Drying process characteristics of dried anchovy (*Stolephorus* sp.) by using cabinet and tunnel of sun dryer

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**Abstract.** Many traditional ways of preserving fish have been carried out to reduce fish water content, so that it cannot provide an opportunity of bacteria (microbes) to live and develop, eventually maintain the shelf life of fish. The study was conducted in the Village of Saliong, Subdistrict of Namlea, District of Buru, Province of Maluku, Indonesia, where the community drained their anchovy on the *karoro* net along the roadside. The most problem faced by the fishermen is the fish sanitation, hygiene and the rain fall. In order to produce the dried anchovy with good quality, this research was aimed to study the characteristics of dried anchovy (*Stolephorus* sp) by application of the cabinet and tunnel type of sun drier. The parameters observed including: organoleptics (appearance, smells and texture), proximate (water, protein, fat and ash content) and the presence of bacteria (total plate count/TPC). The results showed that there were differences in characteristics between the use of cabinet and tunnel dryers. The characteristics of dried anchovy provided by using cabinet dryer indicated that organoleptic such as appearance, smells, and texture were 7.83, 8 and 8 respectively; proximate that is moisture content, protein content, fat content and ash content were 17.51%, 67.25%, 3.66% and 11.56% respectively; and TPC value was 6.05 x 10^1 CFU /ml. On the other hand, the characteristics of dried anchovy by using tunnel dryer showed that organoleptic namely appearance, smells, and texture were 8.56, 8.30 and 8.46 respectively; proximate namely moisture content, protein content, fat content and ash content were 18.19%, 66.3%, 3.69% and 11.8% respectively; and TPC value was 4.1 x 10^1 CFU /ml. Finally, it seems that the tunnel dryer was better than cabinet drier for dried anchovy.

1. **Introduction**

Many traditional ways of preserving fish have been carried out to reduce it water content, so that it cannot provide an opportunity of bacteria (microbes) to live and develop, eventually it maintains the shelf live of fish. The study was conducted in the Village of Saliong, Subdistrict of Namlea, District
of Buru, Province of Maluku, Indonesia, where the community drained their anchovy on the *karoro* net along the road side. Traditionally, the fish processor is very dependent on sun drying and weather conditions [1]. The most distinct problem faced by the fishermen is the lack of fish sanitation and hygiene, transportation facilities, marketing infrastructure, government supported for credit facilities and the rain fall [2]. Most of the dried fish chosen by processors were small fishes, namely *tembang*, anchovies, and squid, because the raw materials are available in large numbers [3].

Another problem faced by traditional fish processor was its poor quality due to poor handling during processing. In order to increase the fish dried quality, this research designed the cabinet and tunnel type of sun drier. Sun dryer using tents can accelerate the drying period [4], avoiding dust and other small particles, as a result, there were a small of acid insoluble ash content of dried product.

Closed solar dryers have been designed to produce anchovy dry products that appropriate to sanitary and hygiene standards, where the production capacity is according to household scale that is often done by women. The type of fish dryer were cabinet and tunnel, made of local materials, using dark plastic as the walls and roof, equipped with multi-level racks in the form of cabinet and drying chamber that forms the tunnel dryer system, and has a small to medium capacity. This closed solar dryer is expected to be ideal for overcoming the traditional drying problem and producing dried anchovy products with better quality in accordance to the standard needed. The research aimed to study the drying characteristics of a fish dryer named cabinet and tunnel dryer.

2. Methodology

2.1. Time and study site

The research was conducted for four months from April 2018 to July 2018 at the Village of Saliong, Subdistrict of Namlea, District of Buru, Province of Maluku, Indonesia.

2.2. The type of dryers.

Two types of closed sun dryer namely cabinet dryer and tunnel dryer were constructed with each having a size for length x width x height of 70 cm x 66 cm x 226 and 200 cm x 100 cm x 60 cm. Each dryer has a wooden frame, covered by a dark plastic sheet. A pictorial view of dryer is shown in Figure 1 and Figure 2.
2.3. *Drying characteristic observation.*

The observation of the drying characteristics during drying consist of: temperature, determining the percentage of moisture loss, determining the drying rate of fish. While, the quality characteristics of
dried anchovy consist of: organoleptic (appearance, smells and texture), proximate (i.e. the content of water, ash, lipid, protein and carbohydrate) and total plate count of bacteria (TPC).

