
II	45.003	45.311
III	46.410	50.602
IV	49.138	51.091
V	46.493	48.023
VI	46.909	49.240
VII	46.515	47.155
VIII	51.295	53.485
IX	46.837	50.962

Source: Elaboration based on own data, n = 6

The determination of the static angle of repose for the studied sea salts was performed on four surfaces: abrasive cloth, glass, smooth plate and metal (Table 5). The best pouring properties on the metal surface (the lowest static angle of repose) was characteristic of the salt from Kotanyi. This would also indicate the lowest frictional forces between the crystals of the product. The salt from Feurtaventura (IV) (43°) was characterized by the greatest angle of repose. On a smooth surface, the salt with the lowest static angle of repose was sea salt from Greece (III) (ca. 19°), while the Danish Laeso Salt (VIII) was the salt with the largest angle (35°). The salt with the lowest static angle of repose on the glass surface was Kotanyi brand salt (16°) and the highest value was characteristic of the salt from Feurtaventura (IV) (34°). The abrasive cloth, due to its coarse granularity, provided the highest resistance for the crystals of the tested products. The salt with the highest static angle of repose on this surface was the Laeso Salt (ca. 66°) and the lowest angle was found for the Kotanyi brand salt and Himalayan salt (34°).

The measurements of the static angle of repose can be used for selection of appropriate materials for the construction of devices for packaging loose materials, as well as for fabrication of unit packages made of various types of packaging materials.

Table 5. Average static angle of repose of the studied sea salts [°]

Salt code no.	Static angle of repose [º]			
	Surface material			
	Metal	Smooth plate	Glass	Abrasive cloth
I	25.333	25.000	20.333	37.000
II	24.667	20.000	21.667	35.667
III	25.000	19.333	20.667	35.667
IV	43.000	35.000	34.000	50.000
V	34.000	29.000	23.000	48.000
VI	25.333	21.000	19.667	35.333
VII	24.000	20.000	16.000	34.000
VIII	35.000	35.333	30.000	66.333
IX	25.333	19.667	19.667	34.000

Source: Elaboration based on own data, n = 6

3.6 *Color of sea salts*

Color measurement in the CIELAB system is based on determining the L* component, describing the brightness, and the a* and b* components, describing the share of green and red, as well as yellow and blue, respectively. The brightness of the color expressed as the L* parameter assumes a value of 0 for black and 100 for white. The brightness of the tested sea salts expressed by the L* parameter varied in a wide range from 61.85 to 89.25 (Table 6). The salt of Laeso Sal (VIII) was closest to the white color, while the Himalayan salt (IX) was closest to the gray color.

Table 6. Color parameters of the studied sea salts

Salt code no.	Color measurement in the CIELAB system ($\overline{X} \pm S$) L* parameter	a* parameter	b* parameter
I	65.11 ± 0.505	–0.18 ± 0.025	1.05 ± 0.017
II	78.50 ± 1.633	–0.10 ± 0.036	0.29 ± 0.026
III	68.80 ± 0.417	–0.15 ± 0.019	0.41 ± 0.048
IV	72.45 ± 0.407	0.06 ± 0.026	1.40 ± 0.113
V	81.61 ± 0.702	–0.30 ± 0.022	0.86 ± 0.040
VI	69.80 ± 0.262	–0.24 ± 0.053	0.39 ± 0.064
VII	73.90 ± 0.407	–0.23 ± 0.024	0.80 ± 0.042
VIII	82.80 ± 0.603	–0.51 ± 0.012	2.54 ± 0.081
IX	64.60 ± 1.273	–0.22 ± 0.071	0.99 ± 0.292

Abbreviation: S – standard deviation
Source: Elaboration based on own data

The a* parameter ranged from –0.51 to 0.39. This parameter indicates the color saturation from green (negative values) to red (positive values). The tested salts do not contain compounds which color lies on the color axis from green to red. Negative values for green and low indications of the share of red in shaping the color of the final product indicate the absence of other compounds that could affect the appearance of such shades in the tested salts.

The value of the b* parameter ranged from 0.26 to 2.54. This parameter tells about the color saturation from blue (–) to yellow (+). The results of the color measurement indicate that the color of the studied salts is dominantly white with a slight shade of gray and a slight yellow tint.

Research on the color of salt was carried out for table salts [21] and showed that the color of the salt may be affected by the geological conditions in which the deposits were formed and by the presence of various types of contaminants in the form of coexistence of other compounds. The salt deposits are not only made up of pure sodium chloride and that is why we observe such a large variation in the color of the salt as yellow, pink or blue.

Drake and Drake [7], studying the composition of sea salts from different parts of the world, also found that sea salts appeared in various colors, such as white, gray, black, pink, peach and brown-red, and the color depended on mineral impurities absorbed from surroundings. For example, black salts got their color by adding activated carbon. The color of pink Himalayan salt comes from trace amounts of iron.

During transport and storage, the color of the salt should be monitored, as under the influence of factors such as temperature and humidity, the color may change.

4 CONCLUSIONS

In the light of the conducted research, more attention should be paid to the informative aspect of the salt packaging. This issue is important for the final consumers of the product.

The regulations concerning the addition of iodine compounds to sea salt and the determination of the iodine content in sea salt require standardization.

