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REVIEW

Drying and salting fish using different methods and their effect on the sensory, chemical and microbial indices

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ABSTRACT The objective of this review is to check modern and common methods used in drying and salting fish as well as their effect on sensory, chemical and microbial indicators. Different types of fish, such as sardines, Hamour, noebi, fsikh, carp, and other kinds, were salted and dried by different drying methods such as natural sun drying, drying by vacuum solar dryer, drying by electric ovens and by using a microwave oven, In different regions of the world. The studies indicated that the drying efficiency was varied with the different drying methods in terms of drying rate and storage period of dried fish and its effect on the organoleptic, chemical and microbial indices. In general, all the drying methods used to drying fish gave a high efficiency except natural sun drying. Even though different methods were used to dry the salted fish, the percentages of chemical composition and indices were close. As for the microbial indices, the microwave drying efficiency exceeded compared with all the drying methods. The natural sun drying method gave less efficiency in eliminating microbes, and it also differed whether the fish was salted or unsalted, and this affected the storage periods. The different methods in drying and salting fish were affected by the rate of dehydration, which led to a variation in the percentage.

KEYWORDS chemical and microbial indices; drying fish; salting fish; sensory

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Secagem e salga de peixes por diferentes métodos e seus efeitos sobre os índices sensoriais, químicos e microbianos

RESUMO O objetivo desta revisão é verificar os métodos modernos e comuns usados na secagem e salga de peixes, bem como seus efeitos nos indicadores sensoriais, químicos e microbianos. Diferentes tipos de peixe, como sardinha, Hamour, noebi, fsikh, carpa e outros, foram salgados e secos por diferentes métodos de secagem, como secagem natural ao sol, secagem por secador solar a vácuo, secagem por fornos elétricos e microondas em diferentes regiões do mundo. Os estudos indicaram que a eficiência de secagem variou com os diferentes métodos de secagem em termos de taxa de secagem e período de armazenamento de peixes secos e seu efeito nos índices organolépticos, químicos e microbianos. Em geral, todos os métodos de secagem utilizados para a secagem de peixes apresentaram alta eficiência, exceto a secagem natural ao sol. Embora diferentes métodos tenham sido utilizados para secar o peixe salgado, as porcentagens de composição química e índices foram próximas. Quanto aos índices microbianos, a eficiência de secagem por microondas excedeu em comparação com todos os métodos de secagem. O método natural de secagem ao sol proporcionou menos eficiência na eliminação de micróbios e também diferiu se o peixe era salgado ou sem sal e isso afetava os períodos de armazenamento. Os diferentes métodos de secagem e salga de peixes foram afetados pela taxa de desidratação, o que levou a uma variação na porcentagem.

PALAVRAS-CHAVE: índices químicos e microbianos, secagem de peixe, salga de peixe, sensorial

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Introduction

Humans have increased their use for the marine environment to obtain important nutrients (Al-Saad et al 2006). Fish is a renewable food resource and is one of the most important sources of animal protein that the human body cannot do without. Humans eat fish directly, either in fresh or processed condition, The intervention of many secondary products for fish in many industries and pharmaceutical teleology (Daham 1986). Fish proteins were characterized as complete and contain essential amino acids and in quantities necessary to meet the needs of the body. Fish were a rich source of vitamins, especially K, E, D, and A. Vitamin D and A were found in the fish liver. Minerals were found in meat and bones of fish, and fish had a rich source of sodium, potassium, sulfur, and iron. Saltwater fish were richer in minerals than freshwater fish, as iodine is not found in freshwater fish while it was found in a large percentage in saltwater fish (Hassan et al 2001). Fish contain omega-3 fatty acid, which has a health effect on the Blood vessels system. The United States Food and Drug Administrations (FDA) were demanded to name traditional foods and fortified foods containing Omega-3 fatty acid in healthily qualified foods (Jōnsson et al 2007). Fish is a perishable foodstuff, their meat was spoiled by self-degradation (enzymatic), chemical reactions (oxidation), or by microbial activity or the three factors combined (Huss 1995). Therefore, fish must be preserved or manufactured as possible quickly by one of the different manufacturing methods, including the use of the drying method, As fish become more resistant to damage while preserving the most natural and apparent characteristics. Given the importance of fish wealth in Iraq and the prevalence of the fish drying methods as one of the traditional methods of conservation common in Iraq and Basra in particular. Therefore, it must be planned to use and manufacture it with high efficiency to reduce pollution and the dangers of food poisoning by following scientific and practical methods studied for conservation. The article aimed to address some of the common and modern methods used for drying and salting different types of fish and to explain its impact on the sensory, chemical and microbial indices.

