

Article

Fleur de sel: How Does a Pinch of Suitable Choice Practices Value This Sustainable Natural Resource?

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Abstract: As mechanized processes developed, small producers of traditional sea salt ceased to be competitive. However, when the valuable salt flower (a.k.a. *fleur de sel*, flower of salt) market appeared, it gave new breath to the activity of traditional salt pan production. Salt flower sensitivity and delicateness became a part of modern food habits. Its crystals present some grain differentiation and these can fulfill diversified consumer tastes. In cooking art, a regular fine flower of salt can be used to finish dishes, whereas a longer and thin grain known as ‘scale’ (a.k.a. *écaille de fleur de sel* in French) can be used for a more gourmet-like palate. Here a suitable method is presented to sort and grade flower of salt to satisfy different palates. The method of salt flower selection is based on four main characteristics, which should be considered: cleansing, moisture, color, and size. It is the grain size that contributes most to demand allocation. The results show that what is produced (supply) and the demand from customers do not exactly match. The tiniest types of salt flower are usually completely absorbed by the market, whereas the largest types have no market at all.

Keywords: coarse salt; cooking art; flower of salt; innovation; tourism; tradition



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1. Introduction

Coarse salt for human consumption has been produced since ancient times. [1]. The Romans used it not only as an indispensable ingredient in the daily life foodstuff, but also as a payment commodity [2]. In history, throughout times, there are countless examples where the control of scarce resources led to wars. The commodity “salt” is a particular example and can be found namely in the history of Brazil, where, in the 17th century, the Portuguese had to pay the Dutch in salt in order to have peace [3]. Before electricity, salt was quite widespread for preserving foodstuffs and, particularly in the Portuguese culture, salt has been related to dried and salted cod since the time of discoveries [4].

The coarse salt in the food industry has been used not only to preserve food, but also for seasoning before cooking raw meat, vegetables, or fish [5,6]. In the last century, salt alone or in conjunction with other ingredients became quite widespread, not only in the household, but also in the hotel and hospitality business sector [7]. By its turn, grinded salt has been traded as table salt and been commonly bought by households worldwide. Due to the reason of being named as table salt, it can be usually found at the tables of hotel and hospitality services [8]. Many other salt alternatives have been put at the table of the customer, such as sesame salt, composing the foodstuff known as “*gomasio*” [9]. This foodstuff has been used as a healthier alternative to salt alone. Other salty alternatives can be found worldwide, often related to the availability of inorganic materials. Some examples of the former are brine, which is a saltwater solution commonly used to preserve food; halite, which is the chemical designation for rock salt; Himalayan salt, which presents a pink color; and several other mineral components with salty properties [10].

In the past, the upper thin layer that appears on the salt pan, known as flower of salt, was either scratched away or given to salt workers because it was believed that its appearance caused a delay in the formation of coarse salt. More recently, during the

1970s, France began the process of using the flower of salt (*fleur de sel*), and soon after this commodity became much more valuable than coarse salt, due to its higher palatable flavor, and became an innovation in cooking art, being adopted worldwide by several renowned chefs [11]. In the next decades, other European Mediterranean countries followed, starting their flower of salt production. In Portugal, the resurgence of former traditional salt pans occurred by the early 1990s [12], and flower of salt started to be harvested in salterns where coarse sea salt was produced previously [13].

It is believed that flower of salt use is not only more sophisticated when compared to grinded salt (or table salt), but also healthier due to its enriched natural composition. However, there is some contention on this aspect of flower of salt being a healthy alternative, as there is universal recognition that excess sodium is associated with numerous diseases [14]. Thus, its advantageous properties are still not well known, because it is relatively recently accepted in the daily life use [15]. The flower of salt has inspired several dishes and, in some countries, has even been used to name hotels and restaurants.

The aim of this paper is to develop a suitable method that producers can rely on to choose their salt flower in order to address each of the requests demanded from their traders. In that scope, it develops a conceptual model showing how to carry out an adequate selection of flower of salt according to four traits (i.e., cleansing, moisture, color, and grain size), aiming to supply the market demand. Based on the methodological approach, it aims to facilitate the best supply–demand match of salt flower.