The studied coarse-grained sea salts were characterized by low water activity, which proves a well-conducted crystallization process and subsequent distribution processes.

Particle size distribution, as well as the values of the static and kinetic angle of repose allow to classify the studied salts as moderately loose materials.

Water activity, as well as particle size distribution and angle of repose are crucially important parameters from the point of view of transportation of a solid bulk cargo such as salt.

The studied sea salts were characterized by an even white color with a shade of gray or a slight yellow tint.

REFERENCES

1. Bandara, B.E.S., De Silva, D.A.M., Maduwanthi, B.C.H., Warunasinghe, W.A.A.I.: Impact of Food Labeling Information on Consumer Purchasing Decision: With Special Reference to Faculty of Agricultural Sciences. Procedia Food Science. 6, 309–313 (2016). https://doi.org/10.1016/j.profoo.2016.02.061.
2. CIE, Colorimetry: Official recommendations of the International Commission on Illumination. , CIE Central Bureau, Vienna (1986).
3. Commission Regulation (EC) No 417/2008 of 8 May 2008: amending Annexes I and II to Council Regulation (EC) No 510/2006 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. (2008).
4. Dasgupta, P.K., Liu, Y., Dyke, J.V.: Iodine nutrition: iodine content of iodized salt in the United States. Environ Sci Technol. 42, 4, 1315–1323 (2008). https://doi.org/10.1021/es0719071.
5. Delahaye, F.: Should we eat less salt? Archives of Cardiovascular Diseases. 106, 5, 324–332 (2013). https://doi.org/10.1016/j.acvd.2013.01.003.
6. Domian, E., Szymanski, P.: Ściśliwość w ocenie sypkości wybranych sypkich produktów spożywczych. Zeszyty Problemowe Postępów Nauk Rolniczych. 558, 51–61 (2011).
7. Drake, S.L., Drake, M.A.: Comparison of salty taste and time intensity of sea and land salts from around the world. Journal of Sensory Studies. 26, 1, 25–34 (2011). https://doi.org/10.1111/j.1745-459X.2010.00317.x.
8. Galvis-Sánchez, A.C., Lopes, J.A., Delgadillo, I., Rangel, A.O.S.S.: Sea Salt. In: de la Guardia, M. and Gonzálvez, A. (eds.) Comprehensive Analytical Chemistry. pp. 719–740 Elsevier (2013). https://doi.org/10.1016/B978-0-444-59562-1.00026-8.
9. Grunert, K.G., Wills, J.M., Fernández-Celemín, L.: Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK. Appetite. 55, 2, 177–189 (2010). https://doi.org/10.1016/j.appet.2010.05.045.
10. Jørgensen, N.O.: Origin of shallow saline groundwater on the Island of Læsø, Denmark. Chemical Geology. 184,

3, 359–370 (2002). https://doi.org/10.1016/S0009-2541(01)00392-8.
11. Kurlansky, M.: Salt. Penguin Books (2003).
12. Langlet, M., Nadaud, F., Benali, M., Pezron, I., Saleh, K., Guigon, P., Metlas-Komunjer, L.: Kinetics of Dissolution and Recrystallization of Sodium Chloride at Controlled Relative Humidity. KONA Powder and Particle Journal. 29, 168–179 (2011). https://doi.org/10.14356/kona.2011019.
13. Leśmian-Kordas, R., Bojanowska, M.: Quality determinants of solid bulk cargoes in marine transport. Zeszyty Naukowe / Akademia Morska w Szczecinie. 26, 98, 66–74 (2011).
14. Macall, D.M., Williams, C., Gleim, S., Smyth, S.J.: Canadian consumer opinions regarding food purchase decisions. Journal of Agriculture and Food Research. 3, 100098 (2021). https://doi.org/10.1016/j.jafr.2020.100098.
15. Palacha, Z., Makarewicz, M.: Aktywność wody wybranych grup produktów spożywczych. Postępy Techniki Przetwórstwa Spożywczego. 21, 2, (2011).
16. Pinho, S.P., Macedo, E.A.: Solubility of NaCl, NaBr, and KCl in Water, Methanol, Ethanol, and Their Mixed Solvents. J. Chem. Eng. Data. 50, 1, 29–32 (2005). https://doi.org/10.1021/je049922y.
17. Popek, M.: Właściwości transportowo-technologiczne jako wyróżniki jakości stałych ładunków masowych. Zeszyty Naukowe Akademii Morskiej w Gdyni. 93, 217–221 (2016).
18. Regulation (EU) No 1169/2011: of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commis-sion Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 Text with EEA relevance. OJUE L 304/18. (2011).
19. Ruszkowska, M., Wiśniewska, A.: Ocena wybranych napojów roślinnych w proszku – charakterystyka właściwości fizykochemicznych |. Scientific Journal of Gdynia Maritime University. 99, 103–113 (2017).
20. Śmiechowska, M.: Ecological threats for coastal systems in the context of acquiring and providing the quality of sea salt. A review. Journal of Research and Applications in Agricultural Engineering. 63, 3, 118–122 (2018).
21. Sonnenfeld, P.: The color of rock salt—A review. Sedimentary Geology. 94, 3, 267–276 (1995). https://doi.org/10.1016/0037-0738(94)00093-A.
22. The Salt Storage Handbook, The Salt Institute, Alexandria, VA, 2006.