3. Results and Discussion

The measurement of drying temperature were conducted on each rack of the cabinet dryer (i.e. rack I, rack II and rack III), tunnel dryer and ambient temperature. During drying process, the temperature inside the dryer is higher than the ambient temperature. The average temperature of ambient temperature was 31.50 °C. While the average temperature of fish in Rack I, Rack II, Rack III, and tunnel dryer were 34.88 °C, 34.76 °C, 33.67 °C, and 34.04 °C respectively. The measurement of fish temperature is shown in Table 1 and Figure 3.

| Local time | Ambient temperature (°C) | Fish temperature (°C) |
|------------|--------------------------|-----------------------|
|            |                          | Cabinet dryer         |
|            |                          | Tunnel dryer          |
|            |                          | Rack I | Rack II | Rack III | Rack I | Rack II | Rack III | Rack I | Rack II | Rack III |
| 8.3        | 26.4                     | 27.7   | 27.3   | 27.6     | 32.3   |
| 9.3        | 34.1                     | 34.8   | 33.7   | 33.7     | 35.2   |
| 10.3       | 31.4                     | 37.9   | 35.1   | 34       | 36.5   |
| 11.3       | 31.8                     | 37.2   | 36     | 35.1     | 36.3   |
| 12.3       | 31.1                     | 36     | 37.1   | 35.1     | 34.8   |
| 13.3       | 31.6                     | 34.8   | 35.6   | 33.3     | 33.6   |
| 14.3       | 31.4                     | 35.3   | 36     | 34.9     | 33.3   |
| 15.3       | 32.4                     | 35.4   | 36.6   | 35.3     | 34.2   |
| 16.3       | 33.5                     | 34.8   | 35.4   | 34       | 30.6   |
Figure 3. Fish temperature during drying

Determination of percent moisture loss and drying rate of anchovy by using cabinet dryer and tunnel dryer during drying have been calculated. The average of percent moisture loss of anchovy dried in Rack I, Rack II and Rack III were 23.44 %, 20.63 %, and 18.83% respectively. While the average of percent moisture loss of fish in tunnel dries was 33.06%. The highest percent moisture loss of anchovy during drying was on the fish where dried in the tunnel dryer. The percent moisture loss was shown in Table 2, 3, 4, and Figure 4.

Determination of drying rate both for cabinet dryer and tunnel dryer were shown in Table 2, 3, 4, and Figure 5. The average of drying rate of anchovy dried in cabinet dryer for rack I, rack II, and rack III were 0.027 kg/h, 0.023 kg/h and 0.023 kg/h respectively. While average drying rate of anchovy dried using tunnel dryer was 0.036 kg/h.

Table 2. Determination of percent moisture loss and drying rate of cabinet dryer Rack I

| Local time | Final mass of fish (kg) | Moisture lost of fish (kg) | Percent moisture loss of fish (%) | Duration of drying (h) | Drying rate (kg/h) |
|------------|------------------------|-----------------------------|----------------------------------|-----------------------|-------------------|
| 08.30      | 0.5                    | 0                           | 0                                | 0                     | 0.000             |
| 09.30      | 0.469                  | 0.031                       | 6.112                            | 1                     | 0.031             |
| 10.30      | 0.438                  | 0.062                       | 12.469                           | 2                     | 0.031             |
| 11.30      | 0.397                  | 0.103                       | 20.538                           | 3                     | 0.034             |
| 12.30      | 0.378                  | 0.122                       | 24.450                           | 4                     | 0.031             |
| 13.30      | 0.347                  | 0.153                       | 30.562                           | 5                     | 0.031             |
| 14.30      | 0.326                  | 0.174                       | 34.719                           | 6                     | 0.029             |
| 15.30      | 0.304                  | 0.196                       | 39.120                           | 7                     | 0.028             |
| 16.30      | 0.285                  | 0.215                       | 43.032                           | 8                     | 0.027             |
### Table 3. Determination of percent moisture loss and drying rate of cabinet dryer Rack II

