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METHOD OF OBTAINING FOOD CONCENTRATE FROM FISH MEAT

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An urgent issue of food safety is the creation of protein-containing food products. Fish remains one of the key sources of protein. In this article, the object of research is hake fish, which has been converted into a soup concentrate by infrared drying and grinding. The results of the experiment showed that with an increase in the irradiation distance, the sensory properties of the hake are improved, but at the same time the drying time increases. When changing the radiation distance, the rate of change in the drying time is lower than the rate of change in the drying temperature. In the temperature range from 55 °C to 65 °C, the moisture content of the dry hake base decreases exponentially over time. As the temperature rises, the drying time for safe storage is shortened and vice versa. Therefore, in order to save business and time costs, the radiation distance must be reduced in accordance with the premise of ensuring the quality of drying. At the final stage of drying, a large amount of free water in the hake is removed by evaporation. As a consequence, it is difficult to remove the internal bound water and chemical water due to the drying effect, and the drying curve becomes flat. We have presented the preparation technologies and recipes for fish soup concentrate. According to this technology, visushina fish is ground to a fine degree of grinding and mixed with other recipe components. The recipe for the soup concentrate is mathematically optimized. The optimal ratio of the recipe components was selected: 20 g of hake powder, 3 g of salt, 0.7 g of sodium glutamate, 0.5 g of ginger powder, 4 g of white sugar, 0.5 g of konjac gum, 0.9 g of xanthan gum, 0.6 g guar gum. Due to the high nutritional value of hake fish, the resulting product will have a high content of proteins, vitamins A and D, calcium, magnesium, selenium and other vital nutrients. Dry powdery structure makes it convenient for storage and transportation

Key words: *hake fish, food concentrate, flavor enhancers, infrared drying, grinding, mathematical model.*

Самілик М.М., Гуо Вангванг. Спосіб отримання харчового концентрату із м'яса риби

Актуальним питанням харчової безпеки є створення харчових продуктів, що містять білок. Риба залишається одним із ключових джерел білків. У цій статті об'єктом дослідження є риба хек, яка шляхом інфрачервоного сушіння та подрібнення була перетворена на концентрат супу. Результати експерименту показали, що зі збільшенням відстані випромінення сенсорні властивості хека покращуються, але водночас збільшується тривалість сушіння. Зі зміною відстані випромінювання ступінь зміни тривалості сушіння нижчий, ніж ступінь зміни температури сушіння. У діапазоні температур від 55 °С до 65 °С вологість сухої основи хека зменшується з часом експоненційно. З підвищенням температури тривалість сушіння, яка забезпечує його безпечне зберігання, скорочується, і навпаки. Тому, щоб заощадити матеріальні ресурси та час, відстань випромінювання має бути зменшена відповідно до передумови забезпечення якості сушіння. На кінцевій стадії висушування велика кількість вільної води у хека виводиться за рахунок випаровування. Як наслідок – важко видалити внутрішню зв'язану воду та хімічну воду через ефект сушки, і крива сушіння поступово стає пологою. Нами представлено технологію приготування та рецептуру рибного супового концентрату. Відповідно до цієї технології, висушена риба подрібнюється до тонкого ступеня подрібнення і змішується з іншими рецептурними компонентами. Рецептура супового концентрату математично оптимізований. Було вибрано оптимальне співвідношення компонентів рецептури: 20 г порошку хека, 3 г солі, 0,7 г глутамату натрію, 0,5 г порошку імбиру, 4 г білого цукру, 0,5 г коньячної *камеді, 0,9 г ксантанової камеді, 0,6 г гуарової камеді. Завдяки високій харчовій цінності риби хек отриманий продукт буде мати високий вміст білків, вітамінів A і D, кальцію, магнію, селену та інших життєво необхідних нутрієнтів. Суха порошкоподібна структура робить його зручним для зберігання та транспортування.*

Ключові слова: *риба хек, харчовий концентрат, підсилювачі смаку, інфрачервона сушка, помел, математична модель.*

Introduction. In the XXIst century, the world's population continues to grow. It is expected to reach 9.1 billion people by 2050. A pressing issue is the ability of agriculture to provide people with sufficient food, especially high quality protein. As a source of many biologically essential substances, marine resources are attracting more and more attention from scientists. The World Food and Agriculture Organization has identified aquatic foods as the most promising protein source. Therefore, the rational development and use of marine resources has become a hot spot of attention of scientists who study nutritional issues.