2. Literature Review

2.1. Human Daily Intake of Salt

Salt solutions are essential in the functioning of the human body [16]. Oppositely, salt in excess or taken wrongly can lead to deterioration of health [17], namely by hypertension and blood pressure problems [18] and cardiovascular diseases [19], among others [20]. Due to health problems signaled in the past, new laws have been put in place. In 2003, a joint report issued by WHO and the UN Food and Agriculture Organization (FAO) recommended the need for a reduction in human salt intake to less than 5 g/day [21]. Still, salt intakes vary worldwide according to different cultures, beliefs, and needs [22]. For instance, in Portugal, new legislation came out recently regulating products in the vending machines in several National Health Service (*Sistema Nacional de Saúde*–SNS) institutions that should present a lower dose of salt [23]. As a result, human daily intake should not exceed a certain amount [24]. For example, in the UK, in 2003 the Food Standards Agency followed the Scientific Advisory Committee on Nutrition in recommending a target of 6 g/day by 2010; Ireland also recommended 6 g/day by 2010, Finland 5 g/day, and France, according to Public Health Law (2004), recommended < 8g/day by 2010 [22].

Notwithstanding, trace elements and halotherapy can be used to treat certain human diseases [25]. Iodized salt is also necessary and present in human nutrition [26].

2.2. Traditional and Innovative Sources of Salt

Due to some physiological processes, humans need some sodium, and this element can be extracted from salt [27]. For human consumption, there are many sources where salt can be found. Mine salt is buried deep into the ground and sea salt evaporates at the edge between air and water in coastal zones [28,29]. The latter can also be produced in several ways. Until the late 1960s, its production was carried out by handcraft means. Due to the reason that salt is traded in the markets as a relatively cheap commodity [30] and for the sake of efficiency, machinery became quite widespread at the benefit of higher production, but at the cost of lesser quality and higher negative impact to the environment [31].

More recently (i.e., since late 1970s in France and early 1990s in Portugal), due to the new market niche for flower of salt, producers felt the need to produce a more environmentally friendly way of traditional harvest [17]. In the traditional production, both coarse sea salt and flower of salt do not contain any added iodine or any anti-caking agents. Notwithstanding, coarse sea salt hardens like a rock and needs to be broken, whereas

flower of salt does not agglomerate. There are some extensions of the French flower of salt concept (e.g., sea salt flakes produced in the river Blackwater, UK) [32].

Alongside the gastronomic–cultural issue of salt consumption, particularly in human food, is the tourist demand for production sites. Tourists have shown interest in knowing how coarse salt and flower of salt are produced in a traditional fashion [33].

2.3. Flower of Salt Identification

Flower of salt’s lower density and flotation are the main properties that make the difference when compared to coarse sea salt [34]. Flower of salt can be defined as a thin layer that forms on the surface of each salt pan, due to the continuous evaporation of almost saturated waters. The flower of salt is harvested as it comes and needs to be dried naturally by being exposed directly to the sun in order to eliminate excess moisture and undesired coloring [35], usually pinkish, yellowish, or grayish hues. In the flower of salt can be found 84 trace elements and micro-nutrients, and it is a natural source of potassium and magnesium [36].

3. Materials and Methods

3.1. Conceptual Model for the Flower of Salt Selection

After being collected and dried, salt flower grains are then sorted and finally graded according to four distinct characteristics: cleanness (cleansing), moisture, grain size, and color (Figure 1). There are other characteristics that can be considered, but those are less common and may vary from the producer or trader themselves. After considering the above-referred traits, flower of salt is sorted out based on cleanness, moisture, and color (ready to pack, not yet, or non-conform). Finally, the flower of salt is graded according to grain size. Acceptance or rejection is dependent upon flower of salt scarcity in the market at a given moment. If is too scarce, even salt of not-so-high standard is accepted due to the pressure inflicted by demand. By opposition, if there is a large supply in the market, solely the best flower of salt is accepted.

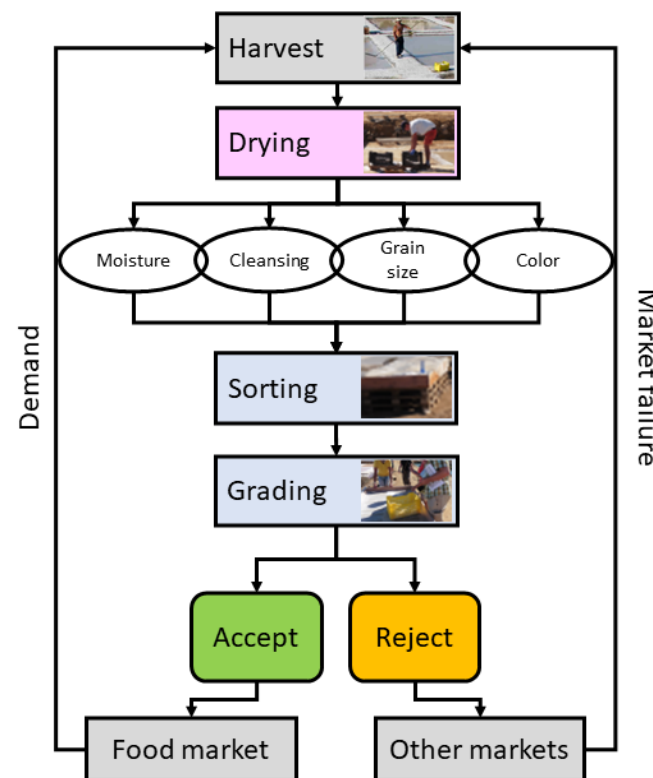


Figure 1. Conceptual model used for flower of salt selection and grading to address market demand. The entire process is shown, from the initial stage of ‘Harvest’ to the ‘Grading’. In ‘Harvest’ salt-workers

