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Analysis of Swallow Nest Nitrite Levels and Export Volume Projections: A Statistical Approach to Quality Improvement and Global Market Development

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ABSTRACT

The global SARS-CoV-2 pandemic is impacting public health and living systems. Edible Bird's Nest (EBN), one of the variants of Swallow's Nest (SBW), is recognized as a medicinal food. The potential of SBW as a therapeutic agent is gaining attention due to its ability to inhibit viral hemagglutination activity. This study provides information on the prediction of SBW demand in the coming year so that it can contribute to determining Indonesia's SBW export performance. Net weight data (tons) of SBW export time series were obtained for 10 years from 2012 to 2022 in 10 countries, namely: Hong Kong, China, Singapore, USA, Vietnam, Canada, Taiwan, Thailand, Japan, and Cambodia, combined with laboratory examination on nitrite levels conducted at the Surabaya Agricultural Quarantine Center, Indonesia. This study shows the minimum limit on nitrite levels in SBW exports and the need for SBW exports in the next four years. One of the requirements for SBW exports is the minimum limit of nitrite levels. The ARIMA method has been implemented to forecast SBW export demand in 10 countries for the next four years. SBW export demand in the next four years is expected to decline. The findings make a significant contribution as a source of information for decision-makers involved in SBW export activities.

Key Words: Edible Bird's Nest, Food Statistics, Global Food Economy, Swallow's Nest.

INTRODUCTION

The global pandemic triggered by the SARS-CoV-2 virus has had a significant impact on public health and living systems around the world (Robinson et al., 2021; Boehm et al., 2021). In March 2020, the World Health Organization (WHO) stated that COVID-19 was spreading rapidly across the globe. The origin of the virus is

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still a mystery, with some theories pointing to the Wuhan Market as a potential place for the virus to have emerged (Kober et al., 2020; Wu et al., 2020). Data from the WHO on December 2, 2022, reported that the number of positive cases of SARS-CoV-2 reached 640,395,651, with a death rate of 6,618,579. The economic and social disruption generated by the pandemic caused destructive impacts, increasing the risk of extreme poverty for tens of millions of people, and an estimated nearly 690 million people were undernourished (Gao et al., 2020; Rothan et al., 2020; WHO, 2021).

Swallow's Nest (SBW) is the product of swallow's saliva (Ali, 2017; Harapuspa and Fitriani, 2018). SBW is one of the livestock subsector commodities that is prioritized in Indonesia's export destinations (Anggraini et al., 2017; Rahmawati et al., 2022). The potential of SBW as a therapeutic agent has gained attention due to its ability to inhibit the hemagglutination activity of influenza viruses, indicating potential efficacy in relieving respiratory viral infections (Gan et al., 2020; Ningrum et al., 2023). Indonesia is the largest exporter of SBW products in the world. According to Rahmawati et al. (2022), the total world export value in 2020 was 982.2 million USD. Indonesia contributed 540.7 million USD, which is about 55% of the total world export value.

Edible Bird's Nest (EBN), a variant of SBW, is recognized as a highly valuable medicinal food with significant potential bioactivity (Hum Lee et al., 2021; El Sheikha, 2021; Yeo et al., 2021). Great attention is paid to the antiviral and anti-inflammatory properties of EBN, which are increasingly becoming the focus of research (Zhao et al., 2016; Lee et al., 2020; Ling et al., 2020). Research by Haghani et al. (2017) showed that EBN can inhibit viral hemagglutination activity (HA). EBN is known to have potential for reducing proinflammatory cytokines and chemokines, such as TNF-α, CCL-2, NF-κB, NO, and IL-6, while increasing IFN-γ, which plays an important role in overcoming the cytokine storm phenomenon that is the peak of susceptibility to COVID-19 (Haghani et al., 2016; Hui Yan et al., 2021). Other studies have shown that EBN can repair apoptosis and normalize the cellular shape of cells infected by Influenza A Virus (IAV) (Yew et al., 2014; Haghani et al., 2017). Consumption of EBN at more severe stages of the disease can reduce damage to the host cells. EBN stimulates DNA synthesis in 3T3 fibroblasts, providing further insight into its potential for tissue recovery and cell growth (Guo et al., 2006).