| Local time | Final mass of fish (kg) | Moisture lost of fish (kg) | Percent moisture loss of fish (%) | Duration of drying (h) | Drying rate (kg/h) |
|------------|-------------------------|----------------------------|-----------------------------------|------------------------|-------------------|
| 08.30      | 0.5                     | 0                          | 0                                 | 0                      | 0.000             |
| 09.30      | 0.4619                  | 0.0381                     | 7.621                             | 1                      | 0.038             |
| 10.30      | 0.4550                  | 0.0450                     | 9.007                             | 2                      | 0.023             |
| 11.30      | 0.4342                  | 0.0658                     | 13.164                            | 3                      | 0.022             |
| 12.30      | 0.4134                  | 0.0866                     | 17.321                            | 4                      | 0.022             |
| 13.30      | 0.3868                  | 0.1132                     | 22.633                            | 5                      | 0.023             |
| 14.30      | 0.3649                  | 0.1351                     | 27.021                            | 6                      | 0.023             |
| 15.30      | 0.2864                  | 0.2136                     | 42.725                            | 7                      | 0.031             |
| 16.30      | 0.2691                  | 0.2309                     | 46.189                            | 8                      | 0.029             |

### Table 4. Determination of percent moisture loss and drying rate of cabinet dryer Rack III

| Local time | Final mass of fish (kg) | Moisture lost of fish (kg) | Percent moisture loss of fish (%) | Duration of drying (h) | Drying rate (kg/h) |
|------------|-------------------------|----------------------------|-----------------------------------|------------------------|-------------------|
| 08.30      | 0.5                     | 0                          | 0.000                             | 0                      | 0.000             |
| 09.30      | 0.4648                  | 0.0352                     | 7.0330                            | 1                      | 0.035             |
| 10.30      | 0.4308                  | 0.0692                     | 13.8462                           | 2                      | 0.035             |
| 11.30      | 0.4242                  | 0.0758                     | 15.1648                           | 3                      | 0.025             |
| 12.30      | 0.4165                  | 0.0835                     | 16.7033                           | 4                      | 0.021             |
| 13.30      | 0.3923                  | 0.1077                     | 21.5385                           | 5                      | 0.022             |
| 14.30      | 0.3648                  | 0.1352                     | 27.0330                           | 6                      | 0.023             |
| 15.30      | 0.3429                  | 0.1571                     | 31.4286                           | 7                      | 0.022             |
| 16.30      | 0.3165                  | 0.1835                     | 36.7033                           | 8                      | 0.023             |

Figure 4. Moisture loss of dried anchovy during drying.
Table 5. Determination of percent moisture loss and drying rate of tunnel dryer

| Local time | Final mass of fish (kg) | Moisture lost of fish (kg) | Percent moisture loss of fish (%) | Duration of drying (h) | Drying rate (kg/h) |
|------------|------------------------|---------------------------|----------------------------------|------------------------|-------------------|
| 08.30      | 0.5                    | 0                         | 0.0000                           | 0                      | 0.000             |
| 09.30      | 0.4637                 | 0.0363                    | 7.2527                           | 1                      | 0.036             |
| 10.30      | 0.4209                 | 0.0791                    | 15.8242                          | 2                      | 0.040             |
| 11.30      | 0.3736                 | 0.1264                    | 25.2747                          | 3                      | 0.042             |
| 12.30      | 0.3341                 | 0.1659                    | 33.1868                          | 4                      | 0.041             |
| 13.30      | 0.2791                 | 0.2209                    | 44.1758                          | 5                      | 0.044             |
| 14.30      | 0.2297                 | 0.2703                    | 54.0659                          | 6                      | 0.045             |
| 15.30      | 0.2132                 | 0.2868                    | 57.3626                          | 7                      | 0.041             |
| 16.30      | 0.1978                 | 0.3022                    | 60.4396                          | 8                      | 0.038             |

![Figure 5. Drying rate of dried anchovy during drying.](image)

Table 6. The average values of ambient temperature, fish temperature, percent moisture loss of fish and drying rate of anchovy.

| Description                | Cabinet dryer | Tunnel dryer |
|----------------------------|---------------|-------------|
|                            | Rack I        | Rack II     | Rack III    |                |
| Average ambient temperature (°C) | 31.50         | 31.50       | 31.50       | 31.50         |
| Average fish temperature (°C)  | 34.88         | 34.76       | 33.67       | 34.08         |
| Average percentage of moisture loss (%) | 23.44         | 20.63       | 18.83       | 33.06         |
| Average drying rate of fish (kg/h) | 0.027         | 0.023       | 0.023       | 0.036         |
Table 7. Determination of organoleptic, proximate, and TPC of dried anchovy.