or *marnotos* collect the floating flower of salt with a special rake called ‘the sieve’. In ‘Drying’, the flower of salt collected is left to dry in open air during the day and covered by late evening. In the final step of the evaluation process the stages include ‘Sorting’ (acceptable or not) and ‘Grading’ (from least acceptable to best and usually according to grain size)—where there is included the 4-step set of visual characteristics choices—before the decision of acceptance or rejection. Source: Author’s own elaboration.

3.2. Acceptability Rules Determined by Changing Demand

In the flower of salt market, there is not just a demand for a grain presenting a certain set of characteristics, but for several. The flower of salt demanded usually must present a fine grain and whitish color. Thus, longer but thinner grains are also accepted and, in certain market niches, preferred. In addition, apparently there is a change in tastes either suggested by fashion or by searching for more exquisite requisites. In occasions of scarcity, traders tend to facilitate the acceptability level. On the contrary, when there is an excess offer, traders tend to be more demanding.

3.3. Set of Visual Characteristics

There are some characteristics that can be observed without using specific devices and are reasoned to be the most important when considering flower of salt choice for human consumption. Below, each of the most important ones is explained briefly but concisely (Figure 2).

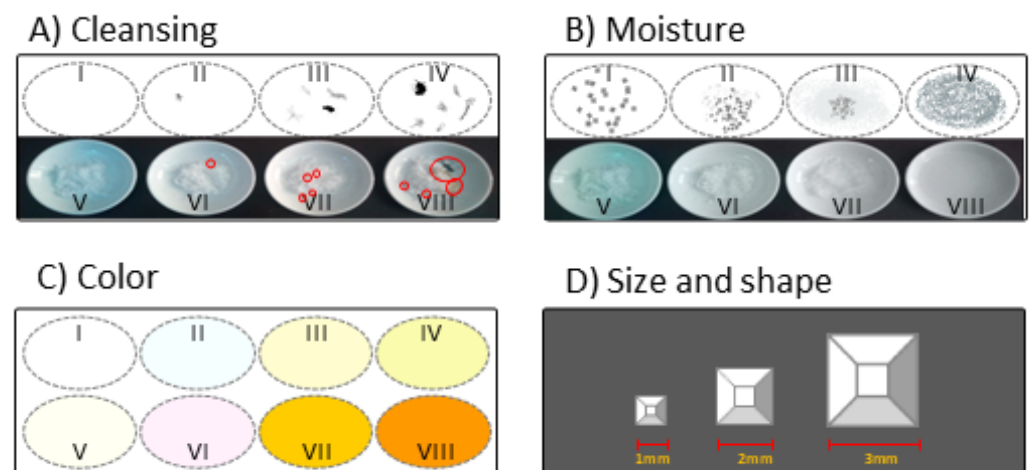


Figure 2. Set of characteristics used for grading flower of salt. (A) Cleansing—*fleur de sel* samples: (I) immaculate (when no fouling of dirt is detected), (II) acceptable (with an insect that is easily removable in order to be clean), (III) with some different sources of dirt (insects, crustaceans, small twigs or leaves of plants), (IV) very dirty [with a wide variety of sources of dirt (insects, crustaceans, small twigs or leaves of plants, bird feathers, stains)]; (V–VIII) are the real image equivalents of I–IV (red circles highlight some dirt spots). (B) Moisture—*fleur de sel* samples: (I) loose (practically dry or with minimal humidity levels), (II) low humidity (if it does not exceed about 7% humidity, it is still acceptable for commercialization), (III) wet (requires more drying time), (IV) wet (in this state the crystals re-dissolve in water); (V–VIII) are the real image equivalents of (I–IV). (C) Color—*fleur de sel* samples: (I) opaque white (rich in minerals), (II) transparent (at the end of the season, when the waters already have few minerals), (III) light pink hue (generally derived from the halophytic bacteria present in the brine), (IV) light orange hue (generally derived from the microalgae *Dunaliella salina* that can grow in brine water), (V) eggshell hue, (VI) slight grayish or brownish hue, (VII) deep yellow, (VIII) orange incorporated into the crystals (derived from the microalgae *D. salina*). (D) Size and Shape—*fleur de sel* samples acceptable for culinary consumption (from the smallest crystal (1 mm) to the largest (3 mm)). Source: Author’s own elaboration.