Cod is a high-quality marine fish resource with high economic value and nutritional value. In addition, it is a cold-water bottom fish, which inhabits deep waters, so it is less polluted, so it is favored by consumers all over the world. At present, the total output of cod in the world is about 6.22 million tons, accounting for about 8% of the total marine catch in the world [1]. However, due to the influence of climate [2], ocean acidification [3–5] and overfishing [6], the sustainable development of cod resources is seriously threatened. Coupled with the increasing demand for cod resources in the market, the main producing countries of cod have adopted the mode of restricting fishing and improving fishery development [7], breeding [8–9] and other means to deal with. Based on this situation, coupled with the development of seafood processing and the increasing demand of consumers, it directly increases the possibility of fake cod products, such as shoddy, adulteration, mislabeling and so on [10–12].

Drying is a very important process in the processing of raw materials, which can reduce the moisture content of the material and suppress the activity of enzymes. The main task of drying is to ensure long-term storage and use of dried products [13]. The storage time of the material depends on its moisture content and storage temperature. After drying, the moisture content of the material must reach its safe value before it can be stored for a long time. According to national standards and empirical data, the moisture content of dried fish does not exceed 25%.

The quality of dried fish products is mainly determined by the following parameters:

1. Color and shine. The products must have the characteristic color of dried fish, the surface of the carcass must be clean and dry, and the flesh must be gray or red [14];

2. Smell. All types of dried fish have their own unique aroma. The presence of acidity indicates spoilage, fatty acid content [15–16];

3. Appearance and form. The shape must be complete, free from breakages, defects or cracks and meet certain specifications [17–18];

4. The degree of dryness. The maximum water content in dried fish should not exceed 25% [19–20];

5. Salt content. The maximum should not exceed 15%, a small amount of salt is allowed on the surface [21];

6. Content of impurities. The surface must not be dirty. If the skin is dirty, it is a defective product, which indicates poor quality of the salt used or that the sanitary conditions during processing are inadequate [22].

Material and methods. The main raw materials used in the experiment: Pacific hake, sea salt, monosodium glutamate, ginger powder, white sugar, konjac gum, xanthan gum, and guar gum. During the research, the following control and measuring devices and devices were used: electronic scales Pioneer cp3102 (Ohaus Instrument Shanghai Co., Ltd.), a homemade infrared drying device consisting of an intelligent control transmitter with a digital display AOT5000 and IRI500D, an interactive infrared thermometer, an electric quartz direct heating infrared emitter, non-contact probe and cabinet. The power of the frequency heating tube was 1000 W, and the temperature measurement range of the thermometer was 0–500 °C.

The principle of operation of an infrared radiating heating element is that directional radiation and other devices become an infrared emitter, which converts electrical energy into infrared radiated energy to achieve rapid drying [23] and it mainly uses the medium and long band of infrared rays, and the band range is 25–1000 μ m [24]. In our experiment, we used an electric quartz infrared radiator of direct heating, which combines a heating element and a radiating element of a radiator. Infrared technology Infrared radiation technology is a new type of pollution-free drying technology with high efficiency, energy saving and environmental protection requirements. It can radiate to a certain depth and be heated evenly. It also has the advantages of high efficiency, low energy consumption and little pollution [25–26]. At present, it has been applied to many food manufacturing processes, such as drying, heating, freeze-drying, food baking and cooking [27].