Salting and drying fish

The Salting

Salting is a physical and chemical process as a result of salt penetration of the fish's body with the forces of moisture to leave the muscles, resulting in a change in weight and is intended to preserve the fish. The salting process leads to loss of part from the protein due to the exit of water from the fish, Salting had a positive role in reducing worked lipolysis enzymes (lipo-phospholipase). Salting works to the decrease of numbers lipolysis bacteria through the decrease of free fatty acids after salting, which was considered a product of enzymatic and microbial lipolysis (Al-Taey 1987; Al-Douri et al 1990). Hilderbrand (2003) indicated that salting with salt solution gives more regularly salting compared to dry salting if the high moisture content of the products will need more salt compared to dry products. Fath El-Bab (2005) observed that the maximum percentage of sodium chloride salt was 23% and 25% for fsikh and sardine salted products respectively. Patir et al (2006) used a dry salting method for salting *Chalcalburnus taricii* fish. Salted fish was a decrease in chemical and microbial quality. Patir et al (2006) observed that the average concentration of salt content was 24.63%, while the salt concentration in dry materials was 43.74%.

Drying

Drying is one of the oldest methods used to preserve foodstuffs. Drying removed water from the foodstuff, which reduces the moisture percentage to the extent that it is difficult for organisms to live to occur damage and stop the enzymes in the events of changes of chemical spam (Hassan and AL-Hakim 1985; AL-Asod, et al 2000). Among these methods were the use of natural solar drying, manufactured solar dryers, electric ovens, and microwave ovens. The natural solar drying method was accompanied by changes in the dried foodstuff associated with changes and different weather conditions, pollution microorganisms, dust, and insects, which leads to a reduction in their nutritional value. Natural solar drying method requires a large area and long drying time, this is not exploited economically and on a large

scale (Darvishi et al 2013; Immaculate et al 2012). Majeed and Al Halphi (2007) concluded that the decrease in moisture percentage for fish and meat was higher by using the solar dryer compared with the using natural sun drying. Dried fish and meat using the solar dryer, it was isolated from the outer environment and did not affect by any change in environmental conditions. AL-Fadhly (2009) used an industrial solar dryer equipped with the return system (Figure 1a) to dry the Thalia fish (*Scomberoides commersonianus*). AL-Fadhly (2009) who found that using industrial solar dryer gave better results than using a natural solar dryer. AL-Gwabrawy (2013) dried the carp fish (*Cyprians Carpio*) by using a vacuum solar dryer (Figure 1b). AL-Gwabrawy (2013) indicated that the quality of dried fish using vacuum solar dryer was good quality and close to the quality of dried fish using a vacuum electric dryer compared with using natural sun drying. AL-Temimi (2018) used microwave oven with three levels 100,300 and 500 watts to dry carp fish (*Hypophthalmichthys molitrix*). AL-Temimi (2018) indicated that the microwave drying method gave good results that exceeded the use of other drying methods, as it gave a high efficiency in drying and eliminating most of the microorganisms.

a

b

Figure 1 (a) Industrial solar dryer (Majeed and AL-Halphi 2007) and (b) Vacuum solar dryer (AL-Gwabrawy 2013).

Effect of salting and drying methods on fish

Sensual qualities

Organoleptic evaluation of foodstuff products manufactured in any technological method was important for estimating the degree of consumer acceptability and organoleptic parameters were important, including color, tissue, smell, and flavor. Quality is not a factor, but there are many factors, the most important is freshness, it is a single measure to judge the quality of fish products and is determined in the microbial, chemical and physical process. The evolution of flavor, texture, and color in cured fish products can be controlled by controlling conditions and preventing duplication of growth and damage factors to the increase of storage Periods (Azam et al 2003). Al-Douri et al (1990) explained that the different sensory qualities of salted and dried fish. Azam et al (2003) confirmed that the results of the organoleptic evaluation of dried fish in winter were higher and better compared to summer dried fish that were acceptable to residents. AL-Gwabrawy (2013) indicated that the decrease of color evaluation, the height of flavor evaluation, texture, and general acceptance of dried carp fish using vacuum solar dryer and vacuum electric dryer compared to dried fish using natural sun drying.