This research emphasizes improving export performance as a top priority for companies competing in the economic environment. The specific focus of this research is to analyze Indonesia's SBW export performance, which is the object of study because Indonesia is the largest producer of SBW in the world. Using statistical methods to make predictions is important as it can assist authorities in making necessary arrangements and enabling appropriate responses, which in turn can prepare for SBW demand in the next few years. This research provides information on the prediction of SBW demand in the coming years to contribute to determining the extent to which Indonesia's SBW export performance can be optimized, with the ultimate goal of making this

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product an Indonesian flagship product capable of making a significant contribution to the country's foreign exchange earnings.

MATERIALS AND METHODS

This study uses the Autoregressive Integrated Moving Average (ARIMA) technique to forecast SBW export demand. Annual time series data of SBW exports were combined with laboratory examination results that included nitrite tests. ARIMA uses past and present values of the dependent variable to produce accurate forecasts (Awan and Aslam, 2020).

Data and Sampling

Net weight data (tons) of SBW export time series for 10 years from 2012 to 2022 in 10 countries namely Hong Kong, China, Singapore, USA, Vietnam, Canada, Taiwan, Thailand, Japan, and Cambodia, were combined with laboratory examination of nitrite levels (BBKP Surabaya and BPS). SBW samples were taken from Swallow Houses (RBW) from February to March 2023 in the East Java region and then tested for nitrite. SBW sample criteria; white color, weight is about 6-8 grams. SBW samples were taken using a stainless-steel spatula and put into a food grade plastic bag. The samples were stored at 4°C in the laboratory.

Research Procedure

ARIMA is a common technique used for forecasting using time series data (Awan and Aslam, 2020). T is modeled through an AR process, which can be written as:

$$y_t = \delta + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \ldots + \phi_p y_{t-p} + \epsilon_t$$

where, δ is intercept; yt-i are regressors; ϕt-i is coefficient and ϵ is an error term (ϵϵ).

MA is another class of linear model. In MA, the output or the variable of interest is modeled via its own imperfectly predicted values of current and previous times. It can be written as follows in terms of error terms:

$$y_t = \mu + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \ldots + \theta_p \epsilon_{t-p} + \epsilon_t$$

The mathematical form of ARMA (p,q) is as follows:

$$y_t = (\delta + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \ldots + \phi_p y_{t-p}) + (\theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \ldots + \theta_q \epsilon_{t-q})$$

In short, we can rewrite the above equation as:

$$y_t = \delta + \sum_{\iota=1}^{p} \phi_1 y_{1-\iota} + \sum_{j=1}^{q} \theta_j \epsilon_{t-j} + \epsilon_t$$

Materials and Tools

The materials used were 100 ppm nitrite standard solution, nitrite working standard, sulfanilamide solution, saturated sodium chloride (NaCl) solution, N-(1-naphthyl) ethylene dichloride (NED) solution (Merck KGaA, Germany), ion-free water, nitrite working standard solutions of 0; 0.2; 0.3; 0.4; 0.5; 0.6 and 0.7 ppm, and SBW. Tools used were a UV-visible spectrophotometer (Shimadzu type UV-1900i spectrophotometer), analytical balance, blender, ultrasonic digester, timer, volumetric flask, glass cup, funnel, erlenmeyer, ice box, refrigerator, sterile tweezers, label paper, microtip/pipette tip (10 µL, 100 µL, 1000 µL), Whatman filter

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paper no. 41, sterile sample plastic, sterile spatula, single channel micropipette, CR 400 chromameter color sensor, and glass plate.