The hake was cut into homogeneous pieces of 2 x 2 x 2 cm, the pieces were laid out on an infrared drying mesh, in which the drying temperature was controlled using an online infrared thermometer. During the drying process, the samples were weighed every 30 minutes using an electronic balance. Weighing was carried out to determine the mass moisture content of the product in real time. The drying process was carried out until a safe water content of 25% in the hake was achieved. The experimental is shown in table 1.

Table 1

Drying mode

Test factor	Drying temperature, °C	Radiation distance, mm
1	55	200
2	55	250
3	55	300
4	60	200
5	60	250
6	60	300
7	65	200
8	65	250
9	65	300

The dried product was ground using a household mill and sieved through a 100 mm sieve. A homogeneous fish powder was obtained. Then all the recipe components were mixed: hake powder (20.0–22.0%), table salt (2.0–4.0%), sodium glutamate (0.54–0.74%), ginger powder (0.33–0.53%), white sugar (2.5–4.5%), konjac gum (0.3–0.5%), xanthan gum (0.75–0.95%), guar gum (0.5–0.7%). Soups were prepared on the basis of the mixture with different proportions of components and water. The preparation of the food soup concentrate was carried out on the basis of the existing technology [28]. The addition of flavor enhancers improves the taste of the finished product.

To obtain the optimal ratio of the constituent components, the quality of several samples of formulas was assessed by the method of fuzzy mathematics.

Index measurement. The initial moisture content of the hake was measured by direct drying in a muffle furnace at 105 °C. For this, 50 grams of a hake sample was placed in an oven and dried to constant weight M. The experiment was repeated 3 times. Following the result of the average of the three tests, the initial water content in the hake was calculated using the formula :

$$W_c = \frac{M_c - M_{ad}}{M_c} 100\%$$

W_c – initial moisture, %;
M_c – initial mass, g;
M_{ad} – weight of absolutely dry material, g.

The real-time dry matter moisture content of the hake is calculated based on the material mass at time t, the initial moisture content and the initial fish mass.

$$M_d = \frac{M_t - Mg}{Mg} 100\%$$

$$M_g = M_c - M_c \cdot W_c$$

M_d – moisture content on dry basis of material, %;
M_t – total mass of the material at time t, g;
M_g – mass of the dry substance of the material, g.

The real-time wet basis moisture content of hake is measured according to the method of GB/5009.3-2010 "Determination of Moisture in Food".

Results and discussions.

Figures 1, 2 and 3 show the infrared radiation of hake at a radiation distance of 200 mm, particle size 2 × 2 × 2 cm and various surface drying temperatures (55 °C, 60 °C, 65 °C). The curve of the moisture content of the dry base over time during the drying process is the drying curve. A single layer thickness was used during the experiment.

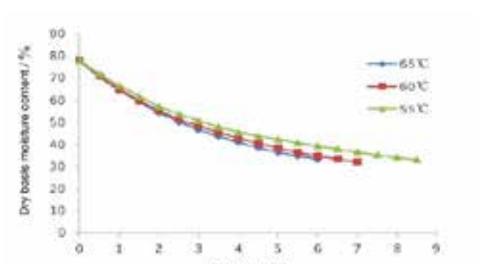

Figure 1 Drying curves at different temperatures when the radiation distance is 200mm

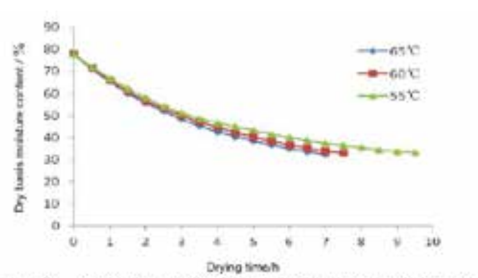

Figure 2 Drying curves at different temperatures when the radiation distance is 250mm