3.3.1. Cleansing

Due to the simple fact that *fleur de sel* is produced outdoors, its cleanliness is highly dependent on the outdoor settings. Ideally, getting *fleur de sel* without impurities is fundamental (Figure 2. Cleansing I, V). Sometimes an easily removable impurity appears (Figure 2. Cleansing II, VI). After the impurity is removed, the *fleur de sel* will be clean again. The surrounding wind is not only a disturbance for crystal formation, but also a problem if even the lightest breeze brings undesired particles to the production area (Figure 2. Cleansing III, VII and IV, VIII). Examples of unwanted objects include dust particles that are brought by the wind during or soon after a forest fire; dust from stronger breezes; insects or their parts; and feathers, guano, and so on due to the presence of several seabirds using surrounding shallow, permanent waters, particularly from September onwards. Still, high density waters, called mother waters, must be also cleaned and adequately sieved to remove any impurities, particularly when the brine shrimp *Artemia salina* (or other species, depending on the geography) and other little organisms seem to be present. Monitoring for microplastics is gaining importance worldwide, and doing so for salt flower is also mandatory [37,38]. In a recent study on microplastics [37], samples of various salt flowers from 17 different locations in the Mediterranean and Atlantic were analyzed for the presence of nine environmentally common polymers at trace levels. The authors (*op. cit.*) found traces of four of these polymers in the geographic area of the present study.

3.3.2. Moisture

After collecting, the flower of salt is left outdoors to sun dry in boxes or trays, aiming to drain the excess water (Figure 2. Moisture IV, VIII). This step may take some days (2 to 5, depending upon air dryness). It is commonly accepted among producers and traders that flower of salt always presents some moisture (between 1 and 7%). As a result, as soon as the excess water is drained and it presents a less consistent aspect when held in the hand, the drying step is considered complete (Figure 2. Moisture I, V). Therefore, when the flower of salt shows evidence of having a high proportion of water, additional drying time is needed (Figure 2. Moisture II, VI and III, VII). After fulfilling this requisite, the sample passes the test and can proceed to the following steps (sorting according to the coloration, grain size, and packing).

3.3.3. Color

Usually an opaque white is desirable (Figure 2. Color I). That color can be obtained every year from the first harvest in spring to late summer, extending eventually to early autumn. Thus, as the waters became less rich in trace elements and other minerals, flower of salt tends to be more transparent and less appealing (Figure 2. Color II). *Fleur de sel* with light or pale hues—pink (Figure 2. Color III), orange (Figure 2. Color IV), eggshell white (Figure 2. Color V), or slightly gray (Figure 2. Color VI)—are generally accepted. Other colors, particularly ranging from yellow to sharp orange, can be acceptable, but with some reserve (Figure 2. Color VII and VIII). These different hues may derive from the halophilic green micro-algae *Dunaliella salina* and, not so commonly, some other, usually harmless microorganisms that thrive in high-salinity waters [36,39].

3.3.4. Size and Shape

This final characteristic is the most decisive one because it allows for proceeding with the grading of the flower of salt and consequently allocating the different market demand niches. From a top perspective, the flower of salt grain presents squared pyramid-shaped crystals more-or-less sensitive to impact forces (Figure 2. Size and Shape). From a lateral view, it presents a cubic-like top over a larger but thinner base, concave in the inner side. The finest grain is often the most desired—but it has some practical restrictions on its collection—while the largest of all grains are often discarded or used only to decorate dishes. More recently, there is an increasing demand for thin but long crystals showing a fluffy aspect.

3.4. The Case Study

Although there are several places in mainland Portugal where traditional salt and *fleur de sel* are produced (for example, in the Center region, namely in the municipalities of Aveiro and Figueira da Foz) [40,41], it is in the South region that salt and *fleur de sel* are produced in greater amounts. Generally, the weather is more favorable for traditional salt and salt flower production in the continental southernmost region, particularly in the Leeward Algarve (i.e., more annual sunshine hours, longer hot season, low precipitation and air humidity) [42].

This study was carried out in the southeast of the Algarve, in production areas located in the municipalities of Olhão, Tavira, and Castro Marim. Field observations and *fleur de sel* samples were all from a single producer who has several production sites in the southeastern Algarve (bordering production areas are more than 30 km apart). With regard to the representativeness of *fleur de sel* traders, the procedure used for the selection was as follows: from the producer's client portfolio, all traders who already have a consolidated connection (i.e., who have been clients for at least 5 years) and who have regular orders (i.e., every year they place orders for at least one type of *fleur de sel*) were selected.