Chemical composition

The chemical composition of fish helps determine the storing age for them and increased the efficiency of planning for their exploitation by providing the necessary technical information for manufacturing, it is also considered one of the main scoring in increasing the productivity of fish with high nutritional value. The fat and water percentage was 80% in most bony fish. High freshness for fish was due to contain a large amount of water and despite its content of the connective tissue, as it contains only collagen (Tai 1987). During the drying method, fish proteins are exposed to many changes. Protein denaturation was beginning at 40 °C and proteins coagulate at 50 °C. The protein hardness was increased by the increase of temperature due to the increase of proteins clotting and accumulation. The protein denaturation was lost their properties such as water solubility or salt solution and their ability to swell. Collagen partial digestion occurs at 55 - 60 °C, and at 60 °C collagen, shrinkage causes a decrease in muscle fibers (Hindi 1986). The chemical composition varies with different classes, ages, gender, seasonal differences, and food availability in the environment. Fish meat contains a small number of carbohydrates in the form of glycogen 0.1–1% of percentage, while in some marine fish; the percentage was 0.12–0.78% (Huss et al 2004). Antony et al (1998) performed a study on dried salted noebi fish and demonstrated the effect of salting time on the quality and stock ability to reach the required moisture about 35% based on the Indian standard specification for dried and salted fish. El-Bab (2005) conducted a study on salted sardines and fsikh fish collected from different Egyptian markets and it was found that the average moisture of these fish was 49.5% and 50.8% respectively. Morshed et al (2005) carried out a study in Bangladesh on a number of marine and river fish, they found that the dried fish by industrial solar dryer was better than dried fish using natural sun dryer, the moisture was decreased from 80% to 20% in dried fish using industrial dryer, while the moisture decreased from 80% to 35% in dried fish by natural dryer. Patir et al (2006) estimated that the moisture content of salted *Chalcalburnus tarichii* fish, they found that the lowest value was 15.60% and the highest value was 55.09%. Al-Noor (2008) who studied that the dried Hamour and sharee fish and its storage for 90 days, there was a noticeable decrease in the percentage of moisture in continuous storage, as it reached 10.19% and 10.16%, respectively. AL-Gwabrawy (2013) compared between the chemical composition of dried carp fish by using vacuum solar dryer and vacuum electric dryer than dried fish by using natural sun dryer, as the moisture, protein, fat, and ash percentage were 19.13, 34.61, 27.42 and 27.96 %, 36.81, 35.34, 17.41 and 19.33% and 15.05, 17.32, 16.62 and 32.90% respectively. AL-Temimi (2018) studied that the chemical composition of dried carp using the microwave at the level of 500 watts and the percentage of moisture, protein, fat, and ash was 12.59, 18.24, 55.73 and 13.41%, respectively. Table (1) showed that the chemical composition of fish in different studies.

Table 1 Chemical composition of dried salted fish in different studies.

Chemical composition%				The scientific name	Common name	Authors
Moisture	Protein	Fat	Ash			
23	44.6	26	6.4	*Mugil cephalus*	Mullet roe	(Burt 1988)
7.91	45.64	25.15	21.3	*Puntius* sp.	Puti fish	(Mansur et al 1989)
10.52	61.10	11.20	17.18	*Mugil cephalus*	Salted fermented Bouri	(Elsebaiy and Metwalli1989)
63	21.2	4.0	11.8	*Sardinella aurita*	Salted Sardine	(Emam and Abou Zeid 1995)
22	54.87	17.33	5.8	*Ictalurus furcattus*	dried Catfish	(Antonia 2002)
21.19	60.27	8.22	10.32	*Mugil cephalus*	dried Parshe	(Azam et al 2003)
35.29	31.50	18.95	14.26	*Tenualosa ilisha*	dried Suboor	(AL-ASatty 2006)
11.66	61.33	6.36	20.65	*Epinephelus coioidis*	dried Hamour	**(**AL-Noor 2008)
28.92	**53.10**	**14.06**	**3.92**	*Clarias gariepinus*	dried Catfish	(Chukwu and Shaba 2009)

Chemical indices

pH

pH is one of the factors affecting microbial growth and food poisoning. General the pH values of fish was ranged between 6.7 -7.0 and its different according to the times of the year, feeding, and the degree of stress for fish. After the fish dies, the pH values were neutral after that it was decreased because of microbial activity, which leads to the increase in the pH values due to the ammonia production and other volatile nitrogenous bases because of the analytic protein by bacterial activity. If the pH values greater than seven in some fish gives that indication of damage (Huss 1995). Azam et al (2003) who compared that the pH values for different dried fish in winter and summer, they found that the high values of pH was 8.07 and 8.13 for *Mugil cephalus* and *Harpodon nehereus* respectively in winter, and reached to 7.93 and 8.07 respectively in summer, while the pH value summer was higher reached to 8.27 and 8.03 compared to winter 8.07 and 7.37 for Setipinna phase and *Scoliodon shorrakowah* respectively. Patir, et al (2006) Observed that the pH values of salted Chalcalburnus taichi the lowest value was 5.36, the highest value was 6.95, and the average value was 5.79.