Nitrite Analysis

Nitrite analysis was conducted based on the Association of Official Agricultural Chemists (AOAC) spectrophotometer method, Determination of Nitrite in Cured Meats, 1997, with some modifications. The stages of the examination included the preparation of standard solutions of nitrite, sulfanilamide, and NED. SBW samples were pulverized and homogenized for the determination of nitrite content, then 40 mL of ion-free water and 3 mL of saturated NaCl solution were added. The mixed solution was heated in an ultrasonic digester at 40°C for 30 minutes and filtered with Whatman paper no. 41. Then 2.5 mL of sulfanilamide was added and allowed to stand for five minutes. The next step was to add 2.5 mL of NED, homogenize it, and leave it for 15 minutes. Then, the absorption was measured using a spectrophotometer at a wavelength of 541 nm. Furthermore, the concentration of nitrite content was calculated using the following formula:

$$Content\ (\mu g.\ g^{-1}) = \frac{C\ of\ the\ curve\ x\ Dissolution\ volume}{W}$$

Description:
C = the amount of nitrite in the sample obtained from the calibrated curve ($\mu g.L^{-1}$)
V = sample solvent volume (mL)
W = sample weight (g)

Data Analysis

The data were analyzed using the ARIMA method with the help of Python software and descriptively by presenting the test results in the form of tables and figures.

RESULTS AND DISCUSSION

The process of testing nitrite levels in SBW used the spectrophotometer method. The determination of nitrite levels was carried out based on the spectrophotometer method recognized by the AOAC Determination of Nitrite in Cured Meats, 1997, with some modifications made at the Surabaya Agricultural Quarantine Center, Indonesia.

The test results of nitrite levels (Table 1 and Figure 1) with the UV-visible spectrophotometer method were used as a reference in classifying the samples. Based on testing conducted by the Surabaya Agricultural Quarantine Center, Indonesia, the threshold result of < 80 mg/kg is a positive result for nitrite for SBW exports to China in accordance with MOA No. 26/2020. The calibration curve results obtained from sample codes 2726, 2977, 2978, 2979, 3320, and 3321 are 0.074 - 1.781 mg/L which is outside the upper and lower limits of the working range of 0.2 mg/L. The 102% recovery is within the range of 8-120% of the AOAC reference.

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Table 1. Nitrite test result (+)

Sample	Repeat	Weight (g)	Volume (ml)	Nitrite Concentration (μ/ml)	(μ/kg)	Average concentration (mg/kg)
2726	a	0.502	50	0.517	51.4940	
	b	0.500	50	0.546	54.6000	53.047
2977	a	0.500	50	0.195	19.5000	
	b	0.501	50	0.200	19.9601	19.730
2978	a	0.500	50	0.325	32.5000	
	b	0.500	50	0.333	33.3000	32.900
2979	a	0.500	50	1.776	117.6000	
	b	0.501	50	1.781	117.7445	177.672
3320	a	0.501	50	0.113	11.2774	
	b	0.502	50	0.116	11.5538	11.416
3321	a	0.501	50	0.074	7.3852	
	b	0.502	50	0.095	9.4622	8.424
	Spike A	0.500	50	0.948	94.8000	
	Spike B	0.500	50	0.929	92.9000	93.850

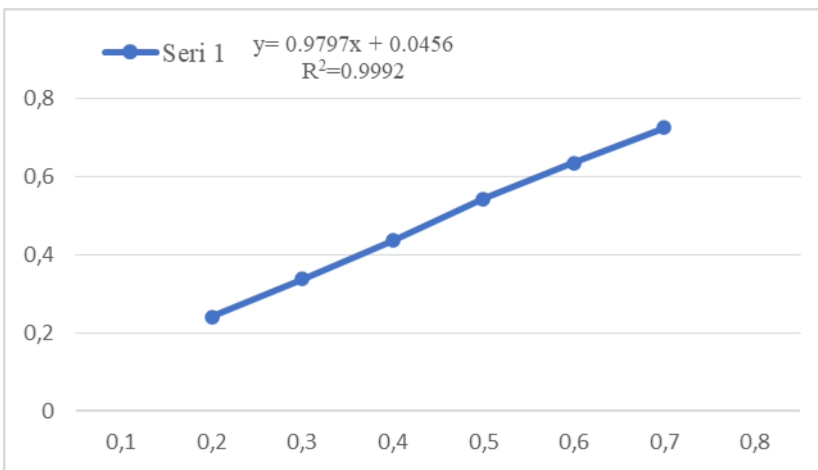

Figure 1. Calibration curve results.