Producers who want to be competitive in the artisanal salt production process have to develop strategies towards sustainability. Examples in this sense are: (1) using the minimum of fossil energy or even reducing the use of electrical energy to pump water from the natural environment (as a sustainable alternative, the potential energy of the highest tides is used to feed saltwater reservoirs by gravity); (2) carrying out all the processes of graduating the water in the evaporators and the formation of salts in the crystallizers in a very artisanal and renewable way, corresponding to minimum energy and in an attempt to reduce the ecological footprint as much as possible, (3) keeping the evaporators—which are artificial ponds of shallow depths containing brine shrimp and other small organisms—with water throughout the year to allow water birds to feed in the natural space surrounding the salt production areas (a.k.a. *Salinas*) without having to look for alternative locations.

3.5. Flower of Salt Preferences

The Analytic Hierarchy Process (AHP) technique is used in many decisional analyses that can be found in scenarios of different complexities [43]. In the present study, it was adopted as the technique used to prioritize the choices of the flower of salt, namely with regard to the set of the 4 main characteristics addressed (i.e., cleansing, moisture, color, and size and shape). The AHP technique was used in order to try to adjust the different types of flower of salt that are harvested, with the demand shown by traders for this commodity.

4. Results

4.1. Visual Differentiation between Coarse Salt and Flower of Salt

Simple observations and contact with the raw materials in the field show evidence that flower of salt presents several differences when compared to traditional coarse salt. The most evident is density because the former floats and the latter precipitates. However, there are other important differences to take into consideration (Figure 3).

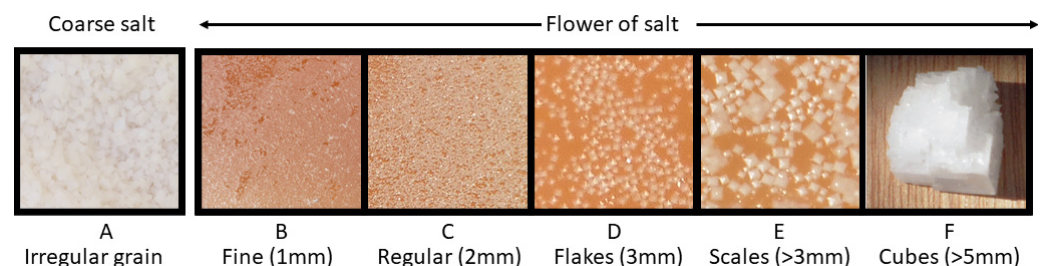


Figure 3. Results showing the typology according to the grain size: Common coarse salt (A) and flower of salt (B–F). Source: Author's own elaboration.

As soon as the weather gets warm, coarse salt needs about six weeks after it starts its formation until being harvested (Figure 3A). On the contrary, as long as rain persists, the coarse salt harvest is not possible due to the dissolution of salt in less dense water.

By its turn, flower of salt can be obtained overnight as soon as the highly saturated waters (mother waters) are saline enough (Figure 3B–F). It should be highlighted as a relevant aspect that, in order to get flower of salt, it is necessary to gather four fundamental weather conditions, empirically perceived as: sunny day, warm air temperature above 30 °C, no wind or just a light breeze, and low atmospheric moisture. By grading the flower of salt according to cleansing, moisture, color, and grain size, it is possible to proceed with a classification that can be used for market purposes. The flower of salt can be graded as follows: (1) Fine (1 mm) is when the crystals are recently formed at the surface. The crust is a very thin layer, almost continuous. It is not very efficient to harvest this type of flower of salt because it takes too much time to collect and it dissolves easily (Figure 3B). (2) Regular (2 mm) is the most common flower of salt and is collected when there is a slightly thicker crust at the surface. It forms continuous arrangements that do not dissolve so easily (Figure 3C). (3) Flakes (3 mm) is when the crystals are larger than regular flower of salt, all having similar size and presenting a short height, resembling snowflakes (Figure 3D). (4) Scales (>3 up to 5 mm) are similar to flakes but of larger sizes; usually they merge into longer and eventually larger arrangements (Figure 3E). (5) Cubes (>5 mm) are when the crystals attain a large size and form pyramidal and cubic shapes (Figure 3F).

4.2. Flower of Salt Traders' Demand

Each producer generally supplies flower of salt to several traders. In the present study it was possible to identify (and anonymize) flower of salt traders who meet the requirements of representativeness (Section 3.4). Considering the four main criteria for the choice of *fleur de sel* (i.e., the set of visual characteristics), the selection priorities were determined for 12 traders who order this commodity from Portuguese producers. Traders' flower of salt preference can be estimated by pairwise comparisons through AHP weighting calculations, according to the method explained by Saaty [43], as can be showed in Tables 1–4.