The results of the study conducted by Al-Noor (2008) on dried Hamour and Sharee fish which dried by using industrially dryer and natural sun dryer, showed that the value of pH was decreased after drying while it increased after storage, it reached 5.83 and 5.55 in the zero hours and then increased to 6.02 and 6.21 after 90 days of storage, while the pH value for fresh Hamour and Sharee was 7 and 6.83 respectively. AL-Fadhly (2009) found that the pH value for the dried Thalha fish by industrial solar dryer was 5.60, which was less than the pH value of the dried Thalh fish using natural sundryer. AL-Gwabrawy (2013) indicated that the pH values of dried carp using vacuum solar dryer and vacuum electric dryer compared to dried fish by natural sun drying were 6.80, 6.33 and 6.39 respectively.

Total volatile nitrogenous bases (TVNB)

TVNB is one of the most important tests used in the evaluation of the fish quality and includes both tri-methyl amine (TMA) produced by bacteria and dimethylamine (DMA) resulting from the self-analytical of enzymes during storage. The ammonia produced by removing the amine from the amino acids and fallout the nucleotides, and its quantity depends on the type and degree of damage in fish, and seafood, and its value does not reflect the type of damage if it was bacterial or analytical (Huss 1995). Azam et al (2003) who arrived that the quality of three dried fish in the summer and winter. TVNB value was higher in winter compared to those in the summer. TVNB value of *Mugil cephalus* was 62.23 mg nitrogen /100g in winter and decreased to 57.82 mg nitrogen/100 g in the summer, while the *Harpoon nehereus* and Setipinna phase were the opposite compared to *Mugil cephalus*. Shakerian et al (2004) estimated that TVNB in 90 bony fish samples, which collected in fall and summer seasons from Irani markets, such as *Chirocentrus drab*, *Teuthis signs*, and *Hilsa kanagurta* fish, was 20.3, 19.37, and 17.69 mg nitrogen/100g respectively. More TVNB value was found in five samples than the normal percentage, which was 25 mg nitrogen/100 g. Al-Nour (2008) indicated that the average value of TVNB for Hammor and sharee fish using the industrial dryer and natural sun drying was increased during the storage period. It is increased from 21.23 and 24.26 mg nitrogen/100 g respectively in zero time to 37.79 and 41.36 mg nitrogen/100 g respectively after 90 days from storage, while the TVNB values in fresh fish were 7.20, 6.75 mg nitrogen/100 g fish respectively.

Thiobarbituric acid (TBA)

The value of TBA was used to estimated of oxidative rancidity in fatty foods, as the unsaturated fatty acids (which found in high percentage in fish fat) reacted with oxygen to produce peroxides (which are the primary products of fat oxidation) and aldehydes, ketones, and short-chain fatty acids (which are the secondary products of fat oxidation) which give the Rancid flavor and Unwanted odor (Huss 1995). Al-Shatty (2006) indicated that the increase in the TBA value for

dried Saboor, Gfot and Biayah fish from 6.32, 2.13 and 1.81 mg MAL/kg fish respectively in the first month to 15.96, 11.83 and 9.99 mg MAL/kg fish respectively after 12 months of storage at room temperature. AL-Noor (2008) found that there was a gradual increased in the values of TBA with the increase of the storage period for dried salted Hamour and Sharee fish was 0.35 and 0.25 mg MAL/kg, respectively at zero time, while it reached 0.47 and 0.42 mg MAL/kg respectively after 90 days from storage. AL-Fadhly(2009) who noticed that a higher TBA value for dried fish using natural sun drying compared to the industrial solar dryer. AL-Gwabrawy (2013) who compared with the TBA values for dried fish by using vacuum solar dryer, vacuum electric dryer, and natural solar drying, were reached 0.531, 0.382 and 0.402 mg MAL/kg fish, respectively. AL-Shatty (2014) confirmed that the TBA values were significantly affected by the drying method, Also he noted that the values of TBA were increased for dried fish by using natural sun drying than electric oven dryer or when using hot air.