The test results of nitrite levels (Table 2 and Figure 2) with the UV-visible spectrophotometer method were used as a reference in classifying the samples. Based on testing conducted by the Surabaya Agricultural Quarantine Center, Indonesia, negative nitrite results were obtained with numbers below 80 mg/kg, which is a negative nitrite result for SBW exports to China according to MOA 26/2020. The calibration curve results obtained from sample codes 4113, 4136, 4137, 4138, and 4139 were 0.063-0.669 mg/L, which is outside the upper and lower limits of the working range of 0.2 mg/L. The recovery of 106.9% was within the range of 8-120% of the AOAC reference.

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Table. 2 Nitrite test results (-)

Sample	Repeat	Weight (g)	Volume (ml)	Nitrite Concentration (μ/ml)	(μ/kg)	Average concentration (mg/kg)
4113	a	0.502	50	0.669	66.6335	
	b	0.500	50	0.610	61.0000	63.817
4136	a	0.500	50	0.065	6.5000	
	b	0.500	50	0.072	7.2000	6.850
4137	a	0.502	50	0.159	15.3386	
	b	0.502	50	0.154	15.3386	15.588
4138	a	0.500	50	0.063	6.3000	
	b	0.501	50	0.071	7.0858	6.693
4139	a	0.501	50	0.383	38.2236	
	b	0.500	50	0.386	38.6000	38.412
	Spike A	0.500	50	0.489	48.9000	
	Spike B	0.500	50	0.500	50.0000	49.450

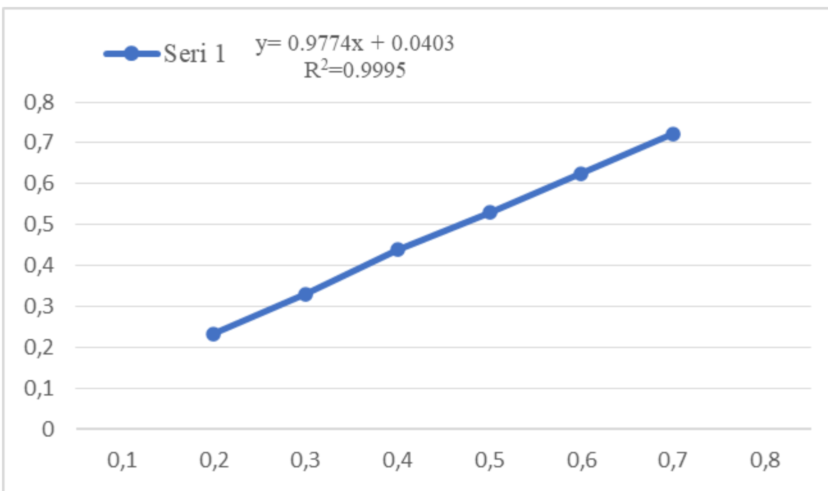

Figure 2. Calibration curve results.

ARIMA is a commonly used technique for forecasting using time series data, based on the smallest AIC value. The best model is selected based on the smallest AIC value among the existing models. The model with the smallest AIC value is used to forecast the demand for SBW exports. The data used are from 2012 to 2022, consisting of 10 countries, namely: Hong Kong, China, Singapore, USA, Vietnam, Canada, Taiwan, Thailand, Japan, and Cambodia. The ARIMA model is applied to annual data from the Surabaya Agricultural Quarantine Center, Indonesia, and the Central Statistics Agency (BPS) for 10 years. Using the selected model, it is possible to forecast SBW export demand for the next four years in 10 countries.