Table 1. Weights and comparison matrix for AHP priority weighting calculation considering flower of salt cleansing preference according to a sample of 12 traders. Source: Author's own calculation.

Type of Flower of Salt	Neat (>99%)	Clean (95–99%)	Faded (90–94%)	Stained (80–89%)	Dirty (<80%)	Priority Weighting
Neat (>99%)	1	6	9	9	9	61.6%
Clean (95–99%)	1/6	1	5	8	9	24.2%
Faded (90–94%)	1/9	1/5	1	2	3	6.7%
Stained (80–89%)	1/9	1/8	1/2	1	2	4.4%
Dirty (<80%)	1/9	1/9	1/3	1/2	1	3.1%

Consistency ratio (C.R.) = 9.9%.

Table 2. Weights and comparison matrix for AHP priority weighting calculation considering flower of salt moisture preference according to a sample of 12 traders. Source: Author's own calculation.

Type of Flower of Salt	Dry (1–3% H ₂ O)	Moist (4–7% H ₂ O)	Damp (8–12% H ₂ O)	Soggy (13–18% H ₂ O)	Wet (>18% H ₂ O)	Priority Weighting
Dry (1–3% H ₂ O)	1	2	5	8	9	44.5%
Moist (4–7% H ₂ O)	1/2	1	7	8	9	37.2%
Damp (8–12% H ₂ O)	1/5	1/7	1	5	2	10.1%
Soggy (13–18% H ₂ O)	1/8	1/8	1/5	1	2	4.5%
Wet (>18% H ₂ O)	1/9	1/9	1/2	1	1	3.7%

C.R. = 8.5%.

Table 3. Weights and comparison matrix for AHP priority weighting calculation considering flower of salt color preference according to a sample of 12 traders. Source: Author's own calculation.

Type of Flower of Salt	Transparent	White	Pinkish	Yellowish	Orange	Priority Weighting
Transparent	1	1/3	1/2	8	9	21.0%
White	3	1	2	8	9	42.8%
Pinkish	2	1/2	1	8	9	29.1%
Yellowish	1/8	1/8	1/8	1	8	4.1%
Orange	1/9	1/9	1/9	1/8	1	2.9%

C.R. = 5.0%.

Table 4. Weights and comparison matrix for AHP priority weighting calculation considering flower of salt size and shape preference according to a sample of 12 traders. Source: Author's own calculation.

Type of Flower of Salt	Fine (1 mm)	Regular (2 mm)	Flakes (3 mm)	Scales (>3–5 mm)	Cubes (>5 mm)	Priority Weighting
Fine (1 mm)	1	2	3	2	9	37.5%
Regular (2 mm)	1/2	1	3	2	9	28.4%
Flakes (3mm)	1/3	1/3	1	1	9	14.7%
Scales (>3–5mm)	1/2	1/2	1	1	9	16.8%
Cubes (>5mm)	1/9	1/9	1/9	1/9	1	2.6%

C.R. = 4.7%.

4.2.1. Cleansing

The cleaning aspect of *fleur de sel* is particularly important in the market, because the purer it looks, the better it will be accepted. Therefore, there is a descending order of preference, where the cleanest *fleur de sel* is preferred and the dirtiest is rejected (Table 1). There is some acceptance of dirty salt flower, exceptionally in years of great shortage in production and high market demand.

4.2.2. Moisture

In terms of humidity, *fleur de sel* always has an oily appearance (i.e., associated interstitial water between the grains). *Fleur de sel* traders buy the commodity with some humidity from producers, usually never exceeding 7% (Table 2). When the *fleur de sel* has a higher amount of water, the producer has to let it dry to the value acceptable to the trader.

4.2.3. Color

The acceptance of *fleur de sel* also has a lot to do with its color (Table 3). The *fleur de sel* has a transparent appearance when it is collected in water at the end of the season, where it already has few minerals in its composition, hence its glassier appearance. The great preference for *fleur de sel* is due to its white appearance, denoting a pristine purity. The rosy appearance of the *fleur de sel* is also well accepted, but it is a color that easily disappears with sunlight. The remaining shades, namely yellowish and orange, generally do not have good acceptance in the market, as they are associated with pigmentations derived from the microalgae *Dunaliella salina* [16].

4.2.4. Size and Shape

With the exception of cubes, all other types of *fleur de sel* are well accepted by traders. However, it is the finer or regular types of *fleur de sel* that are most in demand (Table 4). Flakes and scales, as they are produced in smaller quantities, reach a higher price in the market due to their greater scarcity.