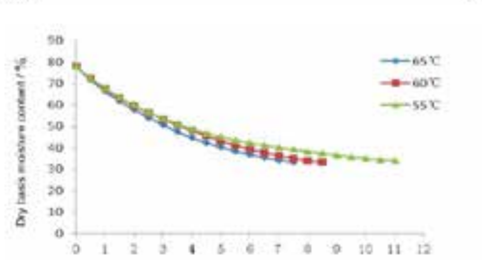

Figure 3 Drying curves at different temperatures when the radiation distance is 300mm

From Figures 1, 2, and 3, it can be seen that the water content of hake with the same radiation distance and different surface drying temperatures varies with time. When the radiation distance is 200 mm, the surface drying temperature is 55 °C, 60 °C, 65 °C, the drying time is 9h, 7.5h, 6.5h respectively; when the radiation distance is 250 mm, the drying temperature is 55 °C, 60 °C, 65 °C Under the conditions, the drying time is 9.5h, 8h, 7h, respectively; when the radiation distance is 300 mm, the drying temperature is 55 °C, 60 °C, 65 °C, and the drying time is 11h, 9h, 8h, respectively.

From 55 °C to 65 °C, the moisture content of the hake dry base decreases exponentially with time. As the drying temperature increases, the time required for the hake to reach safe storage moisture is shorter, and vice versa. In the initial stage of hake drying, the moisture content is relatively high, the moisture difference between the inside and outside of hake is large, and the dehydration speed is relatively fast. At this time, there is no obvious preheating stage, and the drying curve is relatively steep, then it quickly enters the drying slowdown period. At the end of the drying stage, a large amount of free water in the hake fish is discharged through vaporization, and the internal bound water and chemical water are difficult to be discharged through the drying effect, and the curve gradually becomes flat.

Figures 4, 5, and 6 are the drying temperature of the hake on the same surface, the loading capacity is 2 × 2 × 2 cm, and the hake is dried during the infrared drying process under different radiation distances (200 mm, 250 mm, 300 mm). The curve of the base moisture content changing with time is the drying curve.

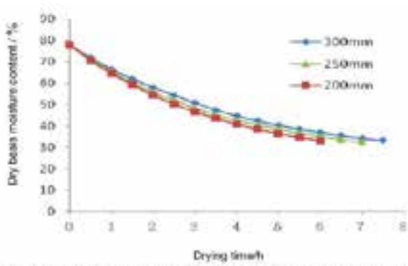

Figure 4 Drying curve of surface drying temperature 65℃ and different radiation distance conditions

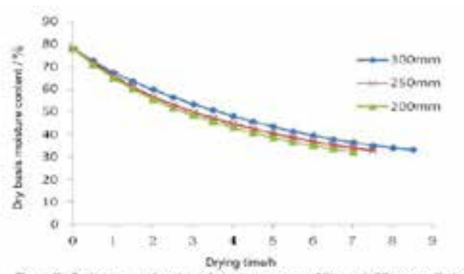

Figure 5 Drying curve of surface drying temperature 60℃ and different radiation distance conditions

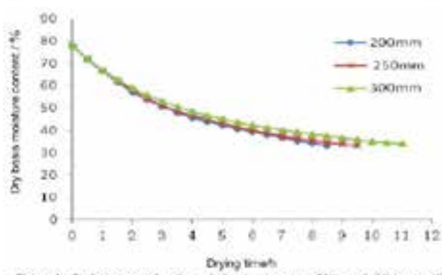

Figure 6 Drying curve of surface drying temperature 55℃ and different radiation distance conditions

It can be seen from Figures 4, 5, and 6 that when the surface drying temperature of hake fish is the same, as the radiation distance increases, the drying rate decreases, and the drying time to the end point is correspondingly extended. The surface drying temperature of hake fish is 65 °C, when the radiation distance is 200 mm, 250 mm, 300 mm, the drying time is 6h, 7h, 7.5h respectively; when the surface drying temperature is 60 °C, the radiation distance is 200 mm, 250 mm, 300 mm, the drying time is respectively 7h, 7.5h, 8.5h; when the surface drying temperature is 55 °C, when the radiation distance is 200 mm, 250 mm, 300 mm, the drying time is 8.5h, 9.5h, 11h respectively. With the change of radiation distance, the degree of change of drying time is lower than the degree of change of drying temperature.