| No | Description | Cabinet Dryer | Tunnel Dryer |
|----|-------------|---------------|--------------|
| 1  | Appearance  | 7.83          | 8.56         |
| 2  | Smells      | 8             | 8.30         |
| 3  | Texture     | 8             | 8.46         |
| 4  | Moisture (%)| 17.51         | 18.19        |
| 5  | Protein (%) | 67.25         | 66.3         |
| 6  | Fat (%)     | 3.66          | 3.69         |
| 7  | Ash (%)     | 11.56         | 11.8         |
| 8  | TPC (CFU/ml)| $6.05 \times 10^1$ | $4.1 \times 10^1$ |

Table 7 showed that there were differences characteristics between using cabinet and tunnel dryers. The characteristics of dried anchovy by using cabinet dryer indicated that organoleptic namely appearance, smells, and texture were 7.83, 8, and 8 respectively; proximate that is moisture content, protein content, fat content and ash content were 17.51, 67.25, 3.66 and 11.56 respectively; and TPC value was 6.05 x 10^1 CFU /ml. On the other hand, the characteristics of dried anchovy by using tunnel dryer showed that organoleptic i.e. appearance, smells, and texture were 8.56, 8.30 and 8.46 respectively; proximate i.e. moisture content, protein content, fat content and ash content were 18.19, 66.3, 3.69, and 11.8 respectively; and TPC value was 4.1 x 10^1 CFU /ml. This product was on the range permitted by the Agency of National Standardization (BSN) [5], where the organoleptics score should not be less than 7, moisture content less than 40% and maximum TPC value of 1 x 10^5 CFU/ml.

Moisture content of various types of dried salted fish in Indonesia ranged from 8.28% - 37.28% [6]. The range of moisture content was 19.71-25.30% and ash content 0.15-0.22% and TPC 2.3x10^3-2.9x10^5 CFU/ml [7]. *Stolephorus commersonii* dried at 31° C contains 18% water and TPC 1.5 x 10^2 CFU/ml [8].

The drying chamber equipped by stacked rack and exhaust produced prevalent air circulation on all sides of the dried product and evaporated the moisture from the fish so that the fish dries evenly. The higher the temperature and drying speed, the shorter the time to reach the critical point of drying [9]. Drying using a closed transparent dryer resulted a higher drying temperature compared to open dryer [10]. The temperature in a closed dryer was found 45 °C and at the same time in an open dryer was 35 °C, while Zebib et al. [11] stated that temperatures on closed and open rack were 50 °C and 26 °C, respectively. Both designs of fish dryer are suitable for small-scale use and provide standardized characteristic of good quality dried fish.

4. Conclusion

Based on the average values of ambient temperature, fish temperature, percent moisture loss of fish and drying rate of anchovy, the tunnel dryer seems to be better than cabinet dryer as it is shown by the higher drying rate. Both cabinet and tunnel dryer produced dried anchovy with good quality and shorter time to dry anchovy. Dried anchovy resulted from this research have fulfilled the requirement suggested by the Agency National Standardization (BSN).
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References

[1] Suprihatin and Romli M 2009 *J. Kelautan Nasiona*. 2 (Edisi Khusus) 131-143
[2] Bharda S, Desai AY, Kumar T R, Kumar TJ 2017 *Research J. of Recent Sciences* 6 (7) 28-32
[3] Yuliana E 2012 *J. Pengolahan Hasil Perikanan Indonesia* 15 (1) 1-8
[4] Relekar S S, Joshi S A, Gore S B, Kulkarni A K 2014 *Int. J. of fisheries and Aquatic studies* 1 (5) 60–66.
[5] [BSN] Badan Standardisasi Nasional 1992 *Cara Uji Ikan Asin Kering*. SNI 01-2721- 1992 (Jakarta: Badan Standardisasi Nasional)
[6] Agustini T W, Darmanto Y S, Susanto E 2009 *J. of Coastal Dev.* 12 (2) 73-80
[7] Rahmani, Yunianta, Martati E 2007 *J. Teknologi Pertanian* 8 (3) 142-152
[8] Immaculate K, SInduja P, Velammal A, Patterson J 2013 *Int. Food Research J.* 20 (4) 1855-1859
[9] Subarkah R, Abdurrachim, Hendrarsakti J and Belyamin 2013 *J. of Food Sci. and Engineering* 3 87-93.
[10] Abraha B, Samuel M, Mohammud A, Tsion H M H, Admassu H, Al-Hajj N Q M 2017 *Turkish J. of Fisheries and Aquatic Sci.* 17 1107-1115.
[11] Zebib H, Teame T, Meresa T *ISABB J. of Food and Agriculture Sci.* 7 (2) 10-18