4.3. Flower of Salt Natural Occurrence

The occurrence of the different flower of salt grains is dependent on the meteorological conditions, but they are also dependent on human decisions (mainly pan depth, wind sheltering, and shade). Concerning flower of salt, there is usually a mismatch between

traders' preference (Tables 1–4) and grain occurrence (Figure 4). Grain size and shape occurrence is usually the most decisive visual characteristic in flower of salt trade.

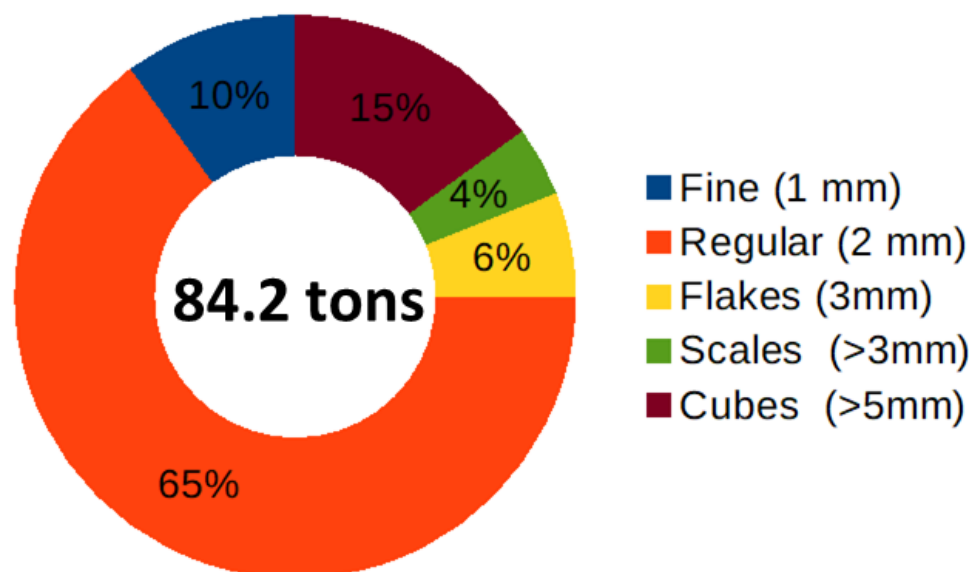


Figure 4. Average occurrence of flower of salt grain in a Portuguese salt pan producer in 2018 ($n = 122$ production days). Source: Author's own calculation.

The most preferred flower of salt depends on traders. For some, the preference goes to scales, followed closely by flakes; whereas for others, it is a fine grain. Thus, scales and flakes are usually the scarcest types of grain. The least-preferred choice is cubes, which is the second-most common, but usually is not desired by traders. Fine and regular flower of salt together are quite common. As such, These two types of grain, if they present acceptable cleansing, moisture, and coloration, can fulfill traders' expectations.

5. Discussion

5.1. On Coarse Salt versus Flower of Salt

The European Union certification obtained by products derived from salt for food use gives stakeholders a guarantee of quality [44]. In Europe—as of the date of the present manuscript—there are nine records, namely three Protected Geographical Indication (PGI) and six Protected Designation of Origin (PDO). The same source also mentions about half a dozen applied. In Portugal, only “Sal de Tavira/Flor de Sal de Tavira” has the PDO registered since 2013. There are two more registration requests for the same certification that are more recent, which are “Sal de Rio Maior/Flor de Sal de Rio Maior” applied in 2019 and more recently “Sal de Castro Marim/Flor de Sal de Castro Marim” applied in 2020. These salts can benefit from EU protection and their production must follow the rules laid down in the production discipline. It is believed that this EU certification can be a robust way to ensure *fleur de sel* quality while meeting traders' demand.

The differentiation between both coarse sea salt and flower of salt is particularly important at all levels, including the producer, intermediate, and consumer. Both salt types present some particular properties useful in the cooking art.

In terms of neatness, coarse salt varies according to the different settings provided by the producer. It tends to be clean because is usually submerged. Some dirtiness (or change in salt color) may appear when the crystals are in contact with bottom sand or mud (composed mainly of clays and silts). The method used to extract coarse salt, as well as the salt worker, also has a role on the neatness or color of the commodity. It can be slightly washed and can present a whitish color. In terms of moisture, coarse salt tends to be quite dry, and, after a while, it becomes rocky. However, in years where rain remains until late, in order to be efficient, salt pan managers avoid taking risks and start the coarse salt harvest

when the precipitated salt is not solid or thick enough. Coarse salt, even when it is mashed, has a grain that is usually very irregular and ranges from fine (about 2 mm) to large (almost 10 mm).