This study analyzes 10 years of SBW export data in 10 countries, namely Hong

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Kong, China, Singapore, USA, Vietnam, Canada, Taiwan, Thailand, Japan, and Cambodia. The ARIMA model was considered to be the most suitable model for forecasting future SBW export demand. Table 3 explains the model selection, while Table 4 and Figure 4 provide details of SBW export demand over the next four years for 10 countries. Of the 10 countries, the largest SBW export demand in 2023-2026 was in Hong Kong with an estimated export demand in 2023 of 469.6 tons, in 2024 of 531.2 tons, in 2025 of 531.2 tons, and in 2026 of 531.2 tons. The second largest SBW export demand occurred in Vietnam, with an estimated export demand in 2023 of 348.4 tons, 2024 of 347.7 tons, and 2025 of 277.1 tons. In 2026, the second largest SBW export demand occurred in China, with an estimated export demand of 239.9 tons, and the smallest SBW export demand occurred in Cambodia, with an estimated export demand in 2023 of 0.0 tons, 2024 of 0.1 tons, 2025 of 0.1 tons, and 2026 of 0.1 tons. The total projected SBW export demand to 10 countries in 2023 was 1306.3 tons, in 2024 it was 1197.6 tons, in 2025 it was 1101.9 tons, and in 2026 it was 1024.9 tons. Forecasting results using the ARIMA method show that SBW export demand tends to decrease during the period 2023-2026, and further information can be seen in Table 4.

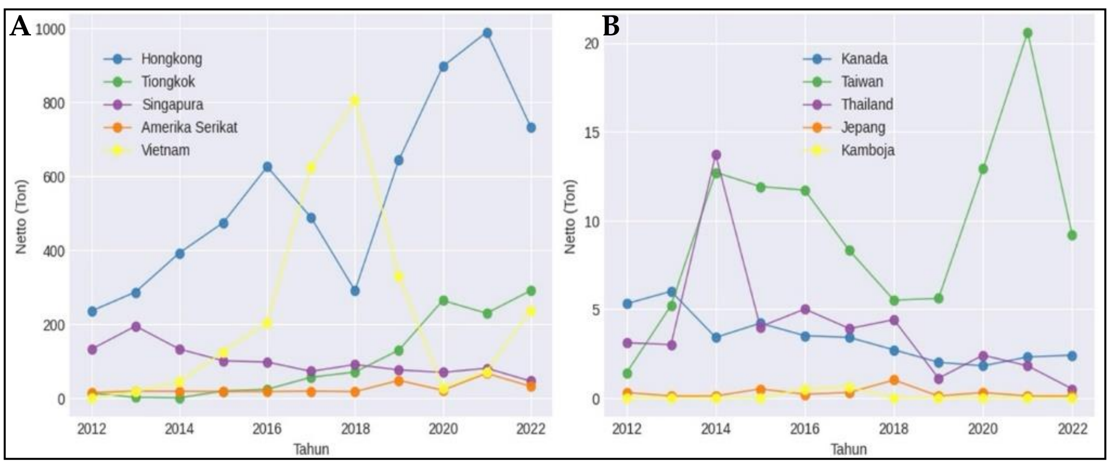

Figure 3. SBW export graph. (A) 5 highest net actual data, (B) 5 lowest net actual data.