It can be concluded that radiation distance has a certain influence on the drying time of hake fish but is lower than the degree of influence of drying temperature. When selecting the radiation distance, it should be as close as possible to meet the drying requirements.

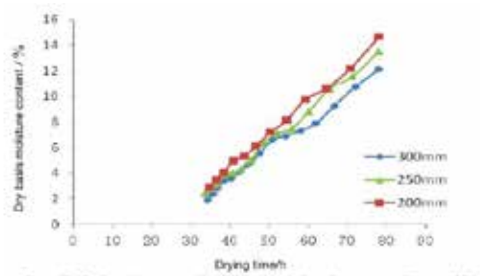

Figure 7 Drying rate curve under different radiation distance conditions at 65℃ surface drying temperature

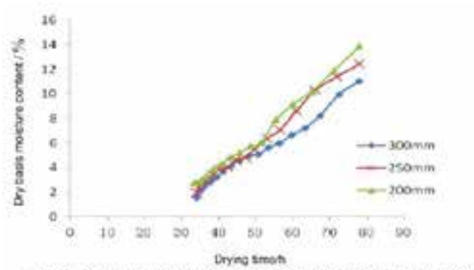

Figure 8 Drying rate curve under different radiation distance conditions at 60℃ surface drying temperature

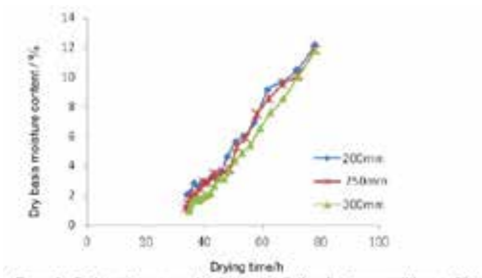

Figure 9 Drying rate curve under different radiation distance conditions at 55℃ surface drying temperature

From Figures 7, 8, and 9, we can see that as the radiation distance increases, the drying rate decreases. The radiation distance is 200 mm and the drying rate of 250 mm is not too different. When the radiation distance is 300 mm, the drying rate during the whole process of hake drying is significantly lower than 200 mm and 250 mm. This is because the longer the radiation distance, the less concentrated the radiation and the slower the drying speed. By observing the dried hake fish, the farther the radiation distance, the better the sensory quality of hake fish's color and taste. Therefore, the smaller the radiation distance, the better under the premise of ensuring the drying quality.

According to the national standard, the sensory index adopts a hundred-point system, and the scoring items are assigned as follows: 65 points for smell, 15 points for organizational status, 10 points for cooking, color 5 points, packing 5 points.

According to the sensory scoring table [29], the criteria for determining various index factors (x) are shown in table 2.

In this paper, matrix multiplication is used to calculate the comprehensive score, which avoids the error caused by the algorithm of taking the big and taking the small [30]. Let u={y1,y2,y3,y4,y5}, constitute the factor set vector, and determine the weight distribution according to the national standard of score distribution (the weight distribution table factor set of the factors) is as follows: F={0.65, 0.15, 0.10, 0.05, 0.05}

Table 2

Nongtangbao Grade Factor Standard

Item	Poor product (x_1)	General product (x_2)	Quality product (x_3)	Premium products (x_4)
Taste and smell (y_1)	45, 50	50, 57	57, 63	63, 65
Organization status (y_2)	5, 8	8, 11	11, 14	14, 15
Cookability (y_3)	0, 2	2, 6	6, 9	9, 10
Color (y_4)	0, 2	2, 3	3, 4	4, 5
Package (y_5)	0, 2	2, 3	3, 4	4, 5

Now the evaluation results are classified into four situations to form an evaluation set: E={x1,x2,x3,x4}.