In comparison to coarse salt, flower of salt presents a slightly different composition and not all flower of salt types are identical [45,46]. Flower of salt needs to be exceptionally clean. Thus, in comparison to coarse salt, it usually seems dirtier. The main reason lies with the fact that flower of salt is found floating in the salt pan unit at the surface. This means that the surface facing downwards is usually clean due to the seawater contact, whereas the surface facing upwards is in direct contact with the atmosphere and, as a result, is more prone to getting dust, insects or their parts (e.g., antennae), tiny feathers, tiny leaves, and many other natural debris. Artificial debris may also occur [37,38]. Flower of salt always presents some moisture. Usually, flower of salt shows a dried texture when there is less than 5% water, and most commonly contains about 1–7% water. Usually, the less water it contains, the fluffier it is. At an extreme, where there is a lack of moisture, the flower of salt is loose, may present some aggregated patches, becomes denser, and eventually may compact. It is especially important that the grains are not soaked; otherwise, the crystals will disappear due to the brine dilution. As such, flower of salt presenting any higher proportion of water either must be left to dry or will be dissolved. The most widely accepted color for flower of salt is an opaque white. Other white hues may vary between a pale white to a more transparent whitish color (poorer waters found at the end of season). In terms of the grain size and shape, there are many factors that are empirically believed to influence size and shape. Meteorological conditions have a great influence on the shape of the grain. For instance, when abrupt temperature changes occur, and the atmosphere presents high moisture, salt flower crystals tend to be coarser.

5.2. Incorporation into the Gastronomic Culture and Tourism

The fine, floating part of salt that is found at the top of the mother waters and is formed by favorable conditions has been gathered and used for a long time, but just some decades ago became part of international gastronomy as a differentiated ingredient when compared to coarse salt. It has developed a proper designation: flower of salt.

Despite being still quite unknown, it is highly expected that flower of salt could contribute to a more reasonable daily intake of sodium, because in flower of salt, in comparison to coarse salt, potassium and magnesium are found at higher rates in detriment to sodium chloride [42,47].

The bond between flower of salt and the tourism and hospitality sector has been increasing, as there is a growing interest in having this commodity at the table and presented alone or in combination with other ingredients to be included not only into gourmet and other sophisticated recipes, but also at a more mundane level. Additionally, in the case of the tourism sector, there has grown an immense interest in visiting saltscapes [48–50].

5.3. Creating Value by Innovating

In comparison to coarse salt, the relative scarcity of flower of salt and its recentness brings about increasing demand [51]. Because of its sophistication, presentation, and richness, flower of salt has been used more in seasoning and finalizing dishes. Its price is generally higher, which raises the demand for higher income people/households.

As a commodity and comparatively to coarse salt, flower of salt presents a higher value in the market. This may be due to its particularities related to scarcity [52], being highly dependent on favorable weather conditions and sensitiveness. To obtain the highest quality, it must be gathered when it is still floating at the production unit and it cannot be left uncollected for a long period of time. It should be harvested, preferentially within a few hours after its formation.

The market for flower of salt is quite wide and diversified but tends to be highly demanding. As a result, there are some characteristics that the flower of salt must present in order to be accepted in the market (acceptability rules). It needs to be clean, present just

a residual amount of seawater, be whitish or tending to colorless, and have a tiny grain (Approximately. 1–2 mm wide) [45]. More recently, some traders preferred larger grain sizes, namely the scale and flake types (over 3 mm).

6. Conclusions

Flower of salt became important because it revitalized the apparently decaying sector of economic, inefficient, handcrafted salt. This phenomenon has been inflicting a positive impact in social and economic terms on certain Southern European regions, with particular incidence in the southeast Portuguese mainland. This new breath in the ancient salt production activity has also stimulated the development of handcraft innovative tools and harvesting methods.

This revitalization of the traditional salt sector has attracted the attention of tour operators, as there is a niche of clientele that is interested in the cultural aspect of production. In addition, the tourist also likes to acquire a local souvenir that can be used in the flavoring of the daily meal in their country of origin, without great concern of deterioration while traveling (since salt and *fleur de sel* are inorganic). Nature tourism is attracted to the traditional salt pan due to the simple fact that it is a more sustainable way of producing this commodity, where no machinery enters into the production area.

Scientific evidence shows that a daily pinch of salt is essential for human life due to the need to keep an ionic blood stream and maintain organ function, but going beyond that certain established amount can endanger human health. One apparently efficient way to address and mitigate the problem of excess salt in food is to recognize that flower of salt could be increasingly used to finish tasteless dishes and simultaneously facilitate the pinch process by regulating the right amount.

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