Table 3. Determination of the ARIMA model

No	Country	Model	AIC
1	Hong Kong	ARIMA(1,0,0) int	151.6
		ARIMA(0,0,1) int	**150.4**
		ARIMA(1,0,1) int	151.2
		ARIMA(1,0,2) int	152.9
		ARIMA(0,0,2) int	151.0
2	China	ARIMA (1,0,0) int	**125.0**
		ARIMA (0,0,1) int	133.0

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No	Country	Model	AIC
		ARIMA (1,0,1) int	127.9
		ARIMA (2,0,0)	127.0
		ARIMA (2,0,1)	129.1
3	Singapore	ARIMA (1,0,0) int	**113.0**
		ARIMA (0,0,1) int	113.0
		ARIMA (1,0,1) int	inf
		ARIMA (2,0,0) int	115.0
		ARIMA (2,0,1) int	inf
4	USA	ARIMA (1,0,0) int	**97.7**
		ARIMA (0,0,0) int	97.7
		ARIMA (1,0,1) int	99.4
		ARIMA (0,0,1) int	97.7
		ARIMA (0,0,0)	108.1
5	Vietnam	ARIMA (1,0,0) int	154.9
		ARIMA (0,0,1) int	inf
		ARIMA (1,0,1) int	inf
		ARIMA (2,0,0)	**151.3**
		ARIMA (2,0,0) int	151.3
6	Canada	ARIMA (1,0,0) int	**36.1**
		ARIMA (0,0,1) int	38.8
		ARIMA (1,0,1) int	37.8
		ARIMA (2,0,0) int	37.5
		ARIMA (2,0,1) int	39.0
7	Taiwan	ARIMA (1,0,0) int	**71.5**
		ARIMA (0,0,0) int	72.5
		ARIMA (0,0,1) int	inf
		ARIMA (0,0,0)	85.5
		ARIMA (1,0,1) int	inf
8	Thailand	ARIMA (1,0,0)	**63.9**
		ARIMA (0,0,0) int	64.0
		ARIMA (0,0,1) int	63.9
		ARIMA (0,0,0)	69.3
		ARIMA (1,0,1) int	65.9
9	Japan	ARIMA (0,0,0) int	7.5
		ARIMA (0,0,1) int	**7.1**
		ARIMA (1,0,0) int	7.2
		ARIMA (0,0,0)	12.1
		ARIMA (1,0,1) int	inf

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No	Country	Model	AIC
10	Cambodia	ARIMA (1,0,0) int	1.7
		ARIMA (0,0,1) int	**-0.5**
		ARIMA (1,0,1) int	1.3
		ARIMA (1,0,1)	inf
		ARIMA (1,0,2)	2.3
Total		ARIMA (1,0,0) int	149.8
		ARIMA (0,0,1) int	inf
		ARIMA (1,0,1) int	148.8
		ARIMA (2,0,0) int	**148.0**
		ARIMA (2,0,0)	148.4

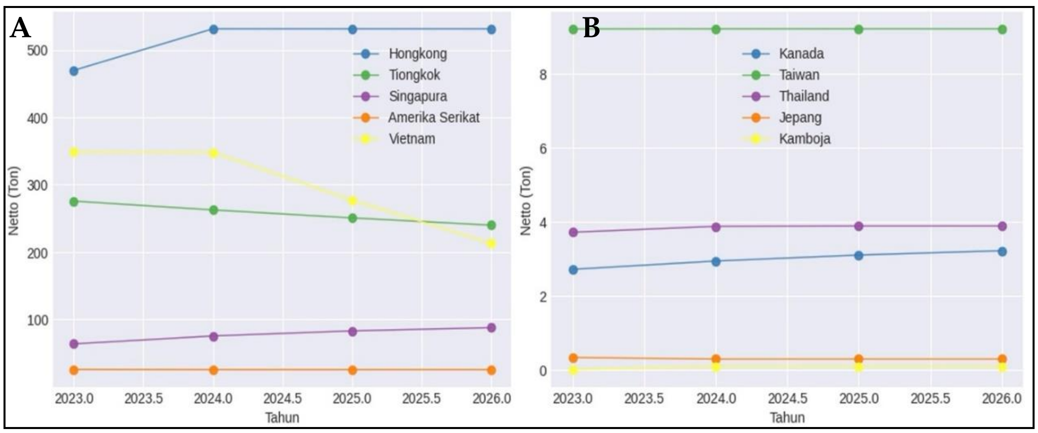

Figure 4. SBW export graph based on ARIMA. (A) 5 highest net actual data, (B) 5 lowest net actual data.