Once again, it is necessary to formulate a suitable converter for each factor, that is, the correlation fuzzy matrix R between the factor set and the evaluation set. For this reason, first establish the membership function bij(X)(i=1, 2, 3, 4, 5, j=1, 2, 3,

4) are as follows:

$$b_{11}(X) = \begin{cases} 1 & (45 \le x < 50) \\ \frac{1}{15}(65-X) & (50 \le X < 65) \end{cases}$$

$$b_{12}(X) = \begin{cases} \frac{1}{5}(X-45) & (45 \le X < 50) \\ 1 & (50 \le X < 57) \\ \frac{1}{8}(65-X) & (57 \le X < 65) \end{cases}$$

$$b_{13}(X) = \begin{cases} \frac{1}{12}(X-45) & (45 \le X < 57) \\ 1 & (57 \le X < 63) \\ \frac{1}{2}(65-X) & (63 \le X < 65) \end{cases}$$

... .

$$b_{54}(X) = \begin{cases} \frac{1}{4}x & (45 \le x < 50) \\ 1 & (50 \le X < 65) \end{cases}$$

According to the measurement, the scores of the samples currently in use of the thick soup recipe are as follows:

y_1=58, y_2=13, y_3=9, y_4=2.5, y_5=4.5, so:

$b_{11}(58)$=0.467, $b_{12}(58)$=0.875...$b_{54}(4.5)$ =1

From this, R can be obtained:

$$R = \begin{pmatrix} 0.467 & 0.875 & 1 & 0.722 \\ 0.286 & 0.5 & 1 & 0.889 \\ 0.125 & 0.25 & 1 & 1 \\ 0.833 & 1 & 0.833 & 0.625 \\ 0.167 & 0.25 & 0.5 & 1 \end{pmatrix}$$

So the evaluation set X=F×R

$$=\{0.65, 0.15, 0.10, 0.05, 0.05\}\times\left\{\begin{matrix} 0.467 & 0.875 & 1 & 0.722 \\ 0.286 & 0.5 & 1 & 0.889 \\ 0.125 & 0.25 & 1 & 1 \\ 0.833 & 1 & 0.833 & 0.625 \\ 0.167 & 0.25 & 0.5 & 1 \end{matrix}\right\}$$

Still use ordinary addition and multiplication to get: X={0.409, 0.731, 0.967, 0.784}

Take xjo=maxej (1≤j≤4), and the evaluation object is xjo. That is, it belongs to the jth product in the standard. Here x_3=0.967 is the largest, so the sample of the pumped thick soup treasure is a high-quality product.

Conclusions

As the distance from the heat source increases, the color and taste of the hake improves, the sensory qualities become better, but the drying time increases. In order to save business and time costs, this must be consistent with the prerequisite for ensuring the quality of drying. After grinding the hake into flour, a thick soup is prepared. Based on the results of calculations and sensory evaluation, the optimal ratio of materials in the food concentrate was found: 20 g of hake fish powder, 3 g of salt, 0.7 g of sodium glutamate, 0.5 g of ginger powder, 4 g of white sugar, 0.5 g of konjac gum, 0.9 g xanthan gum, 0.6 g guar gum.

The nutritional value of hake is extremely rich. Hake fish is rich in protein, vitamin A, vitamin D, calcium, magnesium, selenium and other nutritional elements. It is rich in nutrition and has a sweet meat taste, fish meat is rich in magnesium, which has a good protective effect on the cardiovascular system and is beneficial to prevention Cardiovascular diseases such as hypertension and myocardial infarction. Making the hake fish as a hake fish soup can be convenient for storage and transportation.

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