Microbial indices

Fish damage occurs due to chemical changes, physical damage, and the main reason is the microbes' growth and metabolic products for those microbes and from the fermentation of amines, sulfates, alcohols, aldehydes, ketones, and organic acids, and they have poor flavor. Fish damage occurs according to the type of product, type and number of microbes of dried fish depended on several factors such as fresh fish pollution, and the salting and drying method (Gram and Dalgaard 2002; Huss et al 2004). The total number of bacteria was indicated in the quality and appropriation of the storage period for the products, and it given estimated to the degree of bacterial damage and hygiene applied (Huss 1995). The Iraqi standard specification for the 1998 year was showed the lower and upper microbial limits / g of fresh, chilled and frozen whole sea and river fish, the lower limits of each of the APC air microbes, Fecal coliform and Staphylococcus aureus and V. Parahaemolyticus was 1 × 106, 4, 1 × 103 and 1 × 102 (CFU/gm) respectively, while the upper limits were 1 × 107, 4 × 102, 2 × 103 and 2 × 103 (CFU/gm)) respectively. Youssef et al (2001) who Isolated and diagnosed pathogenic bacteria from salted and common fish, which including Bacillus cereus and Staphylococcus.aureus. Azam et al (2003) Explained in study to comparative to four types of dried fish between summer and winter from the microbial side, they were observed that the total coliform bacteria within acceptable limits is less than 100MPN / gm and that the total number of bacteria in summer samples is lower than in the same samples in winter, and no found Vibrio sp. And Salmonella sp. Patir et al (2006) found that the salted fish collected from markets and homes in Turkey were not produced under health and technological conditions, as they noted that 3% and 100% from samples contained E. coli and S. aureus respectively. Al-Shatty (2006) who studied that the molds and yeasts found in Saboor, gfot, Biayah and Thalh, which stored at 25 °C temperature after 9, 10, 11, and 12 months, and he was isolated 236 isolates of mold, including 13 species, foremost of which was Aspergillus, in five types, and Penicillium in three types. Also, 142 isolates of yeasts were isolated, followed by 6 species, were Candida albicans, Debaryomyces sp. and Pichia, while Al Noor (2008) who noted that did not any found of molds or yeasts in dried Hamour and Sharee fish, which stored at 25-30 °C temperature during different storage periods spanning 90 days.

Rehydration ability

Rehydration ratio is the recovering water process to dried fish again and expressed as kg water/1 kg dried fish, a test conducted to infer the quality of the dried foodstuff. Rehydration Ratio of dried meat and fish was decreased with increasing temperature, in contrast to dried vegetables and fruits (Hassan and Al-Hakim 1985). Water is added to the dried food to re-hydrate it. It was noted that the water temperature used to rehydrate dried foods affected the microbial quality for the impregnated products, as the water temperature 50 °C decreased the number of microbes, while the water temperature was 85-100 °C, almost all vegetable microbes were inhibited. While S. aureus bacteria was inhibited at 100 °C. (Frazier and Westhoff 1988). Poernomo et al (1992) found that the strength of salt solution effected in salt permeation, and the use of a low-salt solution concentration resulted in less salt and higher moisture content in the fish, which effected in the drying percentage. Eikevik et al (2005) explained that the ability of rehydrate and absorption time for cuts of dried codfish was high, and depended on the drying temperature, they noticed less density at -8 °C

compared to + 10 °C and at -5 °C for ten hours compared to 30 °C with higher of rehydrate ability. Majeed and Al-Hilphi (2007) observed that the drying rate was decreased with decreasing moisture content of dried fish and meat using natural sun drying or an industrial solar dryer. Al-Noor (2008) explained that the drying methods effected on the rehydration ratio, rehydration coefficient, and the ratio drying of dried Hamour and Sharee fish, which was stored for 90 days. The rehydration ratio for dried carp fish using microwave was 1.349%, while it was decreased to 1.300 by using natural sun drying (AL-Temimi 2018).

Final Considerations

The difference in the drying and salting methods of fish was given a wide scope in preserving fish for long periods. The method of drying fish using microwave was given a high efficiency in drying and preserving. The possibility of using industrial solar collectors in drying different types of fish. Salted and dried fish yielded a close percentage in chemical and microbial indices, although of different drying methods. Increased storage life of salted dried fish than unsalted dried fish.

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