Table 4. SBW export forecast.

Year	2023	2024	2025	2026
Net Weight: Tons				
Hong Kong	469.6	531.2	531.2	531.2
China	275.6	262.6	250.7	239.9
SingapORE	63.8	75.7	83.2	88.0
USA	26.0	25.7	25.7	25.7
Vietnam	348.4	347.7	277.1	212.8
Canada	2.7	2.9	3.1	3.2
Taiwan	9.2	9.2	9.2	9.2
Thailand	3.7	3.9	3.9	3.9
Japan	0.3	0.3	0.3	0.3
Cambodia	0.0	0.1	0.1	0.1
Jumlah	1306.3	1197.6	1101.9	1024.9

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The measurement of SBW nitrite levels using the spectrophotometer method has become a common approach. This method is considered accurate, simple, and requires equipment that is not too expensive at the laboratory level, so it is widely used by researchers. Previous studies, such as those conducted by Yenil and Yemiş (2018) and Widiyani et al. (2023), emphasized the reliability of spectrophotometers in measuring nitrite levels in SBW. The test results of nitrite levels obtained threshold results < 80 mg/kg and below 80 mg/kg. The nitrite content may vary depending on different washing frequencies. In addition to cleaning the nest from feathers and dirt, washing can indirectly reduce nitrite levels in SBW (Gallant et al., 2013; Hamzah et al., 2013). SBW export technical requirements were according to the RI - PRC protocol, namely, SBW processing units (IKH) registered at Barantan and GACC, application of HACCP and traceability assurance to RBW registered at Barantan and GACC, heating until the core temperature reaches 70°C and a minimum of 3.5 seconds to kill pathogenic agents, nitrite levels of 30 ppm, and 15% moisture content free of biological, chemical and physical contamination.

Nitrite is formed as a result of the decomposition process of the feces in the cage and in the swallow nest (Sirenden et al., 2018). The use of optimal ventilation in SBW can help reduce the fermentation process, resulting in SBW with lower nitrite levels (Quek et al., 2015; Yusuf et al., 2020). The application of good management practices (GMP) from RBW to the SBW washing industry can reduce nitrite levels in SBW (Singh et al., 2019; Ningrum, 2021). The main objective of this study is to predict the demand for SBW exports in the period 2023-2026 in the top 10 countries which are currently confirmed to have the highest number of SBW exports. The importance of this study lies in its ability to provide proactive information to the government and SBW businesses. By having a better understanding of SBW export demand trends, the government and businesses can design strategies accordingly. This research plays a role in determining the extent to which Indonesia's SBW export performance can be optimized. The ultimate goal is to make this product one of Indonesia's leading products capable of significantly contributing to the country's foreign exchange earnings. The prediction results for the next four years show a downward trend, with an indication that the demand for SBW exports in the 10 countries tends to decrease from 2023-2026. On average, SBW export demand is estimated to be highest in Hong Kong, Vietnam, China, Singapore, USA, Taiwan, Thailand, Canada, Japan and Cambodia. This information can be the basis for more effective policies and strategies for managing Indonesia's SBW exports in the global market.

CONCLUSION

One of the requirements for SBW exports is a minimum limit of nitrite content in SBW products. This study uses the ARIMA method to forecast SBW export demand in 10 countries for the next four years. In finding the best prediction model,

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a number of tests were conducted with variations in the amount of data used. The best model for each data set was selected based on the lowest error rate. The test results show that SBW export demand in 2023-2026 is expected to decline. This finding makes a significant contribution as a source of information for decision-makers involved in SBW export activities.

ETHICS APPROVAL

All experiments were carried out without sacrificing live animals. Thus, ethical approval for animal experimentation was not required. All inspections in the field study were conducted with permission from the Surabaya Agricultural Quarantine Center, Indonesia. No animals were sacrificed for the purpose of the field study. No human participants were involved in this study.

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